

# Rexroth IndraDrive Firmware for Drive Controllers MPH,- MPB-, MPD-, MPC-07

R911328670  
Edition 02

## Functional Description



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**Purpose of Documentation** This documentation describes all the functional properties of the IndraDrive firmware in the variants MPH-07, MPB-07, MPD-07 and MPC-07.

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# 1 System Overview

## 1.1 General Information

### 1.1.1 About This Documentation

**Means of Representation in This Documentation**

To make the reading of this documentation easier for you, the table below contains the means of representation and notations of recurring terms.

What?	How?	For example...
Important facts which are to be highlighted in continuous text	Boldface	Transmission of freely configurable external <b>process data</b> (command values and actual values of the external control unit)
Parameter names, diagnostic message names, function designations	Quotation marks	The device function "cross communication (CCD)" is characterized by the following features:

Fig. 1-1: Conventions of Notation

All important notes are highlighted. A symbol tells you what kind of note is used in the text. The symbols have the following significances:



**DANGER**

...

DANGER indicates a hazardous situation which, if not avoided, will result in death or serious injury.



**WARNING**

...

WARNING indicates a hazardous situation which, if not avoided, could result in death or serious injury.



**CAUTION**

...

CAUTION indicates a potentially hazardous situation which, if not avoided, could result in injury or property damage.



This box contains important information which you should take into consideration.



This symbol highlights useful tips and tricks.

**Your Feedback**

Your experience is important for our improvement processes of products and documentations.

If you discover mistakes in this documentation or suggest changes, you can send your feedback to the following e-mail address:

[Dokusupport@boschrexroth.de](mailto:Dokusupport@boschrexroth.de)

We need the following information to handle your feedback:

- The number indicated under "Internal File Reference" .
- The page number.

## System Overview

## 1.1.2 How to Use This Documentation

### Structure of the Functional Description

The functional descriptions of the IndraDrive firmware are divided into fixed chapters. The individual subjects of the firmware description are assigned to these chapters according to their content.

The description of the respective firmware functionality is basically divided into the following sections:

- Brief Description
- Functional Description
- Notes on Commissioning
- Diagnostic and Status Messages, Monitoring Functions

Within one subject, these sections are always contained in the mentioned order, but for practical and formal reasons they are not always existing or may have a different title.

**Brief Description**

The brief description contains an overview of the firmware function or the subject of the section. The brief description can contain, for example, general basics, the most important features of the function, overviews and examples of application. At the end of the brief description you can find, where possible and useful, a list of the parameters and diagnostic messages that are associated with this functions.

**Functional Description**

The section "Functional Description" explains the operating principle of the respective drive function in an application-oriented way. The relevant parameters of this function are described with regard to their settings and effects. The parameter configuration is only explained in detail where this is necessary for the description of the function. As a basic principle, the functional description contains references to the separate documentations for parameters and diagnostic messages.



The detailed description of the parameters, their function and structure is contained in the separate documentation "Rexroth IndraDrive, Parameter Description".



The detailed description of the diagnostic messages, their causes and measures for remedy is contained in the separate documentation "Rexroth IndraDrive, Troubleshooting Guide" (description of diagnostic messages).

**Notes on Commissioning**

The section "Notes on Commissioning" or "Notes on Parameterization" provides the user with the steps required for commissioning the function, similar to a checklist. The necessary parameter settings are described in compact form and, if necessary, instructions are given for activating the function and the diagnostic messages of the immediate functional sequence are mentioned.

**Diagnostic and Status Messages,  
Monitoring Functions**

The section "Diagnostic and Status Messages" (also "Monitoring Functions", if necessary) summarizes the diagnostic messages and possible status displays available for the respective function and describes them briefly. If there are function-specific monitoring functions, they are also described in this section.



The detailed description of the diagnostic messages, their causes and measures for remedy is contained in the separate documentation "Rexroth IndraDrive, Troubleshooting Guide" (description of diagnostic messages).

## Markers and Terms

The complete functionality of the IndraDrive firmware is divided into functional packages (base packages and optional expansion packages). The scope of the available functions does not only depend on the hardware design, but in the majority of cases also on the variant and characteristic of the firmware.

The descriptions of the master communication, the drive functions and the operating modes have a marker containing information on the availability of this functionality in the respective functional package of the firmware, e.g.:



Assignment to functional firmware package, see chapter "Availability of the Optional Device Functions".

**Terms** The application-specific scalability of the hardware and firmware provides a multitude of possibilities. For detailed information, the following terms are used in the Functional Description:

- Firmware **range** e.g. IndraDrive
- Firmware **design** single-axis, double-axis (multi-axis)
- Firmware **variant** e.g. MPH, MPB, MPD, MPC
- Firmware **version** e.g. MPH-07VRS
- Firmware **characteristic** open-loop/closed-loop
- Firmware **performance** Basic/Advanced
- Firmware **type** complete firmware type designation

## Cross References

Many basic subfunctions of the firmware, as well as necessary settings and definitions, are of multiple use within the overall functionality or have an effect on neighboring areas of the drive functionality. Such subfunctions normally are described only once. Descriptions that are part of other IndraDrive documentations (Parameter Description, Troubleshooting Guide, Project Planning Manuals ...) are only repeated in detail in exceptional cases. Cross references indicate the source for more detailed information.

For cross references to other sections or documentations, we make the following distinction:

- References to sections within this documentation are specified by indicating the title of the respective section and the designation of the superordinate topic, if necessary (both can be easily found via the index).



- References to other documentations are additionally signaled by the "info icon", unless contained in a note, in a table or in brackets.

## Reference Documentations

### Drive Systems, System Components

Title	Kind of documentation	Document typecode <sup>1)</sup>	Part number
Rexroth IndraDrive ...		DOK-INDRV*-...	R911...
Drive System	Project Planning Manual	SYSTEM*****-PRxx-EN-P	309636
Mi Drive Systems	Project Planning Manual	KCU+KSM****-PRxx-EN-P	320924
Supply Units, Power Sections	Project Planning Manual	HMV-S-D+HCS-PRxx-EN-P	318790

## System Overview

Title	Kind of documentation	Document typecode <sup>1)</sup>	Part number
<b>Rexroth IndraDrive ...</b>		<b>DOK-INDRV*-...</b>	<b>R911...</b>
Drive Controllers Control Sections	Project Planning Manual	CSH*****-PRxx-EN-P	295012
Additional Components	Project Planning Manual	ADDCOMP****-PRxx-EN-P	306140

1) In the document typecodes, "xx" is a wild card for the current edition of the documentation (example: PR01 is the first edition of a Project Planning Manual)

*Fig. 1-2: Documentations – Drive Systems, System Components*

**Motors**

Title	Kind of documentation	Document typecode <sup>1)</sup>	Part number
<b>Rexroth IndraDyn ...</b>		<b>DOK-MOTOR*-...</b>	<b>R911...</b>
A Series Asynchronous Motors	Project Planning Manual	MAD/MAF****-PRxx-EN-P	295781
H Frameless Synchronous Spindle Motors	Project Planning Manual	MBS-H*****-PRxx-EN-P	297895
L Synchronous Linear Motors	Project Planning Manual	MLF*****-PRxx-EN-P	293635
S MSK Synchronous Motors	Project Planning Manual	MSK*****-PRxx-EN-P	296289
T Synchronous Torque Motors	Project Planning Manual	MBT*****-PRxx-EN-P	298798

1) In the document typecodes, "xx" is a wild card for the current edition of the documentation (example: PR01 is the first edition of a Project Planning Manual)

*Fig. 1-3: Documentations – Motors*

**Cable**

Title	Kind of documentation	Document typecode <sup>1)</sup>	Part number
		<b>DOK-CONNEC-...</b>	<b>R911...</b>
Rexroth Connection Cables	Selection Data	CABLE*STAND-AUxx-EN-P	282688

1) In the document typecodes, "xx" is a wild card for the current edition of the documentation (example: AU03 is the third edition of the documentation "Selection Data")

*Fig. 1-4: Documentations – Cables*

**Firmware**

Title	Kind of documentation	Document typecode <sup>1)</sup>	Part number
<b>Rexroth IndraDrive ...</b>		<b>DOK-INDRV*-...</b>	<b>R911...</b>
Firmware for Drive Controllers	Functional Description	MP*-02VRS**-FKxx-EN-P	299223
Firmware for Drive Controllers	Functional Description	MP*-03VRS**-FKxx-EN-P	308329
Firmware for Drive Controllers	Functional Description	MP*-04VRS**-FKxx-EN-P	315485
Firmware for Drive Controllers	Functional Description	MP*-05VRS**-FKxx-EN-P	320182
Firmware for Drive Controllers	Functional Description	MP*-06VRS**-FKxx-EN-P	
Firmware for Drive Controllers	Parameter Description	GEN-**VRS**-PAxx-EN-P	297317
Firmware for Drive Controllers	Troubleshooting Guide	GEN-**VRS**-WAxx-EN-P	297319
Integrated Safety Technology	Functional and Application Description	SI**-**VRS**-FKxx-EN-P	297838



Title	Kind of documentation	Document typecode <sup>1)</sup>	Part number
Rexroth IndraDrive ...		DOK-INDRV*-...	R911...
Rexroth IndraMotion MLD	Application Manual	MLD-**VRS**-AWxx-EN-P	306084
Rexroth IndraMotion MLD Library	Library Description	MLD-SYSLIB*-FKxx-EN-P	309224

1) In the document typecodes, "xx" is a wild card for the current edition of the documentation (example: PA02 is the second edition of a Parameter Description)

Fig. 1-5: Documentations – Firmware

## 1.1.3 Overview of Drive Firmware

### Firmware Variants

For the IndraDrive range, there are different application-related firmware types available that are characterized by their scope of functions and their performance:

- **MTH:** Drives for Machine Tool Applications With SERCOS interface (**Advanced** Performance and Functionality)
- **MPx:** drives for general automation (incl. machine tool applications) with SERCOS interface, field bus interfaces, parallel and analog interface (the variants of design are **MPH**, **MPB**, **MPD** and **MPC**; see below)



The **first two letters** of the firmware designation identify the application and profile of the firmware:

- **MT:**"Machine Tool" → Drives for machine tool applications with SERCOS interface (drive profile according to SERCOS)
- **MP:**"Multi Purpose" → drives for general automation (incl. machine tool applications) with SERCOS interface, field bus interface as well as parallel and analog interface (drive profile according to SERCOS)

The **third letter** of the firmware designation identifies the hardware, as well as the performance and functionality of the firmware (**x** contains **H**, **B**, **D** and **C**):

- **H:** **Single-axis** firmware with **Advanced** performance and functionality
- **B:** **Single-axis** firmware with **Basic** performance and functionality
- **D:** **Double-axis** firmware with **Basic** performance and functionality
- **C:** **Single-axis** firmware with **Advanced** performance and functionality plus CCD + MLD-M functions

This documentation describes the functionality of the following firmware types:

- FWA-INDRV\*-MPH-07VRS-D5
- FWA-INDRV\*-MPB-07VRS-D5
- FWA-INDRV\*-MPD-07VRS-D5
- FWA-INDRV\*-MPC-07VRS-D5

The "IndraWorks Ds/D/MLD" commissioning tool is available for commissioning these firmware variants.

## System Overview

## Organization of the Firmware

For application-specific definition of drive functionality, the firmware functions are divided into different "functional packages". There are a **generally available base package** and various **additional functional packages** (e.g. integrated safety technology, IndraMotion MLD) that can be optionally activated.



The scope of functions of the functional packages and their possible combinations are described in section "Overview of functions/functional packages" section.

## 1.2 Terms, Basic Principles

### 1.2.1 Parameters

Communication between master and drive takes place, with a few exceptions, by means of parameters.

Parameters are used for:

- Determining the configuration
- Parameterizing the control loop
- Triggering and controlling drive functions and commands
- Transmitting command values and actual values (according to requirements, cyclically or acyclically)

All operating data are mapped to parameters!

The operating data stored in parameters can be identified by means of the IDN. They can be read and transferred, if required. The user write access to parameters depends on the properties of the respective parameter and the current communication phase. Specific parameter values (operating data) are checked for validity by the drive firmware.

### 1.2.2 Data Storage and Parameter Handling

**Data Memory** Several non-volatile data memories are available in an IndraDrive device:

- In the controller
- In the motor encoder (depending on motor type)
- As a MultiMediaCard (MMC), optional

In addition, a volatile data memory (working memory) is available in the controller.

**Condition as Supplied** Condition as supplied of the Rexroth drive components:

- The controller memory contains the drive firmware and the controller-specific parameter values.
- The motor encoder memory contains the encoder-specific and, depending on the motor type, the motor-specific parameter values.
- The MMC contains the drive firmware and the basic parameter sets.

#### Storing the Application-Specific Parameter Values

The application-specific parameter values are stored in the controller. Due to the limited number of writing cycles of non-volatile storage media, application-specific parameter values can be stored in the working memory (volatile memory), too.

#### Storing of Parameter Values

Saving application-specific parameter values is required in the following cases:

- After initial commissioning of the machine axis or the motor
- Before replacing the controller for servicing (if possible)

Application-specific parameter values can be saved via:

- MMC → copying the parameter values by command
- "IndraWorks Ds/D/MLD" commissioning tool → Saving the parameter values on external data carrier
- Control master → saving the parameter values on master-side data carrier

#### Parameter IDN Lists

The drive supports master-side saving of parameter values by listing parameter identification numbers (IDNs). Using these lists guarantees complete storage of the application-specific parameter values. It is also possible to determine IDN lists defined by the customer.

#### Loading of Parameter Values

Loading parameter values is required in the following cases:

- Initial commissioning of the motor (loading basic parameter values and motor-specific parameter values)
- Serial commissioning of machine axes at series machines (loading the values saved after initial commissioning)
- Reestablishing a defined initial status (repeated loading of the values saved after initial commissioning)
- Replacing the controller for servicing (loading the current parameter values saved before servicing)

Possibilities of loading parameter values to the controller:

- Motor encoder data memory → loading the parameter values by command or via the control panel during initial motor commissioning
- MMC → loading the parameter values by command
- "IndraWorks Ds/D/MLD" Commissioning tool → Loading the parameter values from external data carrier
- Control master → loading the parameter values from master-side data carrier

#### Checksum of Parameter Values

By means of checksum comparison, the control master can determine whether the values of the application-specific parameter values currently active in the drive correspond to the values saved on the master side.

## 1.2.3 Password

IndraDrive controllers provide the possibility to protect parameter values against accidental or unauthorized change by means of a password. With regard to write protection, there are 3 groups of parameters that can be written:

- Parameters that are write-protected as a standard, such as motor parameters, hardware code parameters, encoder parameters, error memory, etc. ("administration parameters"). The values of these parameters guarantee correct function and performance of the drive.
- Parameters the customer can combine in groups and protect them with a so-called customer password. This allows protecting parameter values, that are used for adjusting the drive to the axis, after having determined them.
- All other parameters that can be written and are not contained in the above-mentioned groups. They are not write-protected.

#### Kinds of Passwords

The drive firmware allows activating and deactivating the write protection for parameter values by means of three hierarchically different passwords:

- **Customer Password**

The parameter values of a parameter group combined by the customer can be protected.

- **Control Password**

## System Overview

Parameters protected by a customer password can be written; "administration parameters" remain write-protected.

- **Master Password**

All parameters that can be written, including "administration parameters" and parameters protected by a customer password, can be changed.

## 1.2.4 Commands

Commands are used to activate and control complex functions or monitoring features in the drive. The higher-level master can start, interrupt or clear commands.

Each command is assigned to a parameter by means of which the execution of the command can be controlled. During the execution of the command the display of the control panel reads "Cx", "Cx" representing the diagnostic command message and "x" representing the number of the command.



Each command that was started must be actively cleared again.

---

All commands available in the drive are stored in the parameter "S-0-0025, IDN-list of all procedure commands".

### Kinds of Commands

There are 3 different kinds of commands:

- **Drive control commands**
  - Can cause automatic drive motion
  - can be started only when drive enable has been set,
  - Deactivate the active operation mode during its execution
- **Monitor commands**
  - Activate or deactivate monitorings or functions in the drive
- **Administration commands**
  - Carry out administration tasks
  - cannot be interrupted.

See also section "Command Processing"

## 1.2.5 Operation Modes

The selection of operation modes defines which command values will be processed in which way, in order to lead to the desired drive motion. The operation mode does not determine how these command values are transmitted from the master to the slave.

One of the four or eight (for SERCOS) operation modes that are defined in parameters is always active if the conditions below are fulfilled:

- Control section and power section are ready for operation
- Drive enable signal sees a positive edge
- Drive follows command value
- "Drive Halt" function has not been activated
- No drive control command is active
- No error reaction is carried out

The display of the control panel reads "AF" when an operation mode was activated.



All implemented operation modes are stored in the parameter "S-0-0292, List of supported operation modes".

---

See also chapter "Operation Modes"

## 1.2.6 Warnings

Depending on the active operating mode and the parameter settings, many monitoring functions are carried out. If a status is detected that still allows correct operation but in case this status persists will cause an error to occur and therefore cause the drive to be automatically switched off, the drive firmware generates a warning message.



Warnings do not cause automatic shutdown (exception: fatal warnings).

### Classes of Warnings

Warnings are classified in different warning classes which determine whether the drive, when the warning is generated, carries out an automatic reaction or not.



The warning class can be recognized by the diagnostic message.

The following classes of warnings are distinguished:

- **Without** drive reaction → diagnostic message number **E2xxx**, **E3xxx**, **E4xxx**
- **With** drive reaction → diagnostic message number **E8xxx**



Warnings cannot be cleared. They persist until the condition that activated the warning is no longer fulfilled.

## 1.2.7 Errors

Depending on the active operating mode and the parameter settings, many monitoring functions are carried out. If a status is detected that affects or prevents correct operation the drive firmware generates an error message.

### Error Classes

Errors are classified in different error classes. There are 6 error classes with different drive error reactions.



The error class can be recognized by the diagnostic message number.

Diagnostic message number	Error class
F2xxx	Non-fatal error
F3xxx	Non-fatal safety technology error
F4xxx	Interface error
F6xxx	Travel range error
F7xxx	Safety technology error
F8xxx	Fatal error
F9xxx	Fatal system error
E-xxxx	Fatal system error "processor exception"

Fig. 1-6: Overview of Error Classes

## System Overview



Apart from the mentioned error classes that can occur during operation, errors can occur when the devices are booted and during firmware download. These errors are not displayed at the control panel with a diagnostic message number of the "Fxxxx" pattern, but with a short text. Booting and firmware download errors are described in the separate documentation "Troubleshooting Guide" (description of diagnostic messages).

<b>Error Reactions of the Drive</b>	<p>If the drive controller is in control and an error status is detected, the execution of a drive error reaction is automatically started. The diagnostic message number "Fxxxx" flashes on the display of the control panel.</p> <p>The drive reaction in the case of interface errors and non-fatal errors is determined in parameter "P-0-0119, Best possible deceleration". At the end of each error reaction, the drive goes torque-free.</p> <p>See also "Error Reactions"</p>
<b>Clearing an Error Message</b>	<p>Error messages are not cleared automatically, but by the following action:</p> <ul style="list-style-type: none"> <li>• Triggering the command "S-0-0099, C0500 Reset class 1 diagnostics"</li> <li>- or -</li> <li>• Actuating the "Esc" key on the control panel</li> </ul> <p>If the error status persists the error message is immediately generated again.</p>
<b>Clearing Error Messages when Drive Enable was set</b>	<p>If a drive error occurs while operating with drive enable having been set, the drive carries out an error reaction. The drive automatically deactivates itself at the end of each error reaction; in other words, the output stage is switched off and the drive switches from an energized to a de-energized state.</p> <p>To reactivate the drive:</p> <ul style="list-style-type: none"> <li>• Clear the error message and</li> <li>• Input a positive edge for drive enable again.</li> </ul>
<b>Error Memory</b>	<p>The diagnostic message numbers of occurring errors are written to an error memory. This memory contains the diagnostic message numbers of the last 50 errors that occurred and the time when they occurred. Errors caused by a shutdown of the control voltage (e.g. "F8070 +24Volt DC error") are not stored in the error memory.</p> <p>The diagnostic message numbers in the error memory are mapped to the "P-0-0192, Error memory of diagnostic numbers" parameter and can be displayed by means of the control panel. By means of the "IndraWorks Ds/D/MLD" commissioning tool it is possible to display the diagnostic message numbers and the respective times at which the errors occurred.</p>

## 1.3 Drive Controllers

### 1.3.1 Overview

#### Standard Design of the IndraDrive Controllers

As a standard, IndraDrive controllers consist of two hardware components:

- Power section
- Control section

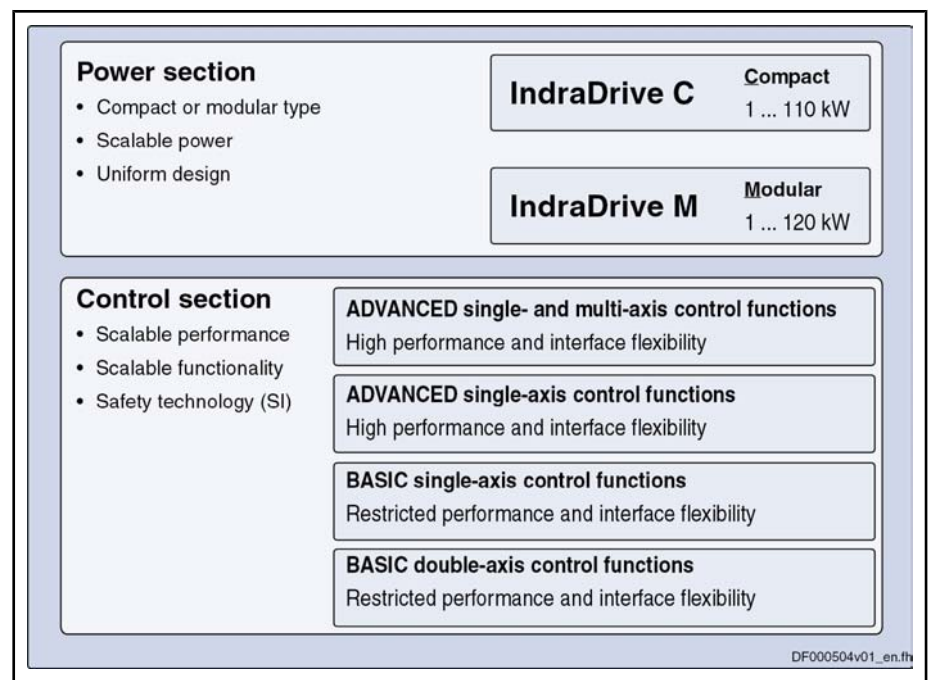


Fig. 1-7: Design of the IndraDrive Controllers

**Power Section** The following are connected to the power section:

- Supply unit (DC bus voltage)
- 24 V control voltage
- Motor



Each of the two types of the control section is described in a separate documentation; e.g. "Supply Units and Power Sections, Project Planning Manual" (DOK-INDRV-HMS+HMD\*\*\*\*-PR\*\*-EN-P; part number: R911318790).

**Control Section** The control section is a separate part of the IndraDrive controller and is plugged in the power section. The drive controller is supplied ex works complete with control section. The control section may only be replaced by a qualified service engineer.



The available control sections are described in the separate documentation "Control Sections for Drive Controllers, Project Planning Manual" (DOK-INDRV\*-CSH\*\*\*\*\*-PR\*\*-EN-P; part number: R911295012).

## Special Design of the IndraDrive Controllers

Apart from the usual device design which consists of power section and control section, there are the following special designs:

- SERCOS analog converter (= control section + housing)
- IndraDrive Mi with
  - Distributed servo drives **KSM**
    - ⇒ Synchronous servo motors with integrated inverter and control section
  - Distributed drive controllers **KMS**
    - ⇒ Very compact inverters with control control sections

System Overview

**SERCOS Analog Converter**

The so-called "SERCOS analog converter" is a control section housing with 24V supply but without output stage. An IndraDrive control section can be plugged in this housing.

The SERCOS analog converter is used to

- connect control units with SERCOS interface to components with analog interface
- and -
- convert SERCOS position command values to analog speed command values.



With these possibilities of use, the SERCOS analog converter is suited for modernization of machines and installations. Drive controllers with analog command value input of the ANAX range can be controlled with IndraDrive; in this case IndraDrive acts as the gateway to the SERCOS control unit.

Implementing the SERCOS analog converter requires the following individual components:

- Housing for **HAC01.1-002** control sections
- Configurable control section with SERCOS master communication, e.g. BASIC UNIVERSAL double-axis **CDB01.1C-SE-NNN-NNN-MA1-NNN-NN-S-NN-FW**
- IndraDrive firmware **as of** version **MPx-04VRS**, e.g. FWA-INDRV\*-MPD-06VRS-\*\*-\*\_\*\*\*\_\*\*

**IndraDrive Mi (KSM01.2-B, Distributed Servo Drive)**

In KSM (distributed servo drive), the control section and the power section are integrated in the motor (synchronous servo motor), configuration of the control section is not possible. The converter can be operated with the IndraDrive firmware **as of** version **FWA-INDRV\*-MPB-04VRS**.

**IndraDrive Mi (KMS01.2-B, Distributed Drive Controller)**

In KMS (distributed drive controller), the control section and the power section are integrated and remote from the motor. Configuration of the control section is not possible. This variant of IndraDrive Mi has a HIPERFACE® encoder interface. The converter can be operated with the IndraDrive firmware **as of** version **FWA-INDRV\*-MPB-06VRS**.

See also separate documentation "Rexroth IndraDrive – Drive System, Project Planning Manual" (DOK-INDRV\*-SYSTEM\*\*\*\*\*-PR\*\*-EN-P; part number: R911309636)!

### 1.3.2 Power Sections

The following power sections for the standard design of IndraDrive controllers can be operated with the firmware **MPx-07VRS**:

IndraDrive M		IndraDrive C		
Single-axis power sections	Double-axis power sections	Single-axis converters in 300mm type of constr.	Single-axis converters in 400mm type of constr.	Single-axis converter
HMS01.1N-W... HMS02.1N-W...	HMD01.1N-W...	HCS02.1E-W... HCS02.1E-F...	HCS03.1E-W... HCS04.1E-W... HCS03.1E-F...	HCS04.2E-W....

Fig. 1-8: Power Sections for IndraDrive Firmware



### 1.3.3 Control Sections

#### Available Control Section Designs

The following control sections can be operated with the appropriate MPx-07VRS firmware variant:

Control section characteristic	Basic device range	Firmware derivate
<b>MPC, Advanced</b> , high-performance drive functions as well as single- and multi-axis control functions	<b>CSH01.3</b>	MPC07
<b>MPH, Advanced</b> , high-performance drive functions as well as single-axis control functions	<b>CSH01.1</b>	MPH07
<b>MPB, Basic single-axis</b> , medium-performance drive functions, designs	<b>CSB01.1C</b> <b>CSB01.1N</b> KSM01.2-B (distributed servo drive) KMS01.2-B (distributed drive controller)	MPB07
<b>MPD, Basic double-axis</b> ,	<b>CDB01.1</b>	MPD07

Fig. 1-9: Control Section Support

- Configurable control sections
  - ADVANCED (single-axis; type CSH01.1)
  - ADVANCED (single-axis; type CSH01.3)
  - BASIC UNIVERSAL (single-axis; type CSB01.xC...)
  - BASIC UNIVERSAL double-axis (type CDB01.xC...)
- Non-configurable control sections
  - BASIC OPENLOOP (single-axis; type CSB01.xN-FC-...)
  - BASIC SERCOS (single-axis; type CSB01.xN-SE-...)
  - BASIC PROFIBUS (single-axis; type CSB01.xN-PB-...)
  - BASIC ANALOG (single-axis; type CSB01.xN-AN-...)

#### Supported Control Section Configurations

The configurable control sections differ with regard to the scope of their configurability. It basically depends on the control section type and the corresponding firmware variant.

The following overview contains the **theoretically possible configurations** of control sections as regards the support by the MPx-07VRS firmware. The abbreviations in the first column identify the configuration of control sections in the type designation.



Our sales representative will help you with the current status of available control section types.

Control section type →		CSH01.1	CSH01.3	CSB01.xC...	CDB01.xC...
Firmware variant →		MPH-07VRS	MPC-07VRS	MPB-07VRS	MPD-07VRS
Optional modules for master communication					
<b>AN</b>	Analog interface	–	–	■	■

## System Overview

Control section type →		CSH01.1	CSH01.3	CSB01.xC...	CDB01.xC...
Firmware variant →		MPH-07VRS	MPC-07VRS	MPB-07VRS	MPD-07VRS
CO	CANopen/DeviceNet™ (connected via spring terminal)	■	■	■	–
CD	CANopen/DeviceNet™ (connected via D-SUB connector)	■	■	■	–
ET	EtherCAT®/SERCOS III	■	■	■	■
ET	PROFINET®/Ethernet	■	■	■	–
PB	PROFIBUS-DP	■	■	■	■
PL	Parallel interface	■	■	■	–
S3	SERCOS III	■	■	■	■
SE	SERCOS II	■	■	■	■
CCD <sup>1)</sup>	Cross communication	–	■	–	–
Optional modules for encoder evaluation and I/O extension					
EN1	Encoder interface for HSF, resolver	■	■	■	■
EN2	Encoder interface for EnDat, 1Vpp sine and TTL signals	■	■	■	■
ENS	Encoder interface for MSK motors and HI-PERFACE® encoders	■	■	■	■
MA1	Analog I/O extension	■	■	■	■
MD1	Digital I/O Extension	■	■	–	–
MD2	Digital I/O extension (with SSI interface)	■	■	–	–
MEM	Encoder emulation	■	■	■	■
Optional modules for safety technology					
L2	Starting lockout	■	■	■	■
S2	Safety technology	■	■	–	■

1) Only required for CCD master  
 Fig. 1-10: Supported Control Section Configurations



The type codes of the individual designs of IndraDrive control sections and the respective assignment of possible optional modules to the slots are described in the separate documentation "Control Sections for Drive Controllers, Project Planning Manual" (DOK-INDRV\*-CSH\*\*\*\*\*-PR\*\*-EN-P; part number: R911295012).

## 1.4 Supported Motors and Measuring Systems

### 1.4.1 Supported Motors

The following table contains an overview of the Rexroth motors which can be operated at IndraDrive controllers.

Rexroth housing motors		Rexroth kit motors	
Synchronous	Asynchronous	Synchronous	Asynchronous
MSK (IndraDyn S)	MAD (IndraDyn A)	MLF (IndraDyn L)	1MB
MHD	MAF (IndraDyn A)	MBS (Standard)	
MKD	MAL	MBSxx2 (IndraDyn H)	
MKE		MBT (IndraDyn T)	
MSP			
SF (by Bosch)			

Fig. 1-11: Appropriate Rexroth Motors for IndraDrive

## 1.4.2 Supported Measuring Systems

### Motor Encoder and External Optional Encoders

In addition to the encoders integrated in the Rexroth motors, the IndraDrive firmware can evaluate the following measuring systems as motor encoders or as external optional control encoders:

- GDS or GDM encoders from Bosch Rexroth (single-turn or multi-turn type)
- Resolvers according to Rexroth signal specification (single-turn or multi-turn type)
- Encoders with sine signals and EnDat2.1 interface (1 Vpp)
- Encoders with sine signals (1 Vpp)
- Encoders with square-wave signals (TTL)
- Hall sensor box and encoder with sine signals (1 Vpp)
- Hall sensor box and encoder with square-wave signals (TTL)
- Encoders with sine signals and HIPERFACE interface (1 Vss)

### Measuring Encoder

For measuring purposes the firmware can evaluate the following measuring systems (measuring encoders, no control encoders):

- GDS or GDM encoders from Bosch Rexroth (single-turn or multi-turn type)
- Encoders with sine signals and EnDat2.1 interface (1 Vpp)
- Encoders with sine signals (1 Vpp)
- Encoders with square-wave signals (TTL)
- Encoders with sine signals and HIPERFACE interface (1 Vss)
- Motor encoders of MSK, MHD, MAD, MAF motors
- SSI encoders



Resolvers cannot be evaluated as measuring encoders!

## 1.5 Overview of Master Communication

The firmware **MPx-07VRS** supports the following interfaces for master communication:

- SERCOS II
- SERCOS III
- PROFIBUS-DP
- EtherCAT®
- EtherNet/IP™
- PROFINET®

## System Overview

- CANopen interface
- DeviceNet™ interface
- Parallel interface (not for double-axis design MPD)
- Analog Interface

## 1.6 Overview of Functions/Functional Packages

### 1.6.1 Overview

#### General Information

The application-specific scope of usable functions of the FWA-INDRV\*-MP\*-07VRS drive firmware depends on

- the available control section and, if available, its configuration - and -
- the licensed functional firmware packages.



Depending on the hardware design, the scope of firmware functionality can be determined according to the respective application (scalability of the firmware functionality). The scope of corresponding parameters depends on the available functions.

#### Scaling the Drive Functionality

##### Firmware Scaling by Control Section Configuration

The control sections of the IndraDrive controllers have a maximum of 4 optional card slots and a master communication slot. Depending on the available optional cards, it is possible to activate certain functions (incl. corresponding parameters), e.g.:

- **Master communication**
- **Safety technology** (starting lockout, standard safety technology)
- **Analog I/O extension card**
- **Digital I/O extension card**



The functions and parameters for the evaluation of the measuring systems as control encoders or measuring encoders do not depend on the control section configuration, since their functions can be freely assigned to the various optional encoder modules.

See also section "Drive Controllers"

##### Firmware Scaling by Functional Packages

The firmware functionality is divided into the following package groups:

- **Base packages** (open-loop or closed-loop)
- **Optional expansion packages:**
  - Alternative functional packages (expansion packages for servo function, main spindle function, synchronization)
  - Additive functional package "IndraMotion MLD" (drive-integrated PLC and technology functions)

Depending on the hardware configuration, the base packages are available without any access enable. Using the optional expansion packages, however, requires licensing.



The desired scope of firmware functions should preferably be defined when the firmware is ordered. This guarantees that the required functional packages have been enabled when the firmware is delivered. In individual cases, it is possible to provide access enable subsequently (additional licensing) or to reduce the activated scope of functions.

This procedure is described in the section "Enabling of Functional Packages" .



The **drive-integrated safety technology** is a functionality only scalable by means of the hardware and does not require any additional enabling of functions!

The figure below contains an overview of the possibilities of firmware scaling by functional packages:

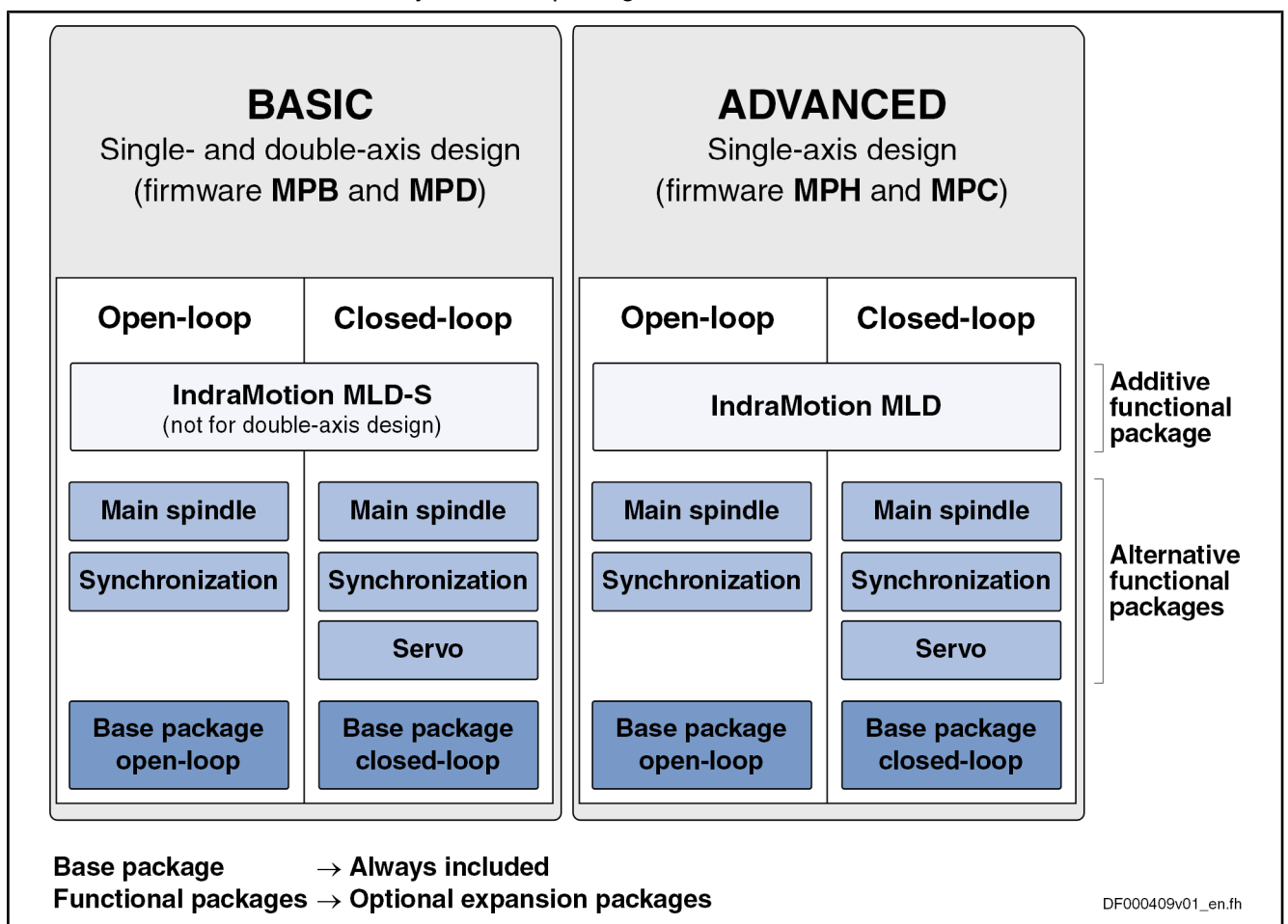


Fig. 1-12: Functional Packages of IndraDrive Firmware MPx07 Depending on Control Performance



With Basic performance, the option "IndraMotion MLD-S" is not allowed for free programming!

## System Overview

## Brief Description of the Functional Packages

The overall functionality of an IndraDrive device is divided into groups of functions, the so-called "functional packages". The firmware **FWA-INDRV\*-MP\*-07VRS** supports the functional packages listed below.



Each of the listed packages is available in **Basic** or **Advanced** characteristic which differ with regard to their performance and functionality.

**Base Packages**

The following base packages are available:

- **Base package "open-loop"** (open-loop motor control)
  - No position evaluation and functions depending thereof and no position control modes are possible
- **Base package "closed-loop"** (closed-loop motor control)
  - Position evaluation and functions and operation modes depending thereof are possible

**Alternative Functional Packages**

The following alternative functional packages are available:

- **Servo functions** <sup>1)</sup>

This package makes available all specific expansions for servo applications, such as compensations and correction functions (e.g. axis error correction, quadrant error correction).
- **Synchronization** <sup>1)</sup>

With this package the possibilities of synchronization of the drive can be used (support of synchronization modes, measuring encoder function, probe function ...).
- **Main spindle functions** <sup>1)</sup>

This package contains the specific functions for the use of main spindles (e.g. spindle positioning, parameter set switching).



<sup>1)</sup>...These functional packages cannot be activated simultaneously (only individually)! → **Alternative functional packages**

**Additive Functional Packages**

There is also an additional functional package available:

- **IndraMotion MLD**



For single-axis devices (ADVANCED and BASIC) the expansion package "IndraMotion MLD" can be activated in addition to a possibly available alternative package.

**Overview of Dependencies**

The overview below illustrates how the individual functional packages are depending on the respective hardware and the firmware variant:

Firmware variant →		MPB		MPD		MPH		MPC		
Control section design →		CSB01.1 CSB01.1N KSM01.2-B KMS01.2-B		CDB01.1		CSH01.1		CSH01.3		
Control section range ↓		OL	CL	OL	CL	OL	CL	OL	CL	
Base pack- age	Basic functions	■	■	■	■	■	■	■	■	
	Base package "open-loop"	BASIC	■	■	■	■	■	■	■	
		ADVANCED	–	–	–	–	■	■	■	■
	Base package "closed-loop"	BASIC	■	■	■	■	■	■	■	■
ADVANCED		–	–	–	–	■	■	■	■	
Alternative functional packages	Servo function	BASIC	–	■	–	■	–	–	–	–
		ADVANCED	–	–	–	–	–	■	–	■
	Synchronization	BASIC	■	■	■	■	–	–	–	–
		ADVANCED	–	–	–	–	■	■	■	■
	Main spindle	BASIC	■	■	■	■	–	–	–	–
		ADVANCED	–	–	–	–	■	■	■	■
Additive functional package	IndraMotion MLD	BASIC	■ 1)	■ 1)	–	–	■	■	■	■
		ADVANCED	–	–	–	–	■	■	■	■

MPB Single-axis firmware with Basic performance  
 MPD Double-axis firmware with Basic performance  
 MPH Single-axis firmware with Advanced performance  
 MPC Single-Axis firmware with Advanced performance and CCD + MLD-M functions

KSM01.2-B Basic device range IndraDrive, distributed servo drive  
 KMS01.2-B Basic device range IndraDrive, distributed drive controller  
 OL Open-loop characteristic  
 CL Closed-loop characteristic  
 1) No free programming and only MLD-S

Fig. 1-13: *Dependence of Functional Packages on Hardware and Firmware Variant*

## Firmware Types

### Structure of the Firmware Type Designation

The type designation of the IndraDrive firmware consists of the following type code elements:

	IndraDrive firmware	Base pack- age of variant (depending on control section)	Version	Release	Lang- uage	OL/CL	Alternative expansion packages	Additive ex- pansion packages
<b>Basic single-axis</b>	FWA-INDRV*	-MPB-	07	VRS-	D5-	x-	xxx-	xx
<b>Basic double-axis</b>	FWA-INDRV*	-MPD-	07	VRS-	D5-	x-	xxx-	xx

System Overview

	IndraDrive firmware	Base package of variant (depending on control section)	Version	Release	Language	OL/CL	Alternative expansion packages	Additive expansion packages
Advanced single-axis	FWA-INDRV*	-MPH-	07	VRS-	D5-	x-	xxx-	xx
Advanced single-axis	FWA-INDRV*	-MPC-	07	VRS- <sup>1)</sup>	D5-	x-	xxx-	xx

OL Open-loop characteristic  
 CL Closed-loop characteristic  
<sup>1)</sup> MPC0602 and MPC0604 operable on CSH1.2; as of MPC06V06, MPC is only operable on CSH1.3

Fig. 1-14: Basic Structure of the Firmware Type Designation

Function-Specific Abbreviations in Type Designation of IndraDrive Firmware

Base package (application and performance):

- **MPB** → Single-axis firmware with Basic performance
- **MPD** → Double-axis firmware with Basic performance
- **MPH** → Single-axis firmware with Advanced performance
- **MPC** → Single-axis firmware with Advanced performance

Firmware characteristic:

- **0** → Open-loop
- **1** → Closed-loop

Alternative expansion packages:

- **NNN** → Without alternative expansion package
- **SRV** → Functional package "servo function"
- **SNC** → Functional package "synchronization"
- **MSP** → Functional package "main spindle"
- **ALL** → All alternative expansion packages

Additive expansion packages:

- **NN** → Without additive expansion package
- **TF** → IndraMotion MLD for using the technology functions (for MPB firmware)
- **ML** → IndraMotion MLD for free programming; incl. use of technology functions (for MPH firmware)
- **MA** → IndraMotion MLD Advanced (only for MPH firmware)



The sales representative in charge will help you with the current status of available firmware types.

## 1.6.2 Base Packages

### General Information

In the base packages of the firmware, the minimum scope of functionalities is available depending on the respective firmware characteristic ("open-loop" or "closed-loop"). They contain the basic functions of a drive firmware and a number of other fundamental functions.

### Basic Functions

The following basic functions are available for every drive and contain the fundamental basic functions of a digital drive (available in the firmware characteristics "open-loop" and "closed-loop"):



- Extensive diagnostic functions:
  - Drive-internal generation of diagnostic messages
  - Monitoring function
  - Analog output
  - Patch function
  - Status displays, status classes
  - Oscilloscope function
  - Code of optional card
  - Parameter value check
  - Operating hours counter, logbook function, error memory
- Undervoltage monitor
- Output of control signals
- Limitations that can be parameterized
- Serial communication

### Scope of Functions of Base Packages

Apart from the basic functions, there are other functions available in the base package of the firmware. Their scope depends on the firmware variant and its characteristic ("open-loop" or "closed-loop").

See "Supported Operation Modes" in section "Operation Modes: General Information"

See "Availability of the Extended Axis Functions"

See "Availability of the Optional Device Functions"

## 1.6.3 Alternative Functional Packages

### General Information

Apart from the base packages that are always available, we provide optional expansion packages. Part of the expansion packages is the group of alternative functional packages; from this group only one package can be activated at a time (alternative activation).

At present, there are the following alternative expansion packages available:

- Expanded servo function
- Synchronization
- Main spindle function

### Servo Function

Depending on the firmware variant and characteristic, the expansion package "servo function" has the following scope of functions:

Firmware variant →	MPB		MPD		MPH		MPC	
Functions of the expansion package "Servo function"	OL	CL	OL	CL	OL	CL	OL	CL
Relative return motion	–	■	–	■	–	■	–	■
Precision axis error correction	–	–	–	■	–	■	–	■

## System Overview

Firmware variant →	MPB		MPD		MPH		MPC	
Functions of the expansion package "Servo function"	OL	CL	OL	CL	OL	CL	OL	CL
Temperature error correction	–	■	–	■	–	■	–	■
Quadrant error correction	–	■	–	■	–	■	–	■
Cogging torque compensation	–	–	–	■	–	■	–	■
Programmable position switch	–	■	–	■	–	■	–	■
Set/shift coordinate system	–	■	–	■	–	■	–	■
Parameter set switching (without motor/gear switching)	■	■	–	–	■	■	■	■

OL Open-loop characteristic  
 CL Closed-loop characteristic

Fig. 1-15: Overview Expansion Package "Servo Function"



With "BASIC ..." hardware design, the probe input is only available for the control sections BASIC SERCOS, BASIC PROFIBUS and BASIC UNIVERSAL (CSB01.1\*\*\*).

## Synchronization

Depending on the firmware variant and characteristic, the expansion package "synchronization" has the following scope of functions, in addition to the functions available in the base package:

Firmware variant →	MPB		MPD		MPH		MPC	
Functions of the expansion package "Synchronization"	OL	CL	OL	CL	OL	CL	OL	CL
Velocity synchronization	■	■	■	■	■	■	■	■
Phase synchronization	–	■	–	■	–	■	■	■
Electronic cam	–	■	–	■	–	■	■	■
Motion profile	–	■	–	■	–	■	–	■
Cogging torque compensation	–	–	–	■	–	■	–	■
Measuring wheel mode	–	■	–	■	–	■	–	■
Virtual master axis generator	■	■	■	■	■	■	■	■
Programmable position switch	–	■	–	■	–	■	–	■
Measuring encoder	■ <sup>1)</sup>	■ <sup>1)</sup>	■	■	■	■	■	■
Parameter set switching (without motor/gear switching)	■	■	–	–	■	■	■	■

OL Open-loop characteristic  
 CL Closed-loop characteristic  
 1) Only with control section BASIC UNIVERSAL

Fig. 1-16: Overview Expansion Package "Synchronization"



With "BASIC ..." hardware design, the probe input is only available for the control sections BASIC SERCOS, BASIC PROFIBUS and BASIC UNIVERSAL (CSB01.1\*\*\*).

## Main Spindle Function

Depending on the firmware variant and characteristic, the expansion package "main spindle" has the following scope of functions, in addition to the functions available in the base package:

Firmware variant →	MPB		MPD		MPH		MPC	
Functions of the expansion package "Main spindle"	OL	CL	OL	CL	OL	CL	OL	CL
Spindle positioning	–	■	–	■	–	■	–	■
Parameter set switching	■	■	–	–	■	■	■	■
Drive-controlled oscillation	■	■	–	–	■	■	■	■

OL Open-loop characteristic

CL Closed-loop characteristic

Fig.1-17: Overview Expansion Package "Main Spindle"

## 1.6.4 Additive Functional Packages

### General Information

The so-called additive functional packages are part of the optional expansion packages. Additive functional packages can be used in addition to the basic function and one of the alternative functional packages (additive activation).

At present, there is the following additive functional package available (in different designs):

- **IndraMotion MLD** (drive-integrated PLC and technology functions)



The **drive-integrated safety technology** is a functionality only scalable by means of the hardware and is not part of the expansion packages that can be enabled!

### IndraMotion MLD (Drive-Integrated PLC)

Depending on its performance (type designation), the extension package "IndraMotion MLD" provides the following scope of functions:

- **Integrated logic control** (type designation "ML")  
Standard PLC tasks
- **Integrated multi-axis/single-axis motion control** (type designation "ML")  
Motion function block according to PLCopen for single-axis positioning on local and remote axes and synchronization mode (synchronous running, cam shaft) → "low-level motion functions"
- **Basis for technology functions** (type designation "TF" or "ML")  
Examples: Following-on cutting devices, pick&place, process controller (register controller, winding computation, etc.), preventive maintenance, free function block combination
- **IndraMotion MLD Advanced** (type designation "MA")

Firmware variant →	MPB	MPD	MPH	MPC
Integrated logic control	■	–	■	■

## System Overview

Integrated multi-axis motion control	■	–	–	■
Integrated single-axis motion control	■	–	■	■
Basis for technology functions	■	–	■	■
IndraMotion MLD Advanced	–	–	■	■

Fig.1-18: Overview Expansion Package "IndraMotion MLD"

## Integrated Safety Technology



The **drive-integrated safety technology** is a functionality only scalable by means of the hardware and does not require any additional enabling of functions! The requirement for using this function is the use of the optional safety technology modules "L2" or "S2" depending on the control section configuration.

By using the optional safety technology module "Safe Torque Off" (L2), the safety function "Safe torque off" can be implemented.

The following safety functions can be implemented in the different operating states by using the optional safety technology module "Safe Motion" (S2) or PROFIsafe:

- In **normal operation** and in **special mode**
  - Safe maximum speed
  - Safely-limited position
  - Safe direction
- In **special mode "safe standstill"**
  - Safe torque off
  - Safe stop 1
  - Safe stop 2
  - Safe stop 1 (Emergency stop)
  - Safe braking and holding system
- In **special mode "safe motion"**
  - Safely-limited speed
  - Safe direction
  - Safely-limited increment
  - Safely-monitored position
- **Additional or auxiliary functions**
  - Safely-monitored stopping process
  - Safe homing procedure
  - Safe brake check
  - Safe parking axis
- **Safety functions for "safe feedback"**
  - Safe diagnostic outputs
  - Safe door locking (not PROFIsafe)
  - Safe inputs/outputs

## 1.7 Performance Data

### 1.7.1 Overview

#### Levels of Control Performance

For the control performance of the IndraDrive range, we basically distinguish three levels with regard to the clock rates (cycle times):

- **Advanced** performance
  - Highest degree of control performance by high internal clock rates for the control loops and the signal processing of inputs/outputs or drive-integrated PLC (IndraMotion MLD)
- **Basic** performance
  - Standard control performance by medium internal clock rates for the control loops and the signal processing of inputs/outputs or drive-integrated PLC (IndraMotion MLD)
- **Economy** performance
  - Low control performance by reduced clock rates for the control loops and the signal processing of inputs/outputs or drive-integrated PLC (IndraMotion MLD)

#### Performance and Clock Rates

In this documentation the clock rate data refer to the following characteristic values:

- Current loop clock  $T_{A\_current}$
- Velocity loop clock  $T_{A\_velocity}$
- Position loop clock  $T_{A\_position}$
- Cycle time of PLC (IndraMotion MLD)  $T_{MLD}$
- Cycle time of master communication  $T_{MastCom}$

The table below contains an overview of the clock rates depending on the respective control performance. The detailed assignment of clock rate to control section design, performance level and parameter setting is contained in the table "Performance depending on the control section design" in the section "Control Section Design and Performance" (see below).

Performance	$T_{A\_current}$	$T_{A\_velocity}$	$T_{A\_position}$	$T_{MLD}$	$T_{MastCom}$
Advanced	62,5/83,3/125	125	250	1000	250
Basic	62,5/83,3/125/250	250	500	2000	500
Economy	83,3/125/250	500	1000	2000	1000 <sup>1)</sup>

1) With half the quantity of cyclic data

Fig. 1-19: Clock Rates (in  $\mu s$ )



The control performance is not equivalent to the control section design (Advanced or Basic), because it is determined by several factors (e.g. P-0-0556, bits 2 and 5).

The available performance depends on the following requirements and parameter settings:

- **Control section design** (SH, CSB or CDB) and the corresponding drive **firmware** (MPH, MPB, MPD and MPC)

## System Overview

- **Activation of functional packages** (cf. P-0-2004)
- Performance level in "P-0-0556, Config word of axis controller" (bits 2 and 5)
- Switching frequency in "P-0-0001, Switching frequency of the power output stage"

See also "Overview of Drive Control"

## 1.7.2 Control Section Design and Performance

The control section design differs with regard to the performance levels that can be reached (cycle times or switching frequencies).

The table below contains an overview of the performance levels and clock rates that can be reached depending on the control section design and parameter settings.

Control section/ firmware	Functional packages 1)	Performance level	f <sub>PWM</sub> 2)	P-0-0556		PWM reduc. 4)	Rotor-syn-chronous PWM	T <sub>A,current</sub>	T <sub>A,velocity</sub>	T <sub>A,position</sub>	T <sub>MLD</sub>	T <sub>Mast-Com</sub>
				Bit 2	Bit 5							
CHS01.3 /MPC		Basic	2 kHz 3)	0	0	No	No	250	500	500 μs	1000 μs	500 μs
		Basic	4 kHz	0	0	No	No	125	250	500 μs	1000 μs	500 μs
		Basic	8 kHz	0	0	Yes	Yes	125	250	500 μs	1000 μs	500 μs
		Basic	12 kHz	0	0	Yes	Yes	83.3 μs	250	500 μs	1000 μs	500 μs
		Basic	16 kHz	0	0	Yes	Yes	62.5 μs	250	500 μs	1000 μs	500 μs
		Advanced	4 kHz	1	0	No	No	125 μs	125 μs	250	1000 μs	250
		Advanced	8 kHz	1	0	Yes	Yes	62.5 μs	125 μs	250	1000 μs	250
		Advanced	16 kHz	1	0	Yes	Yes	62.5 μs	125 μs	250	1000 μs	250
CSH01.1 /MPH	All	Basic	2 kHz 3)	0	0	No	No	250 μs	500 μs	500 μs	1000 μs	500 μs
		Basic	4 kHz	0	0	No	No	125 μs	250 μs	500 μs	1000 μs	500 μs
		Basic	8 kHz	0	0	Yes	Yes	125 μs	250 μs	500 μs	1000 μs	500 μs
		Basic	12 kHz	0	0	Yes	Yes	83.3 μs	250 μs	500 μs	1000 μs	500 μs
		Basic	16 kHz	0	0	Yes	Yes	62.5 μs	250 μs	500 μs	1000 μs	500 μs
		Advanced	4 kHz	1	0	No	Yes	125 μs	125 μs	250 μs	1000 μs	250 μs
		Advanced	8 kHz	1	0	Yes	Yes	62.5 μs	125 μs	250 μs	1000 μs	250 μs
		Advanced	16 kHz	1	0	Yes	Yes	62.5 μs	125 μs	250 μs	1000 μs	250 μs

Control section/ firmware	Functional packages 1)	Performance level	f <sub>PWM</sub> 2)	P-0-0556		PWM reduc. 4)	Rotor-syn-chronous PWM	T <sub>A,current</sub>	T <sub>A,velocity</sub>	T <sub>A,position</sub>	T <sub>MLD</sub>	T <sub>Mast-Com</sub>
				Bit 2	Bit 5							
CSB01.1 /MPB	All, except SY and MLD	Basic	2 kHz 3)	0	0	No	No	250 μs	250 μs	500 μs	--	500 μs
		Basic	4 kHz	0	0	No	No	125 μs	250 μs	500 μs	--	500 μs
		Basic	8 kHz	0	0	Yes	No	125 μs	250 μs	500 μs	--	500 μs
		Economy	2 kHz 3)	0	1	No	No	250 μs	500 μs	1000 μs	--	1000 μs 5)
		Economy	4 kHz	0	1	No	No	125 μs	500 μs	1000 μs	--	1000 μs 5)
		Economy	8 kHz	0	1	Yes	No	125 μs	500 μs	1000 μs	--	1000 μs 5)
	SY and MLD	Economy	2 kHz 3)	0	1	No	No	250 μs	500 μs	1000 μs	2000 μs	1000 μs 5)
		Economy	4 kHz	0	1	No	No	125 μs	500 μs	1000 μs	2000 μs	1000 μs 5)
		Economy	8 kHz	0	1	Yes	No	125 μs	500 μs	1000 μs	2000 μs	1000 μs 5)
		Economy	12 kHz	0	1	Yes	No	83.3 μs	500 μs	1000 μs	2000 μs	1000 μs 5)
CDB01.1 /MPD	All	Basic	4 kHz	0	0	No	No	125 μs	250 μs	500 μs	--	500 μs
		Basic	8 kHz	0	0	No	No	125 μs	250 μs	500 μs	--	500 μs

- 1) SY ... Synchronization; MLD ... IndraMotion MLD
  - 2) Switching frequency of the power output stage (can be set via P-0-0001)
  - 3) Only with power section HCS04.1... and MAD/MAF
  - 4) Reduction of PWM frequency depending on work load or PWM switching depending on speed
  - 5) With half the quantity of cyclic data
- P-0-0556 Config word of axis controller  
 Fig. 1-20: Performance Depending on the Control Section Design

### 1.7.3 Selecting Performance via Parameter P-0-0556

For certain applications it is necessary to use the same clock rates in all axes so that the slowest drive sets the clock. It is therefore possible to specifically reduce the performance via bit 2 and bit 5 of parameter "P-0-0556, Config word of axis controller".

- For **BASIC control sections** it is possible to select the performance levels "Basic" or "Economy" via bit 5 of P-0-0556.
- For **ADVANCED control sections** it is possible to select the performance levels "Advanced" or "Basic" via bit 2 of P-0-0556.



See also Parameter Description "P-0-0556, Config word of axis controller"

## System Overview



The effective clock rates of the active performance level can be contained in the table "Performance depending on the control section design" in section "Control Section Design and Performance".

---

### 1.7.4 PWM Frequency Reduction Depending on Load

For switching frequencies of 8kHz, 12 kHz or 16 kHz and corresponding performance settings in the parameters "P-0-0556, Config word of axis controller and P-0-0045, Control word of current controller"

reduction of the switching frequency depending on the thermal load of the controller is possible.



When the load-dependent reduction of the PWM frequency is used, the switching frequency of the power output stage is changed, but not the cycle times!

---

See "Current Limitation: Dynamic Current Limitation"

### 1.7.5 PWM Frequency Reduction Depending on Speed

For switching frequencies of 8kHz, 12 kHz or 16 kHz and corresponding performance settings in the parameters "P-0-0556, Config word of axis controller" and "P-0-0045, Control word of current controller"

reduction of the switching frequency depending on the electric output frequency of the controller is possible.



When the speed-dependent reduction of the PWM frequency is used, the switching frequency of the power output stage is changed, but not the cycle times!

---

See "Motor Control"

### 1.7.6 Rotor-Synchronous PWM

For switching frequencies of 8kHz, 12 kHz or 16 kHz and corresponding performance settings in the parameters "P-0-0556, Config word of axis controller" and "P-0-0045, Control word of current controller"

reduction of the switching frequency depending to the electric output frequency of the controller is possible.



When the speed-dependent reduction of the PWM frequency is used, the cycle time of the current loop and the switching frequency of the power output stage are changed!

---

See "Motor Control"

### 1.7.7 Restricted Performance With Certain Functional Packages

If you use extensive and complex functions, the internal clock rates for **BASIC control sections** (CSB with firmware MPB and CDB with firmware MPD) are automatically reduced. This applies to the use of the following functional packages:

- Drive-integrated PLC "IndraMotion MLD" (functional package "ML")
- Expansion package "synchronization" (functional package "SNC")

If you use one of these functional packages for BASIC control sections, the clock rates (position loop, velocity loop) are reduced to the lowest performance level "Economy"!





For **ADVANCED control sections** (CSH with firmware MPH or MPC) the clock rates are not reduced depending on the functional packages that are used (reduction possible via P-0-0556).

---



The effective clock rates of the active performance level are contained in the table "Performance depending on the control section design" in section "Control Section Design and Performance" (see above).

---



## 2 Important Directions for Use

### 2.1 Appropriate Use

#### 2.1.1 Introduction

Rexroth products represent state-of-the-art developments and manufacturing. They are tested prior to delivery to ensure operating safety and reliability.



#### **Personal injury and property damage caused by incorrect use of the products!**

The products have been designed for use in the industrial environment and may only be used in the appropriate way. If they are not used in the appropriate way, situations resulting in property damage and personal injury can occur.



Rexroth as manufacturer is not liable for any damages resulting from inappropriate use. In such cases, the guarantee and the right to payment of damages resulting from inappropriate use are forfeited. The user alone carries all responsibility of the risks.

Before using Rexroth products, make sure that all the pre-requisites for an appropriate use of the products are satisfied:

- Personnel that in any way, shape or form uses our products must first read and understand the relevant safety instructions and be familiar with appropriate use.
- If the products take the form of hardware, then they must remain in their original state, in other words, no structural changes are permitted. It is not permitted to decompile software products or alter source codes.
- Do not mount damaged or faulty products or use them in operation.
- Make sure that the products have been installed in the manner described in the relevant documentation.

#### 2.1.2 Areas of Use and Application

Drive controllers made by Rexroth are designed to control electrical motors and monitor their operation.

Control and monitoring of the Drive controllers may require additional sensors and actors.



The drive controllers may only be used with the accessories and parts specified in this documentation. If a component has not been specifically named, then it may neither be mounted nor connected. The same applies to cables and lines.

Operation is only permitted in the specified configurations and combinations of components using the software and firmware as specified in the relevant Functional Descriptions.

Drive controllers have to be programmed before commissioning, making it possible for the motor to execute the specific functions of an application.

Drive controllers of the Rexroth IndraDrive line have been developed for use in single- and multi-axis drive and control tasks.

To ensure application-specific use of Drive controllers, device types of different drive power and different interfaces are available.

Typical applications include, for example:

## Important Directions for Use

- Handling and mounting systems,
- Packaging and food machines,
- Printing and paper processing machines and
- Machine tools.

Drive controllers may only be operated under the assembly and installation conditions described in this documentation, in the specified position of normal use and under the ambient conditions as described (temperature, degree of protection, humidity, EMC, etc.).

## 2.2 Inappropriate Use

Using the Drive controllers outside of the operating conditions described in this documentation and outside of the indicated technical data and specifications is defined as "inappropriate use".

Drive controllers must not be used, if ...

- they are subject to operating conditions that do not meet the specified ambient conditions. This includes, for example, operation under water, under extreme temperature fluctuations or extremely high maximum temperatures.
- Furthermore, Drive controllers must not be used in applications which have not been expressly authorized by Rexroth. Please carefully follow the specifications outlined in the general Safety Instructions!



Components of the drive system Rexroth IndraDrive are **products of category C3** (with restricted distribution) according to IEC 61800-3. These components are not provided for use in a public low-voltage mains supplying residential areas. If these components are used in such a mains, high-frequency interference is to be expected. This can require additional measures of radio interference suppression.

---

## 3 Safety Instructions for Electric Drives and Controls

### 3.1 Definitions of Terms

<b>Application Documentation</b>	The entire documentation used to inform the user of the product about the use and safety-relevant features for configuring, integrating, installing, mounting, commissioning, operating, maintaining, repairing and decommissioning the product. The following terms are also used for this kind of documentation: User Guide, Operation Manual, Commissioning Manual, Instruction Manual, Project Planning Manual, Application Manual, etc.
<b>Component</b>	Combination of elements with a specified function, which are part of a piece of equipment, device or system. Components of a drive and control system are, for example, supply units, drive controllers, mains choke, mains filter, motors, cables, etc.
<b>Control System</b>	Several interconnected control components placed on the market as a single functional unit.
<b>Device</b>	Finished product with a defined function, intended for users and placed on the market as an individual piece of merchandise.
<b>Drive System</b>	A group of components consisting of electric motor(s), motor encoder(s) and cable(s), supply units and drive controllers, as well as possible auxiliary and additional components, such as mains filter, mains choke, etc.
<b>Electrical Equipment</b>	Objects used to generate, convert, transmit, distribute or apply electrical energy, such as machines, transformers, switching devices, cables, lines, power-consuming devices, circuit board assemblies, plug-in units, control cabinets, etc.
<b>Installation</b>	Several devices or systems interconnected for a defined purpose and on a defined site which, however, are not intended to be placed on the market as a single functional unit.
<b>Machine</b>	Entirety of interconnected parts or units at least one of which is movable. Thus, a machine consists of the appropriate machine drive elements, as well as control and power circuits, which have been assembled for a specific application. A machine is, for example, intended for processing, treatment, movement or packaging of a material. The term "machine" also covers a combination of machines which are arranged and controlled in such a way that they function as a unified whole.
<b>Manufacturer</b>	Individual or legal entity bearing responsibility for the design and manufacture of a product which is placed on the market in the individual's or legal entity's name. The manufacturer can use finished products, finished parts or finished elements, or contract out work to subcontractors. However, he must always have overall control and possess the required authority to take responsibility for the product.
<b>Product</b>	Produced device, component, part, system, software, firmware, among other things.
<b>Project Planning Manual</b>	Part of the application documentation used to support the dimensioning and planning of systems, machines or installations.
<b>Qualified Persons</b>	In terms of this application documentation, qualified persons are those persons who are familiar with the installation, mounting, commissioning and operation of the components of the drive and control system, as well as with the hazards this implies, and who possess the qualifications their work requires. To comply with these qualifications, it is necessary, among other things, <ul style="list-style-type: none"> <li>• to be trained, instructed or authorized to switch electric circuits and devices safely on and off, to ground them and to mark them,</li> </ul>

## Safety Instructions for Electric Drives and Controls

- to be trained or instructed to maintain and use adequate safety equipment,
- to attend a course of instruction in first aid.

**User** A person installing, commissioning or using a product which has been placed on the market.

## 3.2 General Information

### 3.2.1 Using the Safety Instructions and Passing Them on to Others

Do not attempt to install and operate the electric components of the drive and control system without first reading all documentation provided with the product. Read and understand these safety instructions and all user documentation prior to working with these components. If you do not have the user documentation for the components, contact your responsible Rexroth sales partner. Ask for these documents to be sent immediately to the person or persons responsible for the safe operation of the components.

If the component is resold, rented and/or passed on to others in any other form, these safety instructions must be delivered with the component in the official language of the user's country.



**Improper use of these components, failure to follow the safety instructions in this document or tampering with the product, including disabling of safety devices, could result in property damage, injury, electric shock or even death.**

Observe the safety instructions!

---

### 3.2.2 Requirements for Safe Use

Read the following instructions before initial commissioning of the electric components of the drive and control system in order to eliminate the risk of injury and/or property damage. You must follow these safety instructions.

- Rexroth is not liable for damages resulting from failure to observe the safety instructions.
- Read the operating, maintenance and safety instructions in your language before commissioning. If you find that you cannot completely understand the application documentation in the available language, please ask your supplier to clarify.
- Proper and correct transport, storage, mounting and installation, as well as care in operation and maintenance, are prerequisites for optimal and safe operation of the component.
- Only qualified persons may work with components of the drive and control system or within its proximity.
- Only use accessories and spare parts approved by Rexroth.
- Follow the safety regulations and requirements of the country in which the electric components of the drive and control system are operated.
- Only use the components of the drive and control system in the manner that is defined as appropriate. See chapter "Appropriate Use".
- The ambient and operating conditions given in the application documentation at hand must be observed.
- Safety-relevant applications are only allowed if clearly and explicitly specified in the application documentation "Integrated Safety Technology". If

## Safety Instructions for Electric Drives and Controls

this is not the case, they are excluded. Safety-relevant are all such applications which can cause danger to persons and property damage.

- The information given in the application documentation with regard to the use of the delivered components contains only examples of applications and suggestions.

The machine and installation manufacturer must

- make sure that the delivered components are suited for his individual application and check the information given in this application documentation with regard to the use of the components,
- make sure that his individual application complies with the applicable safety regulations and standards and carry out the required measures, modifications and complements.
- Commissioning of the delivered components is only allowed once it is sure that the machine or installation in which the components are installed complies with the national regulations, safety specifications and standards of the application.
- Operation is only allowed if the national EMC regulations for the application are met.
- The instructions for installation in accordance with EMC requirements can be found in the section on EMC in the respective application documentation.

The machine or installation manufacturer is responsible for compliance with the limit values as prescribed in the national regulations.

- The technical data, connection and installation conditions of the components are specified in the respective application documentations and must be followed at all times.

*National regulations which the user must take into account*

- European countries: According to European EN standards
- United States of America (USA):
  - National Electrical Code (NEC)
  - National Electrical Manufacturers Association (NEMA), as well as local engineering regulations
  - Regulations of the National Fire Protection Association (NFPA)
- Canada: Canadian Standards Association (CSA)
- Other countries:
  - International Organization for Standardization (ISO)
  - International Electrotechnical Commission (IEC)

### 3.2.3 Hazards by Improper Use

- High electrical voltage and high working current! Danger to life or serious injury by electric shock!
- High electrical voltage by incorrect connection! Danger to life or injury by electric shock!
- Dangerous movements! Danger to life, serious injury or property damage by unintended motor movements!
- Health hazard for persons with heart pacemakers, metal implants and hearing aids in proximity to electric drive systems!
- Risk of burns by hot housing surfaces!

## Safety Instructions for Electric Drives and Controls

- Risk of injury by improper handling! Injury by crushing, shearing, cutting, hitting!
- Risk of injury by improper handling of batteries!
- Risk of injury by improper handling of pressurized lines!

### 3.2.4 Explanation of Safety Symbols and Hazard Classification

The safety instructions describe the following hazard classification. The hazard classification informs about the consequences resulting from non-compliance with the safety instructions:




Safety symbol	Signal word	Hazard classification according to ANSI Z535.4-2002
	Danger	Death or serious injury <b>will</b> occur.
	Warning	Death or serious injury <b>could</b> occur.
	Caution	Minor or moderate injury or property damage may occur.

Fig.3-1: Hazard Classification (According to ANSI Z535.4-2002)

## 3.3 Instructions with Regard to Specific Dangers

### 3.3.1 Protection Against Contact with Electrical Parts and Housings



This section concerns components of the drive and control system with voltages of **more than 50 volts**.

Contact with parts conducting voltages above 50 volts can cause personal danger and electric shock. When operating components of the drive and control system, it is unavoidable that some parts of these components conduct dangerous voltage.



**WARNING****High electrical voltage! Danger to life, risk of injury by electric shock or serious injury!**

- Only qualified persons are allowed to operate, maintain and/or repair the electric components of the drive and control system.
- Follow the general installation and safety regulations when working on power installations.
- Before switching on, the equipment grounding conductor must have been permanently connected to all electric components in accordance with the connection diagram.
- Even for brief measurements or tests, operation is only allowed if the equipment grounding conductor has been permanently connected to the points of the components provided for this purpose.
- Before accessing electrical parts with voltage potentials higher than 50 V, you must disconnect electric components from the mains or from the power supply unit. Secure the electric component from reconnection.
- With electric components, observe the following aspects:  
Always wait **30 minutes** after switching off power to allow live capacitors to discharge before accessing an electric component. Measure the electrical voltage of live parts before beginning to work to make sure that the equipment is safe to touch.
- Install the covers and guards provided for this purpose before switching on.
- Never touch electrical connection points of the components while power is turned on.
- Do not remove or plug in connectors when the component has been powered.
- As a basic principle, residual-current-operated circuit-breakers cannot be used for electric drives to prevent direct contact.
- Secure built-in devices from penetrating foreign objects and water, as well as from direct contact, by providing an external housing, for example a control cabinet.

**WARNING****High housing voltage and high leakage current! Danger to life, risk of injury by electric shock!**

- Before switching on and before commissioning, ground or connect the components of the drive and control system to the equipment grounding conductor at the grounding points.
- Connect the equipment grounding conductor of the components of the drive and control system permanently to the main power supply at all times. The leakage current is greater than 3.5 mA.
- Establish an equipment grounding connection with a copper wire of a cross section of at least 10 mm<sup>2</sup> (8 AWG) or additionally run a second equipment grounding conductor of the same cross section as the original equipment grounding conductor.

### 3.3.2 Protective Extra-Low Voltage as Protection Against Electric Shock

Protective extra-low voltage is used to allow connecting devices with basic insulation to extra-low voltage circuits.

All connections and terminals with voltages between 5 and 50 volts at the components of the Rexroth drive and control system are PELV ("Protective Extra-Low Voltage") systems. It is allowed to connect devices equipped with basic

## Safety Instructions for Electric Drives and Controls

insulation (such as programming devices, PCs, notebooks, display units) to these connections.



### **Danger to life, risk of injury by electric shock! High electrical voltage by incorrect connection!**

If extra-low voltage circuits of devices containing voltages and circuits of more than 50 volts (e.g., the mains connection) are connected to Rexroth products, the connected extra-low voltage circuits must comply with the requirements for PELV ("Protective Extra-Low Voltage").

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### 3.3.3 Protection Against Dangerous Movements

Dangerous movements can be caused by faulty control of connected motors. Some common examples are:

- Improper or wrong wiring or cable connection
- Operator errors
- Wrong input of parameters before commissioning
- Malfunction of sensors and encoders
- Defective components
- Software or firmware errors

These errors can occur immediately after equipment is switched on or even after an unspecified time of trouble-free operation.

The monitoring functions in the components of the drive and control system will normally be sufficient to avoid malfunction in the connected drives. Regarding personal safety, especially the danger of injury and/or property damage, this alone cannot be relied upon to ensure complete safety. Until the integrated monitoring functions become effective, it must be assumed in any case that faulty drive movements will occur. The extent of faulty drive movements depends upon the type of control and the state of operation.

**WARNING****Dangerous movements! Danger to life, risk of injury, serious injury or property damage!**

- A **risk assessment** must be prepared for the installation or machine, with its specific conditions, in which the components of the drive and control system are installed. As a result of the risk assessment, the user must provide for monitoring functions and higher-level measures on the installation side for personal safety. The safety regulations applicable to the installation or machine must be taken into consideration. Unintended machine movements or other malfunctions are possible if safety devices are disabled, bypassed or not activated.

**To avoid accidents, injury and/or property damage:**

- Keep free and clear of the machine's range of motion and moving machine parts. Prevent personnel from accidentally entering the machine's range of motion by using, for example:
  - Safety fences
  - Safety guards
  - Protective coverings
  - Light barriers
- Make sure the safety fences and protective coverings are strong enough to resist maximum possible kinetic energy.
- Mount emergency stop switches in the immediate reach of the operator. Before commissioning, verify that the emergency stop equipment works. Do not operate the machine if the emergency stop switch is not working.
- Prevent unintended start-up. Isolate the drive power connection by means of an emergency stop circuit or use a safe starting lockout.
- Make sure that the drives are brought to a safe standstill before accessing or entering the danger zone.
- Additionally secure vertical axes against falling or dropping after switching off the motor power by, for example,
  - mechanically securing the vertical axes,
  - adding an external braking/arrester/clamping mechanism or
  - ensuring sufficient equilibration of the vertical axes.
- The standard equipment **motor holding brake** or an external holding brake controlled by the drive controller is **not sufficient to guarantee personal safety!**
- Disconnect electrical power to the components of the drive and control system using the master switch and secure them from reconnection for:
  - Maintenance and repair work
  - Cleaning of equipment
  - Long periods of discontinued equipment use
- Prevent the operation of high-frequency, remote control and radio equipment near electric/electronic components of the drive and control system and their supply leads. If the use of these devices cannot be avoided, check the machine or installation, before initial commissioning of the drive and control system, for possible malfunctions when operating such high-frequency, remote control and radio equipment in its possible positions of normal use. It might possibly be necessary to perform a special electromagnetic compatibility (EMC) test.

### 3.3.4 Protection Against Magnetic and Electromagnetic Fields During Operation and Mounting

Magnetic and electromagnetic fields generated by current-carrying conductors or permanent magnets of electric motors represent a serious danger to persons with heart pacemakers, metal implants and hearing aids.



**WARNING**

#### Health hazard for persons with heart pacemakers, metal implants and hearing aids in proximity to electric components!

- Persons with heart pacemakers and metal implants are not allowed to enter the following areas:
  - Areas in which components of the drive and control systems are mounted, commissioned and operated.
  - Areas in which parts of motors with permanent magnets are stored, repaired or mounted.
- If it is necessary for somebody with a heart pacemaker to enter such an area, a doctor must be consulted prior to doing so. The noise immunity of implanted heart pacemakers differs greatly so that no general rules can be given.
- Those with metal implants or metal pieces, as well as with hearing aids, must consult a doctor before they enter the areas described above.

### 3.3.5 Protection Against Contact with Hot Parts



**CAUTION**

#### Hot surfaces of components of the drive and control system. Risk of burns!

- Do not touch hot surfaces of, for example, braking resistors, heat sinks, supply units and drive controllers, motors, windings and laminated cores!
- According to the operating conditions, temperatures of the surfaces can be **higher than 60 °C (140 °F)** during or after operation.
- Before touching motors after having switched them off, let them cool down for a sufficiently long time. Cooling down can require **up to 140 minutes!** The time required for cooling down is approximately five times the thermal time constant specified in the technical data.
- After switching chokes, supply units and drive controllers off, wait **15 minutes** to allow them to cool down before touching them.
- Wear safety gloves or do not work at hot surfaces.
- For certain applications and according to the respective safety regulations, the manufacturer of the machine or installation has to take measures to avoid injuries caused by burns in the end application. These measures can be, for example: Warnings at the machine or installation, guards (shieldings or barriers) or safety instructions in the application documentation.

### 3.3.6 Protection During Handling and Mounting

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**Risk of injury by improper handling! Injury by crushing, shearing, cutting, hitting!**

- Observe the relevant statutory regulations of accident prevention.
  - Use suitable equipment for mounting and transport.
  - Avoid jamming and crushing by appropriate measures.
  - Always use suitable tools. Use special tools if specified.
  - Use lifting equipment and tools in the correct manner.
  - Use suitable protective equipment (hard hat, safety goggles, safety shoes, safety gloves, for example).
  - Do not stand under hanging loads.
  - Immediately clean up any spilled liquids from the floor due to the risk of slipping.
- 

### 3.3.7 Battery Safety

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Batteries consist of active chemicals in a solid housing. Therefore, improper handling can cause injury or property damage.

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**Risk of injury by improper handling!**

- Do not attempt to reactivate low batteries by heating or other methods (risk of explosion and cauterization).
  - Do not attempt to recharge the batteries as this may cause leakage or explosion.
  - Do not throw batteries into open flames.
  - Do not dismantle batteries.
  - When replacing the battery/batteries, do not damage the electrical parts installed in the devices.
  - Only use the battery types specified for the product.
- 



Environmental protection and disposal! The batteries contained in the product are considered dangerous goods during land, air, and sea transport (risk of explosion) in the sense of the legal regulations. Dispose of used batteries separately from other waste. Observe the national regulations of your country.

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### 3.3.8 Protection Against Pressurized Systems

According to the information given in the Project Planning Manuals, motors and components cooled with liquids and compressed air can be partially supplied with externally fed, pressurized media, such as compressed air, hydraulics oil, cooling liquids and cooling lubricants. Improper handling of the connected supply systems, supply lines or connections can cause injuries or property damage.

Safety Instructions for Electric Drives and Controls

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**Risk of injury by improper handling of pressurized lines!**

- Do not attempt to disconnect, open or cut pressurized lines (risk of explosion).
  - Observe the respective manufacturer's operating instructions.
  - Before dismounting lines, relieve pressure and empty medium.
  - Use suitable protective equipment (safety goggles, safety shoes, safety gloves, for example).
  - Immediately clean up any spilled liquids from the floor due to the risk of slipping.
- 



Environmental protection and disposal! The agents (e.g., fluids) used to operate the product might not be environmentally friendly. Dispose of agents harmful to the environment separately from other waste. Observe the national regulations of your country.

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## 4 Master Communication

### 4.1 Basic Functions of Master Communication

#### 4.1.1 Brief Description

##### General Information

The basic functions of master communication for IndraDrive devices apply to SERCOS interface, SERCOS III, field bus interface, parallel and analog interface.

##### Features

All variants of master communication supported by IndraDrive have the following functional features in common:

- **Address assignment**
  - Communication address to be freely parameterized (via master communication, serial and control panel) via parameters "P-0-4025, Drive address of master communication" and "S-0-1040, Drive address of master communication"
- **Command Processing**
  - Drive commands to be externally activated (via master communication, serial and control panel)
- **Device control (state machine)**
  - Individual state machines for master communication and device
    - According to the variant of master communication, the master communication state machine has different functionality and complexity. The communication-specific states are distinguished and mapped to the status words of the corresponding master communication (e.g. for SERCOS: S-0-0014, S-0-0135, S-0-1045).
    - The device state machine is independent of the variant of master communication and maps the device-specific states to parameter "S-0-0424, Status parameterization level" ab. We always distinguish operating mode (OM) and parameter mode (PM).
- **Extended possibilities of control**
  - Signal control word (S-0-0145) and signal status word (S-0-0144)
  - Multiplex Channel

See section "Control Options / Additional Functions"



The state machine of the master communications is briefly outlined in this section; it will be described in detail, i.e. including the individual status transitions, in the main chapter of the respective master communication.

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##### Pertinent Parameters

The following parameters are used independent of the variant of master communication:

##### Parameters for State Machine and Phase Switch

- S-0-0011, Class 1 diagnostics
- S-0-0012, Class 2 diagnostics
- S-0-0013, Class 3 diagnostics

## Master Communication

- S-0-0014, Interface status
- S-0-0420, C0400 Activate parameterization level 1 procedure command
- S-0-0422, C0200 Exit parameterization level procedure command
- S-0-0423, IDN-list of invalid data for parameterization levels
- S-0-0424, Status parameterization level
- P-0-4086, Master communication status
- P-0-4088, Master communication: Drive configuration

## Operation Mode Parameters

- S-0-0032, Primary mode of operation
- S-0-0033, Secondary operation mode 1
- S-0-0034, Secondary operation mode 2
- S-0-0035, Secondary operation mode 3
- S-0-0284, Secondary operation mode 4
- S-0-0285, Secondary operation mode 5
- S-0-0286, Secondary operation mode 6
- S-0-0287, Secondary operation mode 7

Device-Specific Control and Status  
Words

- S-0-0099, C0500 Reset class 1 diagnostics
- S-0-0144, Signal status word
- S-0-0145, Signal control word
- P-0-0115, Device control: status word
- P-0-0116, Device control: control word
- P-0-4028, Device control word

## SERCOS-Specific Parameters

For the "SERCOS interface" the following **additional** parameters are used:

- S-0-0021, IDN-list of invalid operation data for CP2
- S-0-0022, IDN-list of invalid operation data for CP3
- S-0-0127, C0100 Communication phase 3 transition check
- S-0-0128, C5200 Communication phase 4 transition check
- S-0-1044, SERCOS III: Device Control (C-Dev)
- S-0-1045, SERCOS III: Device Status (S-Dev)

For the "SERCOS III" interface the following **additional** parameters are used:

- S-0-0134, Master control word
- S-0-0135, Drive status word

## Field-Bus-Specific Parameters

The following **additional** parameters are used for field buses:

- P-0-4068, Field bus: control word IO
- P-0-4077, Field bus: control word
- P-0-4078, Field bus: status word

Specific Parameters for Parallel/  
Analog Interface

For the parallel/analog interface, the following **additional** parameters are used:

- P-0-4028, Device control word
- P-0-0115, Device control: status word

## Pertinent Commands

- C0100 Communication phase 3 transition check
- C5200 Communication phase 4 transition check



- C0200 Exit parameterization level procedure command
- C0400 Activate parameterization level 1 procedure command
- C5300 SERCOS III: Command SYNC delay measurement

## 4.1.2 Setting the Axis Address

### Overview

Each drive is identified by its own address.



Multiple addressing is not allowed; i.e. an address number may only be assigned once in the drive group!

The drive address can be set in the following ways:

- Direct writing to parameters "P-0-4025, Drive address of master communication" and "S-0-1040, Drive address of master communication" via master communication

- or -

- Changing the content of "P-0-4025, Drive address of master communication" via the control panel (see below)



The address entered in parameter "P-0-4025, Drive address of master communication" takes effect during the transition from P0 → P1. This address is displayed in parameter "P-0-4031, Overview of device addresses".

For SERCOS III the parameter "S-0-1040, Drive address of master communication" always takes effect immediately, as it is already required in P0.

**Condition as Supplied** In the condition as supplied the address "99" is set.

### Address Setting via Standard Control Panel

The drive address for IndraDrive controllers can be set via the standard control panel at the front of the device.

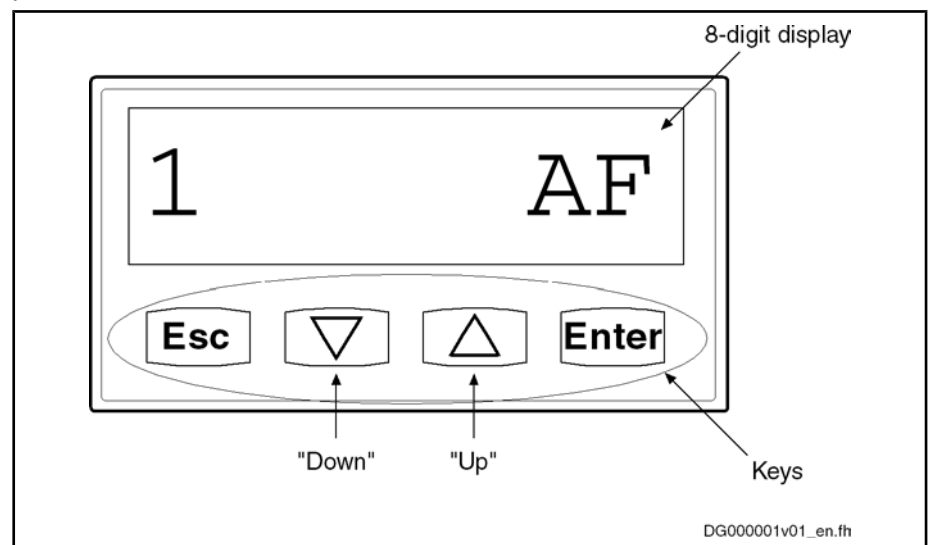


Fig. 4-1: Standard Control Panel (Example of Display)

The address is set via the control panel as follows:

1. Change to "commands/settings" mode

Master Communication

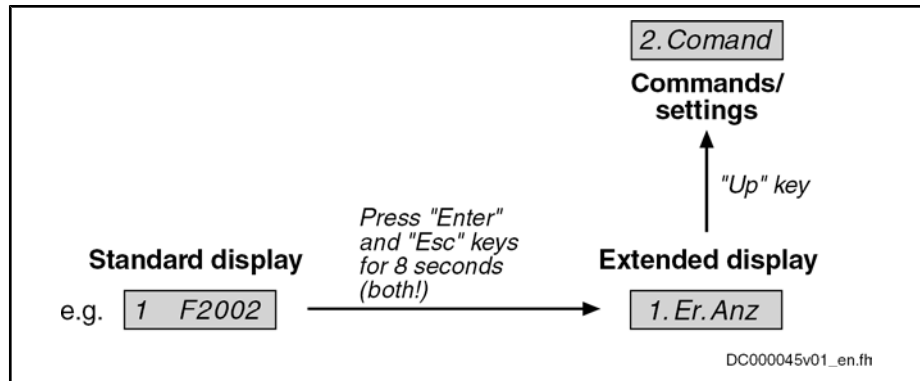


Fig.4-2: Activating the "Commands/Settings" Mode

2. Select element "2.1 drive address" by means of "Up/Down" keys, then confirm by means of "Enter" key
3. set drive address by means of "Up/Down" keys, then confirm by means of "Enter" key
  - First set **tens digit**
    - The display reads "2.1.1 drive address"
  - Then set **units digit**
    - The display reads "2.1.2 drive address"



The tens or units digit is accepted by pressing the "Enter" key. To return press the "Esc" key.

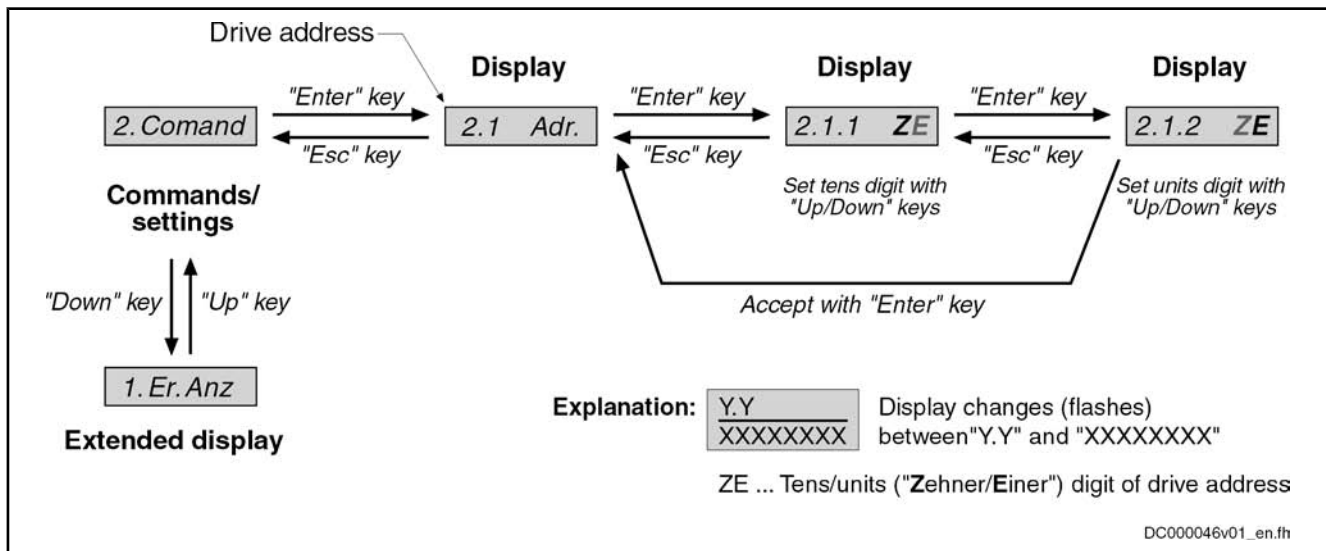


Fig.4-3: Selecting and Setting the Drive Address

Address Setting via Parameter Access

The drive address can also be set by writing the parameter "P-0-4025, Drive address of master communication". This is particularly interesting if you administrate the axis data in centralized form in the control unit and want to set the address from the control unit when replacing devices.

In this connection see "Notes on How to Replace the Devices"



The address written to parameter "P-0-4025, Drive address of master communication" will only take effect after repeated booting process or, in the case of SERCOS devices, after the transition from P-1 → P1.

## 4.1.3 Command Processing

### Overview

Commands are used to control complex functions in the drive. For example, the functions "Drive-controlled homing procedure" or "Transition check for communication phase 4" are defined as commands.



All commands available in the drive are stored in the parameter "S-0-0025, IDN-list of all procedure commands".

#### Kinds of Commands

We distinguish 3 kinds of commands:

- **Drive control commands**
  - Can cause automatic drive motion
  - Can only be started when drive enable has been set
  - Deactivate the active operation mode during its execution
- **Monitor commands**
  - Activate or deactivate monitorings or functions in the drive
- **Administration commands**
  - Carry out administration tasks
  - Cannot be interrupted

### Command Execution

#### General Information

Observe the following aspects for command execution:

- Belonging to each command there is a parameter with which the command execution can be controlled.
- The higher-level master can start, interrupt or clear commands.
- While a command is being executed, the diagnostic message "Cx" appears on the display, "x" representing the number of the command.
- Each command that was started by the master must be actively cleared again.



**CAUTION**

**Damage to the internal memory (flash) caused by cyclic command execution (write access to the flash)!**

⇒ During the execution of some commands (see description of the respective diagnostic command message; e.g. C0500), data are written to the internal memory (flash), too. This memory, however, only allows a limited number of write access. For this reason, you should make sure that such write access is not carried out too often.

#### Controlling the Command Execution

The command execution is controlled and monitored by command input and command acknowledgment. In the input the drive is informed on whether the command execution is to be started, interrupted or completed. The input takes place via the operating data of the respective parameter.

Commands are started or terminated by:

## Master Communication

- Directly writing data to the respective command parameter (e.g. parameter S-0-0099 in the case of command C0500) via serial interface of master communication

- or -

- A 0-1 edge when the command was assigned to a digital input

See also the following sections:

- "Configurable Signal Control Word"
- "Parallel Interface"
- "Digital Inputs/Outputs"

**Possible Command Inputs**

For command execution, we distinguish the following inputs (= content of command parameter):

- **0**: Not set and not enabled
- **1**: Interrupted
- **3**: Set and enabled

**Command Acknowledgment**

In the command acknowledgment, the drive informs about the current status of the command execution. The current status is contained in the data status of the command parameter.



The command status can be obtained by executing a command to write data to the parameter element 1 (data status) of the command parameter.

---

**Command Status**

The command status can be:

- **0x0**: Not set and not enabled
- **0x7**: In process
- **0xF**: Error, command execution impossible
- **0x5**: Command execution interrupted
- **0x3**: Command correctly executed

**Command Change Bit**

For master-side detection of a change of the command acknowledgment by the drive the "command change bit" (KA bit) is available for SERCOS in "S-0-0135, Drive status word".

- The drive sets this bit when the command acknowledgment changes from the status "in process (0x7)" to one of the following states:
  - Error, command execution impossible (0xF)
- or -
- Command correctly executed (0x3)
- The bit is cleared when the master clears the input (0x0), i.e. writes "0" to the parameter belonging to the command.



The command change bit is only set if the command is activated via master communication.

---

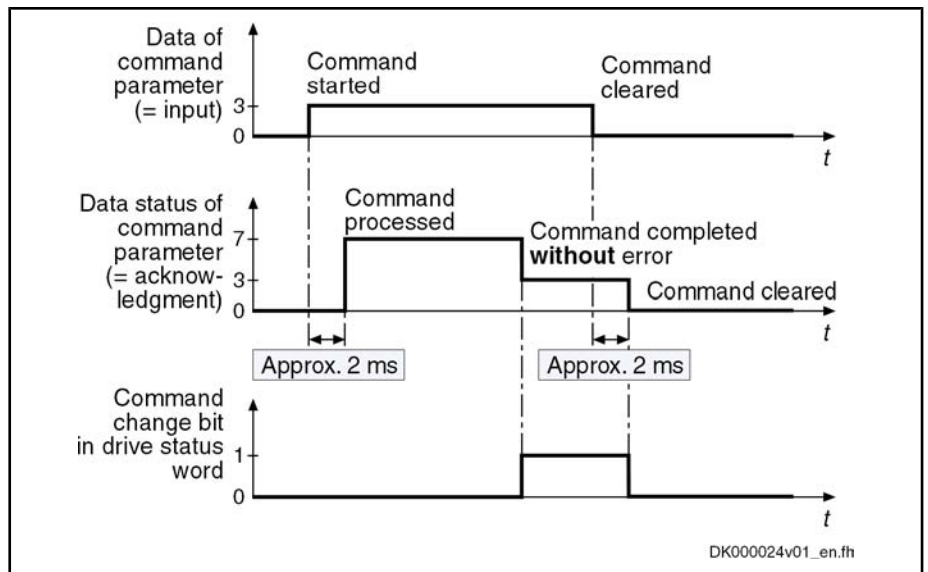


Fig.4-4: Input, Acknowledgment and Command Change Bit in the Case of Correct Execution

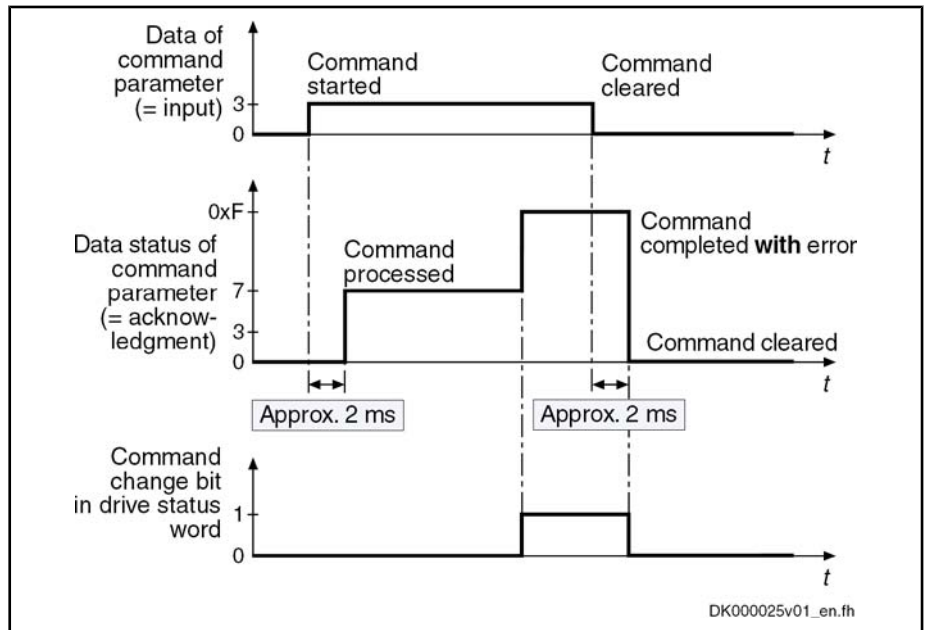


Fig.4-5: Input, Acknowledgment and Command Change Bit in the Case of Incorrect Execution

## 4.1.4 Device Control and State Machines

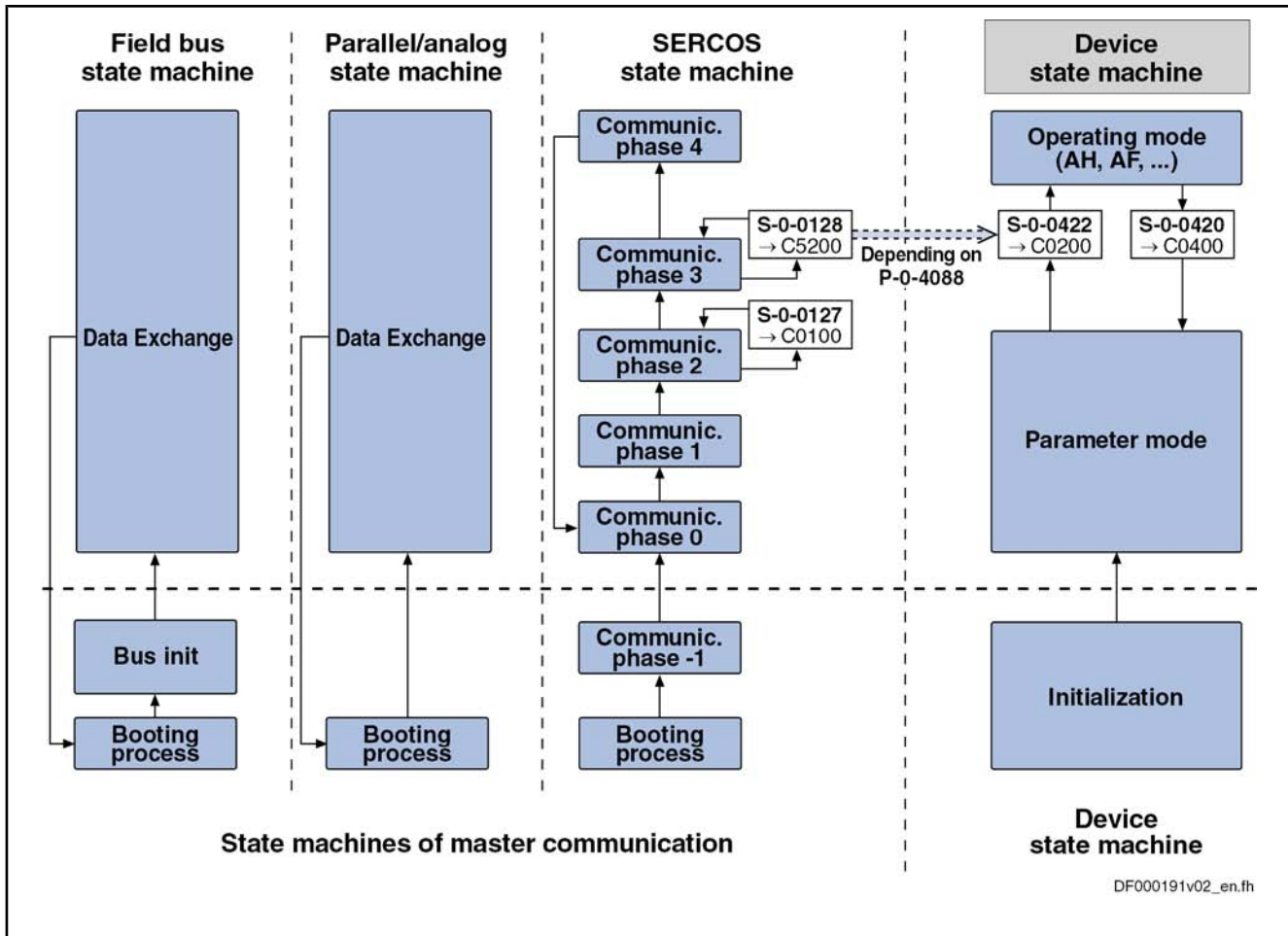
### Overview

The drive status (e.g. Drive Halt, drive error) represents a specific internal and external drive behavior. The drive status can be exited by defined events (e.g. drive commands, switching of operating modes). Corresponding status transitions are assigned to the events. The status transitions or the interaction of control and status bits are called state machine.

We distinguish between:

- Device-internal state machine (defines the device-specific states which determine the behavior of the device)
- State machine of master communication

Master Communication



S-0-0127 C0100 Communication phase 3 transition check  
 S-0-0128 C5200 Communication phase 4 transition check  
 S-0-0420 C0400 Activate parameterization level 1 procedure command  
 S-0-0422 C0200 Exit parameterization level procedure command  
 P-0-4088 Master communication, configuration  
 Fig.4-6: Overview: State Machines of Master Communications and Device

Device-Internal State Machine

- Parameter Mode/Operating Mode** For the device-internal state machine we distinguish the following states:
- **Parameter mode (PM)**  
→ Allows write access to all drive parameters which are not password-protected
  - **Operating mode (OM)**  
→ Only allows write access to all drive parameters which can be changed in operation and preferably can be cyclically transmitted
- Switching** You can change between these two states via the following commands:
- S-0-0420, C0400 Activate parameterization level 1 procedure command
  - S-0-0422, C0200 Exit parameterization level procedure command
- Observe the following aspects for switching:
- Switching is generally possible by direct execution of the transition commands S-0-0420 or S-0-0422.

## Master Communication

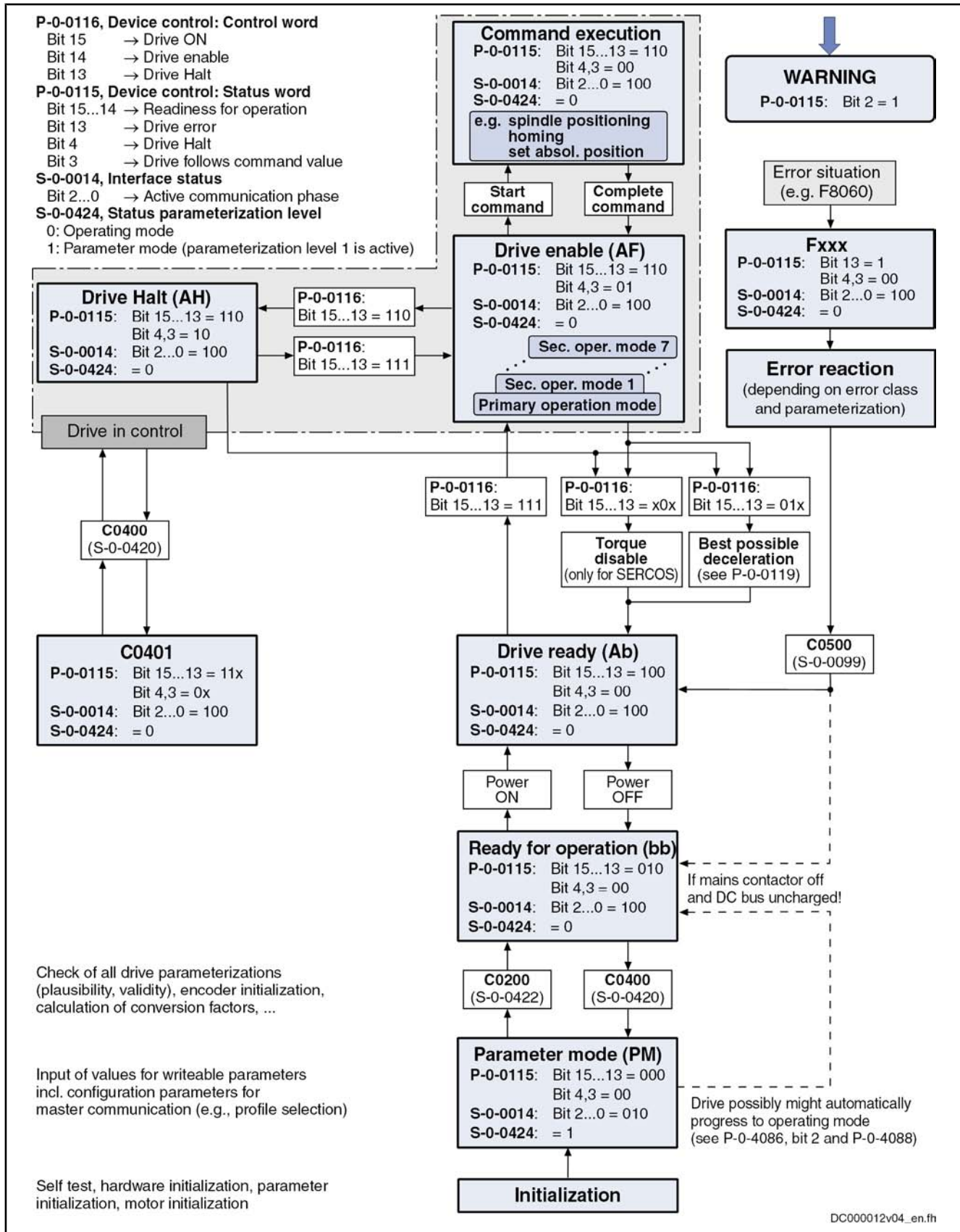
- For field bus devices, switching can additionally take place in the freely configurable operating mode (P-0-4084 = 0xFFFE or 0xFFFD) by presetting the desired mode via bit 1 in "P-0-4077, Field bus: control word":
- For the "SERCOS interface" the state machine of the master communication is connected to the device-internal state machine. This means that when master communication is switched (communication phase 2 → communication phase 4 or back), the device-internal state machine is switched, too. Via parameter "P-0-4088, Master communication: Drive configuration" this dependence can be deactivated.
- In the case of master communication other than SERCOS interface, the device-internal state machine changes to the operating mode after the booting process. This behavior, too, can be set via the parameter "P-0-4088, Master communication: Drive configuration".

**Control Word and Status Word** The device-specific states are mapped to the following parameters:

- S-0-0424, Status parameterization level
- P-0-0115, Device control: status word
- P-0-0116, Device control: control word

Master Communication

State Machine of Master Communication



DC000012v04\_en.fh

Fig.4-7: Device Control (General State Machine)



For the state machine of master communication, we distinguish 3 characteristics which differ with regard to functionality and complexity:

- SERCOS State Machine
- Field Bus State Machine
- Parallel/analog state machine



The following sections only describe the most important states which are described in detail in the section of the respective master communication.

**SERCOS State Machine**

For the master communication "SERCOS interface", we distinguish the following states specific to this kind of communication:

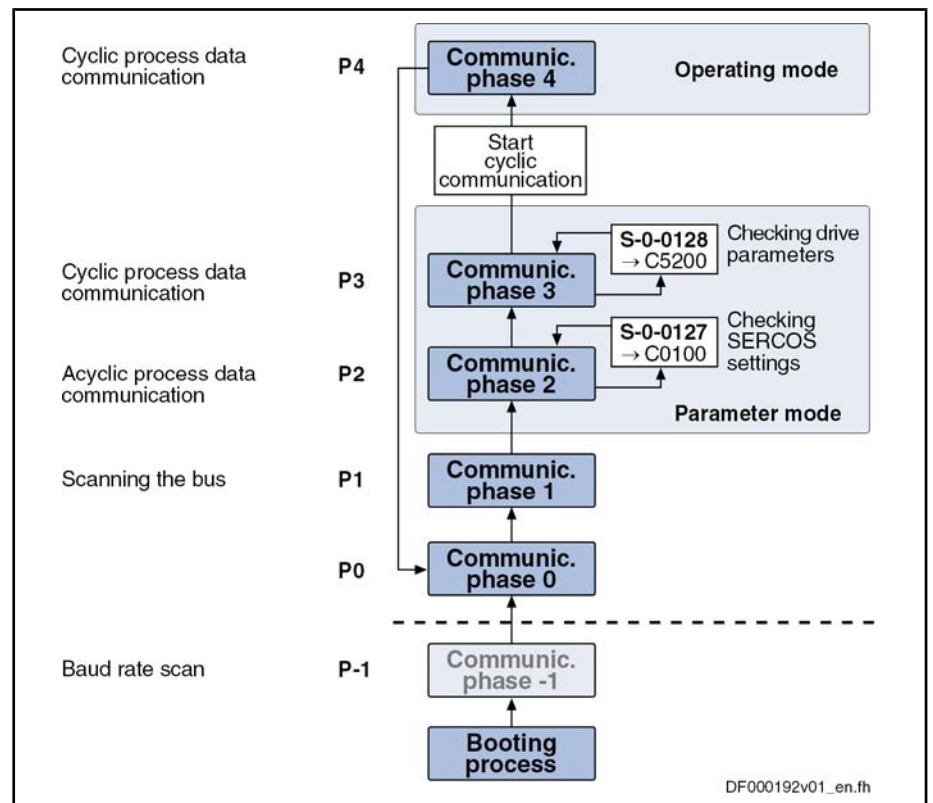


Fig.4-8: State Machine of the Communication Phases of the Drive According to SERCOS II Specification

See also "SERCOS Interface"

Master Communication

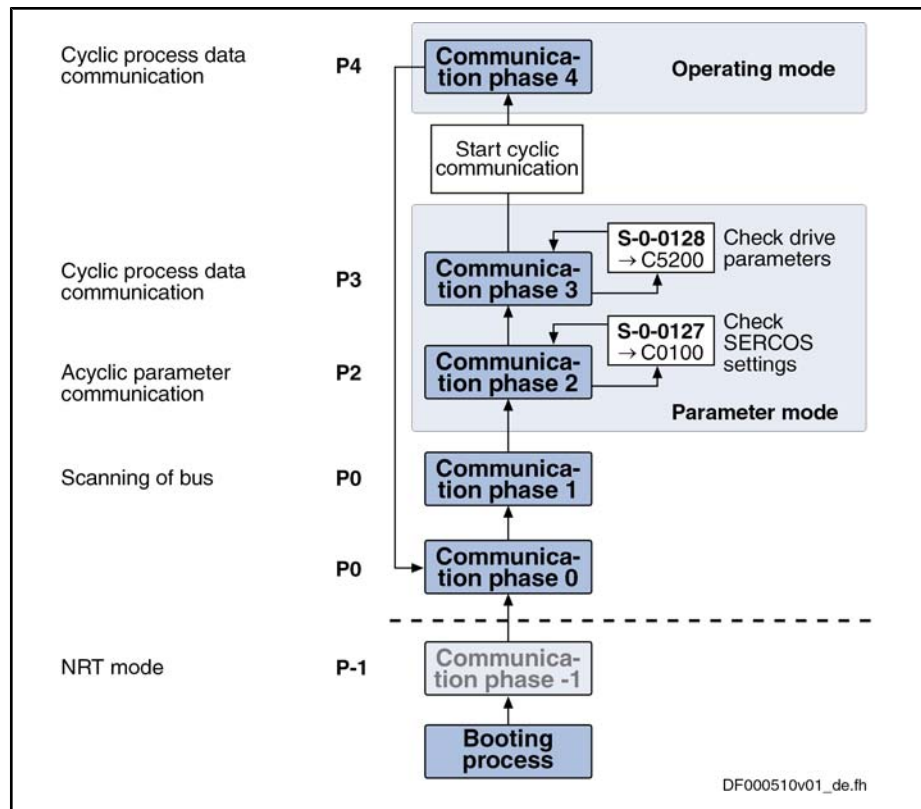


Fig.4-9: State Machine of the Communication Phases of the Drive According to SERCOS III Specification



The currently valid communication phase is contained in parameter "S-0-0014, Interface status" (bit 0...2).

Field Bus State Machine

For field bus master communication, we distinguish the following states specific to this kind of communication:

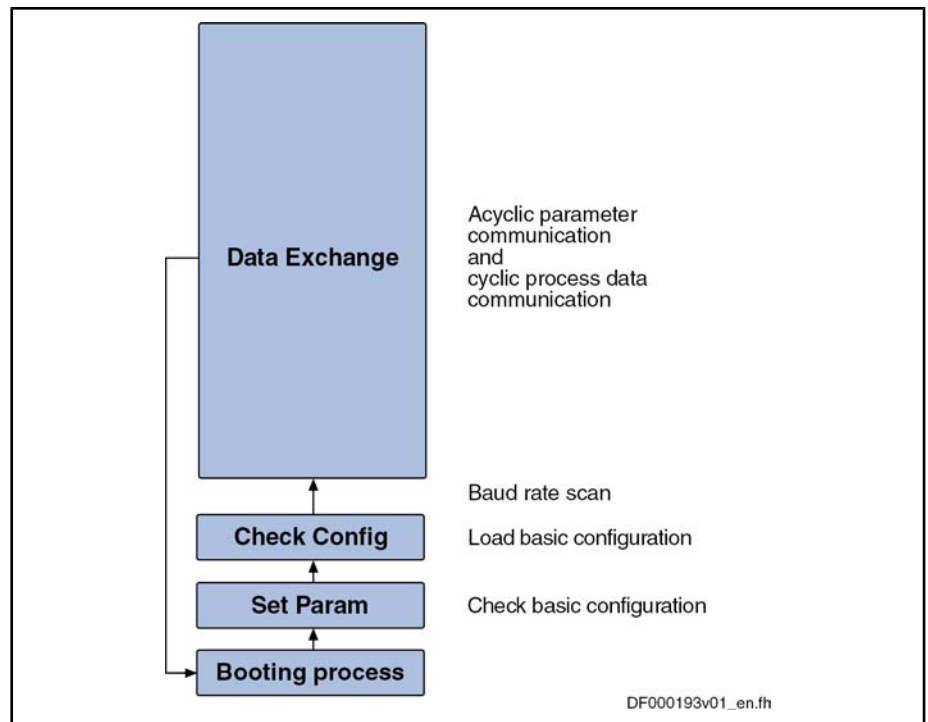


Fig.4-10: State Machine for Field Bus Interfaces

See also sections on the respective variants of the field bus master communication

## Communication Phases of Master Communication

The supported communication phases, as well as the handling of the switching between the communication phases (e.g. parameter and operating mode), depend on the master communication that is used.



The currently valid communication phase is contained in parameter "S-0-0014, Interface status" (bit 0..2) and for field bus drives additionally in parameter "P-0-4078, Field bus: status word" (bit 0,1).

### Communication Phases According to SERCOS Specification

According to **SERCOS specification**, the individual communication phases (states) have the following significance:

- **P-1**: After it is switched on, the drive goes to phase -1 and carries out a baud rate scan. As soon as the drive receives valid SERCOS telegrams from the master, it changes to phase 0.
- **P0**: The master checks the SERCOS ring by sending synchronization telegrams. During phase 0, communication between master and drive isn't possible yet.
- **P1**: When the ring is closed, the master changes to phase 1 and scans the slaves. In addition, it checks the configuration of the ring.
- **P2**: In phase 2, the complete drive parameterization can be carried out.

The following kinds of parameters **can only be changed in phase 2**:

- Communication parameters (according to SERCOS)
- Configuration of axis control (sampling times)
- All factory-specific settings (can only be changed via master password)

## Master Communication

- **P3:** When changing from P2 → P3, only the parameters that can be changed in phase 2 (see above) are checked.

In phase 3, the following parameters can be changed:

- Parameters for operating mode configuration
- Error reaction settings
- Motor configuration parameters, holding brake parameters
- Encoder configuration parameters
- Mechanical transmission elements (gear, feed constant)
- Scaling and polarity parameters, position data format, modulo value
- Configuration of analog and digital inputs/outputs
- Configuration of switch-on / switch-off sequence of drive enable (waiting times, ...)



According to SERCOS specification, the parameter mode is divided into phases 2 and 3. In phase 3, the limit values for all scaling-dependent parameters are not yet known. When these parameters are written in phase 3, the extreme value check is only carried out during phase switch to phase 4.

- **P4:** In phase 4, the so-called "operating mode", only the cyclic data can be changed, the configuration parameters cannot. The switch to the operating mode always causes a new initialization of all functions available in the drive.

The following aspects have to be observed for **phase switch**:

- After the controller has been switched on, it does not automatically go to the operating mode, but has to be switched to this mode by the master.
- This switching of the drive controller to the operating mode is closely connected to establishing the readiness for operation.
- The procedure comprises several steps and is controlled by the master by presetting communication phases -1 to 4 and starting/completing the following commands:
  - S-0-0127, C0100 Communication phase 3 transition check
  - S-0-0128, C5200 Communication phase 4 transition check



SERCOS devices support **all 5 communication phases** (as well as phase -1 → baud rate scan). According to SERCOS specification, switching takes place by the master setting the communication phase.

#### Communication Phases for Field Bus Interface

For devices with **field bus interface**, there only is the status "Data Exchange", apart from the basic initialization. In the status "Data Exchange" we distinguish the following device states:

- Parameter mode
- Operating mode

#### Communication Phases for Parallel or Analog Interface

Basically, the same communication phases apply to devices with **analog or parallel interface** and to devices with field bus interface.

Switching always takes place when the transition check commands are executed.



After the drive controller has been switched on, it automatically changes to the operating mode!

---

## Control Words and Status Words of Master Communication

The control word and status word of the respective master communication are an essential part of the communication between the master communication master and the drive.

Depending on the master communication, different parameters are used:

- SERCOS interface:
  - S-0-0134, Master control word
  - S-0-0135, Drive status word
- SERCOS III:
  - S-0-1044, SERCOS III: Device Control (C-Dev)
  - S-0-1045, SERCOS III: Device Status (S-Dev)
- Field bus interface (e.g. PROFIBUS®, CANopen, DeviceNet™)
  - P-0-4077, Field bus: control word
  - or -
  - P-0-4068, Field bus: control word IO
  - P-0-4078, Field bus: status word
  - or -
  - S-0-0144, Signal status word
- Analog/parallel interface (analog mode):
  - P-0-4028, Device control word
  - P-0-0115, Device control: status word

The following device-specific parameters are used drive-internally:

- P-0-0115, Device control: status word
- P-0-0116, Device control: control word

The figure below illustrates the interaction of the above control and status words:

Master Communication

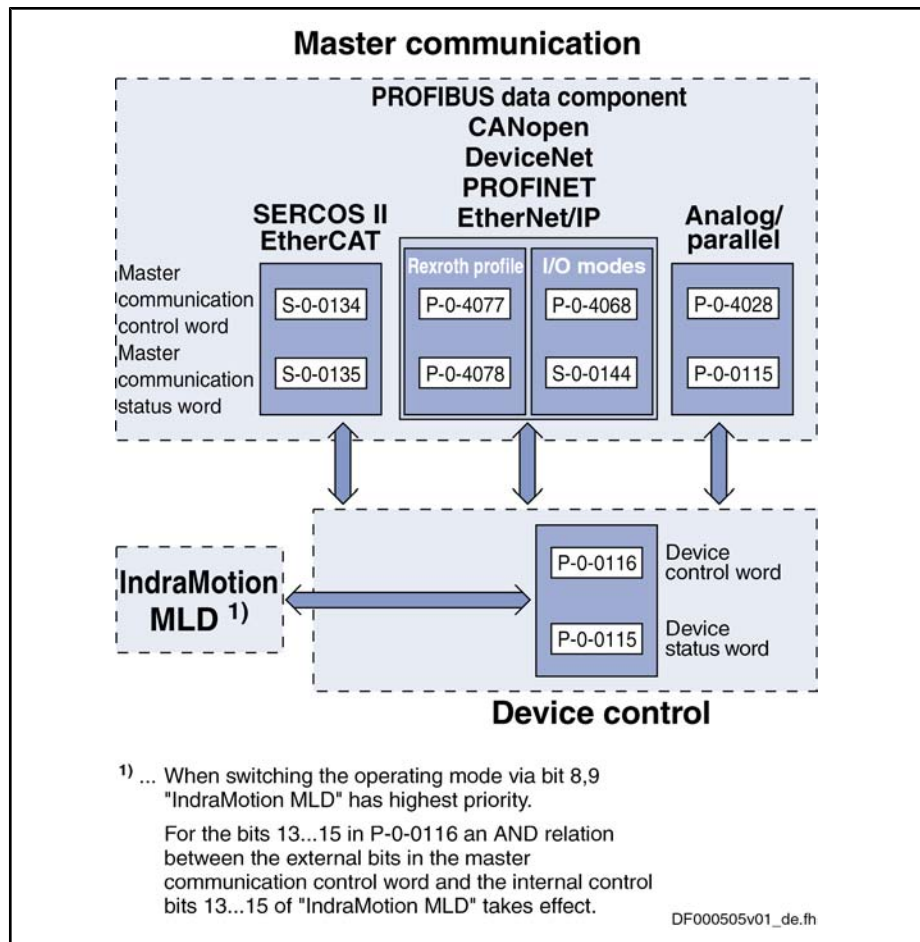


Fig.4-11: Interaction of the Existing Control and Status Words According to **SERCOS II** Specification

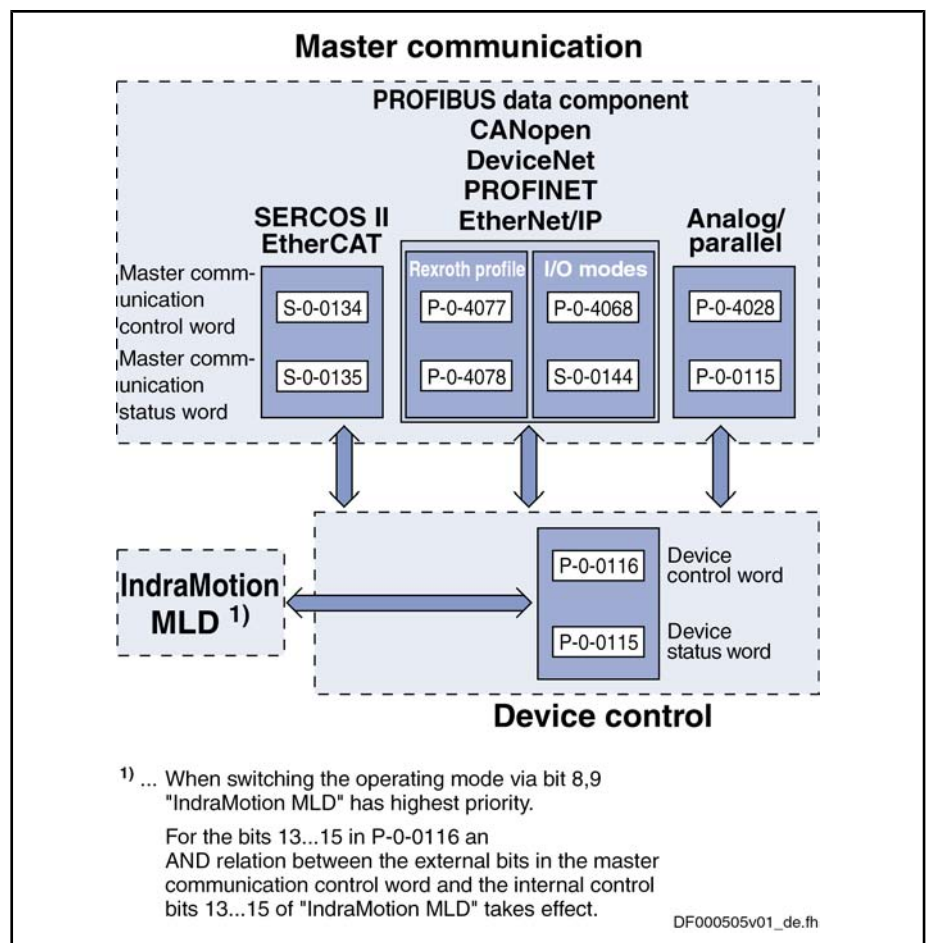


Fig. 4-12: Interaction of the Existing Control and Status Words According to **SERCOS III Specification**



See also separate documentation "IndraMotion MLD".



The internal control and status words can only be directly reached via the PLC integrated in the drive (functional package "IndraMotion MLD" as optional expansion). If this function has not been activated, it is always the specific control and status words that are accessed via the master communication. But it is always possible to read the parameters P-0-0115 and P-0-0116 in order to obtain information on the internal device status.

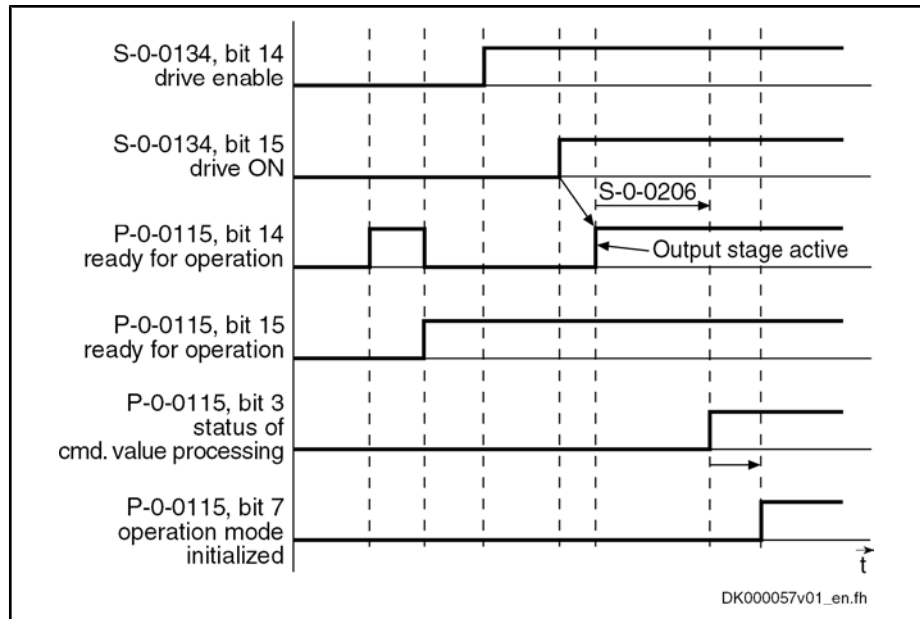
### Timing Diagrams for Device Control



The control bits in parameter "S-0-0134, Master control word" are input externally via the master communication (the following examples apply to SERCOS)!

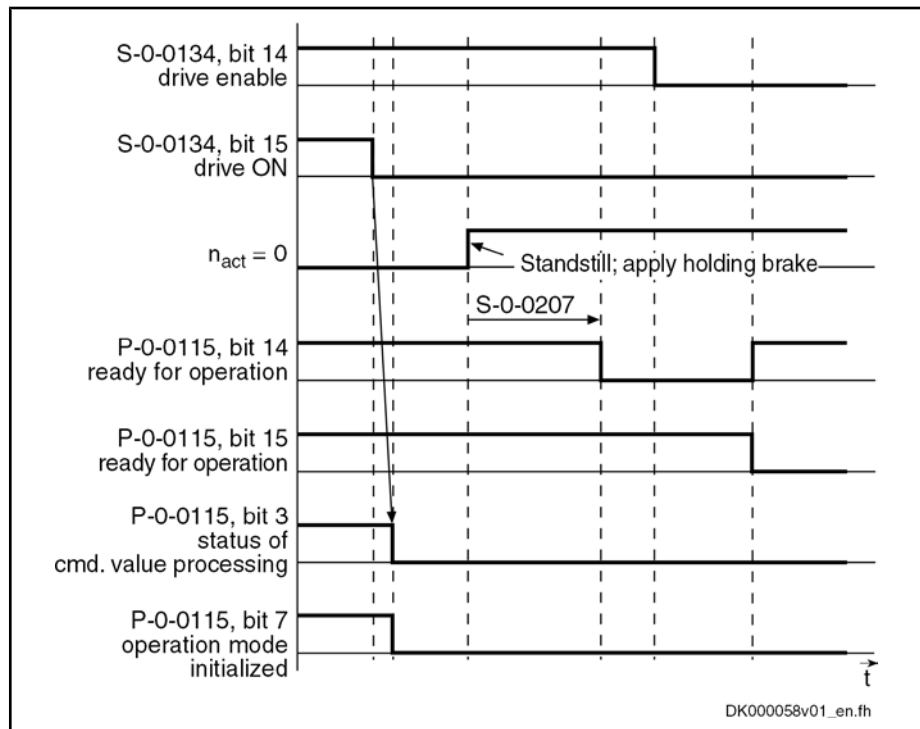
Master Communication

Bit Sequence During Switch-On Process



S-0-0206 Drive on delay time  
 Fig.4-13: Bit Sequence During Switch-On Process

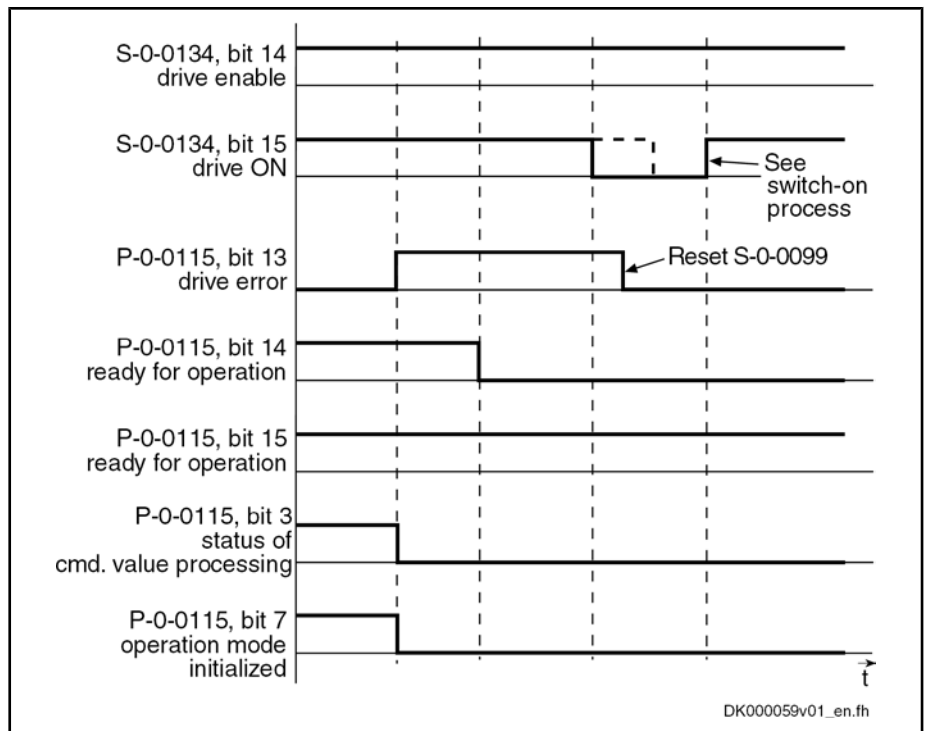
Bit Sequence During Switch-Off Process



S-0-0207 Drive off delay time  
 Fig.4-14: Bit Sequence During Switch-Off Process



**Bit Sequence During Error Reaction**



S-0-0099 C0500 Reset class 1 diagnostics  
Fig.4-15: Bit Sequence During Error Reaction

**Bit Sequence During Change of Operation Modes**

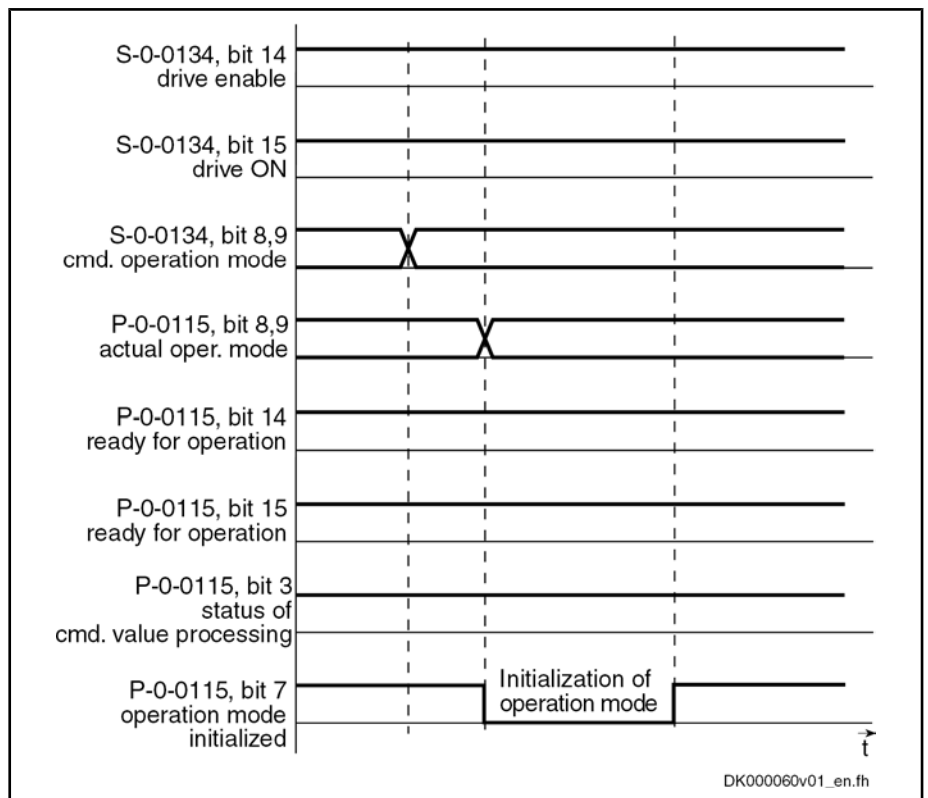


Fig.4-16: Bit Sequence During Change of Operating Modes

## Master Communication

**Commands and Diagnostic Messages for Mode Change and Phase Switch**

**Distinguishing the Commands** According to the desired action, the commands are related to the following groups:

- Commands for changing between parameter mode and operating mode:
  - S-0-0420, C0400 Activate parameterization level 1 procedure command
  - S-0-0422, C0200 Exit parameterization level procedure command
- Commands for transition check to communication phases 3 and 4 (only with SERCOS!):
  - S-0-0127, C0100 Communication phase 3 transition check
  - S-0-0128, C5200 Communication phase 4 transition check



With SERCOS, the command C0200 (S-0-0422) is automatically called during the execution of command C5200 (S-0-0128). This is why a diagnostic command message C02xx can be displayed after the command C5200 has been started.

**Communication Phase 3 Transition Check**

By executing the command "S-0-0127, C0100 Communication phase 3 transition check", a number of checks and parameter conversions are carried out that can possibly cause the listed diagnostic command messages:

- Checking validity of parameters required for switching to phase 3
 

If one of these parameters has never been written or the backup was carried out incorrectly, the error message "C0101" generated. The IDNs of the faulty parameters are listed in parameter "S-0-0021, IDN-list of invalid operation data for CP2". These parameters have to be set valid by writing correct values to them.

  - C0101 Invalid parameters (-> S-0-0021)
- Checking device configuration
  - C0132 Invalid settings for controller cycle times
- Checking telegram configuration, especially in the case of configured telegrams
 

In this case a check is run to find out whether the parameters selected for the configurable data block in the cyclic command value channel (MDT) or actual value channel (AT) may be configured and whether the allowed length of the configurable data blocks is complied with.

  - C0104 Config. IDN for MDT not configurable
  - C0105 Maximum length for MDT exceeded
  - C0106 Config. IDNs for AT not configurable
  - C0107 Maximum length for AT exceeded
  - C0170 Config. IDNs for connection not configurable
  - C0171 Maximum length for connections exceeded
  - C0173 Connections (number) not configurable
  - C0174 Connection configuration not allowed
- If necessary, checking timing parameters for SERCOS communication in phases 3 and 4 for validity and compliance with requirements
  - C0108 Time slot parameter > Sercos cycle time
  - C0109 Telegram offset unsuitable
  - C0110 Length of MDT (S-0-0010) odd

- C0111 ID9 + Record length - 1 > length MDT (S-0-0010)
- C0112 TNcyc (S-0-0001) or TScyc (S-0-0002) error
- C0113 Relation TNcyc (S-0-0001) to TScyc (S-0-0002) error
- C0114 T4 > TScyc (S-0-0002) - T4min (S-0-0005)
- C0115 T2 too small
- C0116 T3 (S-0-0008) within MDT (S-0-0089 + S-0-0010)
- C0139 T2 (S-0-0089)+length MDT (S-0-0010)>TScyc (S-0-0002)
- C0175 Producer cycle time of a connection not correct
- Limit value check of communication parameters and system
  - C0102 Limit error in parameter (-> S-0-0021)
  - C0103 Parameter conversion error (->S-0-0021)
  - C0131 Switching to phase 3 impossible
  - C0172 Delay measurement (S-0-1024) not carried out

**Communication Phase 4 Transition  
Check or Command "Exit Parameterization Level Procedure"**

With the command "S-0-0128, C5200 Communication phase 4 transition check" or "S-0-0422, C0200 Exit parameterization level procedure command" the following checks and initializations are carried out that can possibly cause the listed command errors:

- Checking whether functional package selection was changed
  - C0299 Configuration changed. Restart  
→ Drive has to be rebooted before it is possible to switch to the operating mode (OM)
- Checking validity of parameters required for subsequent initializations
  - C0201 Invalid parameters (->S-0-0423)
  - C0212 Invalid control section data (->S-0-0423)
- Checking device configuration
  - C0223 Invalid settings for controller cycle times
- If necessary, checking parameters for field bus communication for validity and compliance with requirements
  - C0229 Field bus: IDN for cycl. command val. not configurable
  - C0230 Field bus: Max. length for cycl. command val. exceeded
  - C0231 Field bus: IDN for cycl. actual val. not configurable
  - C0232 Field bus: Length for cycl. actual values exceeded
  - C0233 Field bus: Tcyc (P-0-4076) incorrect
  - C0234 Field bus: P-0-4077 missing for cycl. command values
- Checking configuration of multiplex channel
  - C0238 Order of cyclic command value configuration incorrect
  - C0239 IDN for command value data container not allowed
  - C0240 IDN for actual value data container not allowed
- Checking motor and encoder configuration
  - C0210 Feedback 2 required (->S-0-0423)
  - C0219 Max. travel range too large
  - C0270 Error when reading encoder data => motor encoder
  - C0271 Incorrect parameterization of motor encoder (hardware)

## Master Communication

- C0272 Incorr. parameteriz. of motor enc. (mechanical system)
- C0273 Modulo value for motor encoder cannot be displayed
- C0274 Motor encoder unknown
- C0275 Error when reading encoder data => optional encoder
- C0276 Incorrect parameterization of optional enc. (hardware)
- C0277 Incorr. parameteriz. of opt. enc. (mechanical system)
- C0278 Modulo value for optional encoder cannot be displayed
- C0279 Optional encoder unknown
- C0280 Maximum travel range cannot be displayed internally
- C0284 Invalid motor data in encoder memory (->S-0-0423)
- C0285 Type of construction of motor P-0-4014 incorrect
- C0286 Several motor encoders connected
- C0287 Error during initialization of motor data (->S-0-0423)
- C0288 Rotary scaling not allowed
- C0289 Error at init. of synchr. motor with reluctance torque
- C0290 Error when reading encoder data => measuring encoder
- C0291 Incorr. parameterization of measuring enc. (hardware)
- C0292 Measuring encoder unknown
- C0293 Modulo value for measuring encoder cannot be displayed
- C0294 Incorrect measuring encoder configuration
- Checking modulo range
  - C0244 Act. modulo value cycle greater than max. travel range
- Checks during encoder initialization
  - C0220 Error when initializing position of encoder 1
  - C0221 Initialization velocity encoder 1 too high
  - C0224 Error when initializing position of encoder 2
  - C0225 Initialization velocity encoder 2 too high
  - C0227 Error when initializing position of measuring encoder
  - C0228 Initialization velocity measuring encoder too high
- Initializing optional additional functions (digital I/Os)
  - C0243 Brake check function not possible
  - C0250 Probe inputs incorrectly configured
  - C0260 Incremental enc. emulator resol. cannot be displayed
- Initializing integrated safety technology
  - C0254 Configuration error PROFIsafe
  - C0255 Safety command for system init. incorrect
  - C0256 Safety technology configuration error
  - C0257 Error in safety technology encoder initialization
- Limit value check
  - C0202 Parameter limit error (->S-0-0423)
  - C0203 Parameter conversion error (->S-0-0423)
- General system checks

- C0245 Operation mode configuration (->S-0-0423) not allowed
- Initializing fine interpolator
  - C0258 Error in relation TNcyc (S-0-0001) to fine interpol.
- Initializing digital inputs/outputs
  - C0246 Trav. range lim. switch not ass. to dig. input
  - C0247 Dig. output already assigned to other axis
  - C0248 Dig. input assigned differently to axes
  - C0249 Dig. I/Os: Bit number too large
- Checking interface configuration
  - C0242 Multiple configuration of a parameter (->S-0-0423)
- Checking master communication
  - C0251 Error during synchronization to master communication
- Checking whether boot error is present or firmware download has been carried out
  - C0298 Impossible to exit parameterization level
- Checking whether it was possible to switch CCD group without error
  - C0265 Incorrect CCD address configuration
  - C0266 Incorrect CCD phase switch
  - C0267 CCD timeout phase switch

**"Error-Free" Message** When the drive has reached communication phase 4 without error, the display reads "bb". The corresponding diagnostic message is:

- A0013 Ready for power on

## 4.2 Control Options/Additional Functions

### 4.2.1 Configurable Signal Control Word

#### Brief Description

The signal control word allows writing individual control bits, that are available in different parameters, by a freely configurable collective parameter. The configurable signal control word is used to accept a maximum of 16 copies of bits from other drive parameters.



The bits in the signal control word are processed in every interface cycle at the point of time defined in parameter "S-0-0008, Command value valid time (T3)".

#### Examples of Use

This functionality can be used, for example,

- for freely configuring the digital inputs
- for setting-up mode via digital inputs
- for setting bits in drive parameters and for starting commands via the cyclic channel (master communication)



For SERCOS and field bus interface the parameter "S-0-0145, Signal control word" must be accordingly configured in the cyclic data so that the configured control bits are evaluated.

#### Pertinent Parameters

- S-0-0027, Configuration list for signal control word

## Master Communication

- S-0-0145, Signal control word
- S-0-0329, Assign list signal control word
- S-0-0399, IDN-list of configurable data in signal control word

**Notes on Commissioning of the Signal Control Word**

**Selection List** Only parameters which are contained in "S-0-0399, IDN-list of configurable data in signal control word" can be assigned to parameter "S-0-0027, Configuration list for signal control word".

**Configuring the IDNs** In parameter "S-0-0027, Configuration list for signal control word", the IDNs of those parameters are indicated that are to be configured by means of the signal control word (= targets).

The position of an IDN in this list defines which bit is assigned to which IDN (targets) in the signal control word. For example, the 1st list element determines the parameter to which bit 0 of the signal control word is assigned.

**Configuring the Bit Numbers** Which bit of the selected parameters (= targets in parameter S-0-0027) is set (or cleared) by the signal control word, has to be defined in parameter "S-0-0329, Assign list signal control word".



If this list remains empty, bit 0 of the mentioned parameters is automatically influenced. Otherwise the bit that is to be assigned to the target parameter is entered in this list.

---

Bit numbers from "0" (LSB) to "31" (MSB) can be specified.

---



A maximum of 16 bits can be configured. Configuration must always be carried out from the least significant to the most significant bit; in other words, the position of the bit copy in the signal control word results from the continuous configuration in parameter "S-0-0027, Configuration list for signal control word".

---

- Exceptions**
- If the assigned parameter is a command, the bit number in parameter "S-0-0329, Assign list signal control word" is irrelevant.
  - If the parameter assigned is parameter "S-0-0346, Positioning control word", a positive edge in the respective bit of the control word causes toggling of parameter S-0-0346.
- 



When cross communication is used in the "CCD system mode" "S-0-0145, Signal control word" is used to map the control bits which are not contained in "S-0-1134, SERCOS III: Master control word". That is why this parameter, in the CCD system mode, has already been configured by default in the cyclic master data telegram (MDT → S-0-0024)! In addition, other bits have been permanently configured so that in this case the user can only define the bits 12 to 15!

---

**Diagnostic Messages and Error Messages**

When writing in the parameters "S-0-0027, Configuration list for signal control word" and "S-0-0329, Assign list signal control word" the following check is carried out:

- If an IDN specified in parameter S-0-0027 is not contained in parameter "S-0-0399, IDN-list of configurable data in signal control word" the error message "0x7008 Invalid data" is generated.



In this case, only those inputs up to the faulty element are accepted!

## 4.2.2 Configurable Signal Status Word

### Brief Description

The configurable signal status word is used to accept a maximum of 16 copies of bits from other drive parameters. The user can thereby freely configure a bit list with status bits. This allows defining a bit list which contains all important status information of the drive for the control unit.



The bits in the signal status word are configured in every master communication cycle at the point of time defined in parameter "S-0-0007, Feedback acquisition starting time (T4)".

#### Pertinent Parameters

- S-0-0026, Configuration list for signal status word
- S-0-0144, Signal status word
- S-0-0328, Assign list signal status word
- S-0-0398, IDN-list of configurable data in signal status word

### Notes on Commissioning of the Signal Status Word

#### Configuring the IDNs

In parameter "S-0-0026, Configuration list for signal status word", the IDNs of those parameters are indicated that contain the original bits (sources). The parameters which can be entered in the configuration list are listed in parameter "S-0-0398, IDN-list of configurable data in signal status word". The position of an IDN in the list determines the bit in the signal status word to which the IDN applies. For example, the 1st list element determines from which parameter bit 0 of the signal status word is taken.

#### Configuring the Bit Numbers

Which bit of the parameters selected in "S-0-0026, Configuration list for signal status word" is copied to the signal status word has to be determined in "S-0-0328, Assign list signal status word".



If this list remains empty, bit 0 of the mentioned parameters is automatically copied. Otherwise, the bit to be taken from the source parameter is specified in the list.

Bit numbers from "0" (LSB) to "31" (MSB) can be specified.

The signal status word can have the following configuration, for example:

Bit no. in signal status word (S-0-0144)	IDN of original parameter in S-0-0026	Bit no. of original parameter in S-0-0328	Significance
0	S-0-0403	0	position status

Fig. 4-17: Example of Configuration of Signal Status Word



A maximum of 16 bits can be configured. Configuration must always be carried out from the least significant to the most significant bit; in other words, the position of the bit copy in the signal control word results from the continuous configuration in parameter "S-0-0026, Configuration list for signal status word".

## Master Communication



When cross communication is used in the "CCD system mode", the parameter "S-0-0144, Signal status word" is used to map the status bits which are not contained in parameter "S-0-1135, SERCOS III: Drive status". That is why this parameter, in the CCD system mode, has already been configured by default in the cyclic drive telegram (AT → S-0-0016)! In addition, other bits have been permanently configured so that in this case the user can only define the bits 12 to 15!

## Diagnostic Messages and Error Messages

When writing in the parameters "S-0-0328, Assign list signal status word" and "S-0-0026, Configuration list for signal status word" the following check is carried out:

- Check whether the IDN specified in S-0-0026 has variable data length (list parameter) or a so-called online read function. If yes, the service channel error message "0x7008 Invalid data" is generated.

Parameters with online read function generally are parameters with physical units (position, velocities, accelerations and currents), as well as the parameters "S-0-0135, Drive status word" and "S-0-0011, Class 1 diagnostics".



In this case, only those inputs up to the faulty element are accepted!

## 4.3 Multiplex Channel

### 4.3.1 Brief Description

The multiplex channel is an expansion of the limited cyclic data channel. By means of index assignment and switching, cyclic access to list elements is possible for the multiplex channel, too.



To be able to use the "multiplex channel" mechanism it is necessary to use master communication via SERCOS or field bus (e.g. PROFIBUS-DP) and configure the multiplex parameters in the cyclic real-time channel.

- Features**
- 8 multiplex containers with 4 bytes each are available for cyclic command value data (MDT) and cyclic actual value data (AT)
  - Multiplex data to be transmitted is addressed via parameter "S-0-0368, Data container A: addressing" (L-byte for MDT; H-byte for AT)
  - Individual elements from list parameters can be addressed via parameters S-0-0362 and S-0-0366
  - Multiplex data are transmitted in communication cycle

**Possible Applications** By means of the multiplex channel it is possible:

- To increase the number of transmittable bytes in the cyclic real-time channel (command and actual values) by multiplexing data,
- To transmit the multiplex data with a cycle time of " $T_{\text{cyc}} \times \text{number of multiplex data}$ " by incrementing the addressing index (S-0-0368)
- To achieve operating mode dependent configuration of the cyclic data by index switching in case the operating mode is changed.





When IndraMotion MLC is used, the multiplex channel is used for communication between MLC and drive and therefore cannot be freely used any more!

**Pertinent Parameters**

Parameters for command value channel:

- S-0-0362, Data container A: list index command values
- S-0-0368, Data container A: addressing
- S-0-0360, Data container A: command value 1
- S-0-0450, Data container A: command value 2
- to -
- S-0-0456, Data container A: command value 8

Parameters for actual value channel:

- S-0-0366, Data container A: list index feedback values
- S-0-0364, Data container A: feedback value 1
- S-0-0480, Data container A: feedback value 2
- to -
- S-0-0486, Data container A: feedback value 8

Configuration lists of the command value data containers:

- S-0-0370, Data container A: configuration list command value-1
- S-0-0490, Data container A: configuration list command value 2
- to -
- S-0-0496, Data container A: configuration list command value 8

Configuration lists of the actual value data containers:

- S-0-0371, Data container A: configuration list feedback value-1
- S-0-0500, Data container A: configuration list feedback value 2
- to -
- S-0-0506, Data container A: configuration list feedback value 8

**Pertinent Diagnostic Messages**

- C0238 Order of cyclic command value configuration incorrect
- C0151 IDN for command value data container not allowed
- C0152 IDN for actual value data container not allowed
- E4008 Invalid addressing command value data container A
- E4009 Invalid addressing actual value data container A

## 4.3.2 Functional Description

### General Information

**Possible Multiplex Data**

In the multiplex channel it is possible to configure all parameters that can be transmitted in the cyclic real-time channel. The possible multiplex data are contained in the list parameters for the command value and actual value channel:

- S-0-0187, List of configurable data in the AT
- S-0-0188, List of configurable data in the MDT

**Data Containers**

For data exchange between master and drive there is a total of 8 data containers available. For each container the following distinction is made according to its content or direction of data transfer:

- Master → drive: Data Container A: Command Value-x

## Master Communication

- Drive → master: Data Container A: Feedback Value-x



"x" represents a command/actual value from 1 to 8.

**Configuration Lists**

The 8 multiplex channels are configured via 2 configuration lists (command value and actual value) per channel:

- In the "configuration list command value-x" lists (S-0-0370, ...) the IDNs of those parameters are entered the data of which are to be transmitted to the "Data container A: Command value-x"(S-0-0360, ...), depending on the definition in parameter "S-0-0368, Data container A: addressing" (L byte).
- In the "configuration list actual value-x" lists (S-0-0371, ...) the IDNs of those parameters are entered the data of which are to be transmitted to the "Data container A: Actual value-x"(S-0-0364, ...), depending on the definition in parameter "S-0-0368, Data container A: addressing" (H byte).



It is possible to define a maximum of 32 parameter IDNs in the configuration lists; but these lists can only be changed in communication phase 2 (parameter mode).

**Addressing the Data Containers****Addressing the Parameters to be Transmitted**

The parameter "S-0-0368, Data container A: addressing" contains the indices for selecting the parameters from the configuration lists the values of which are to be transmitted to the data containers (command values and actual values).

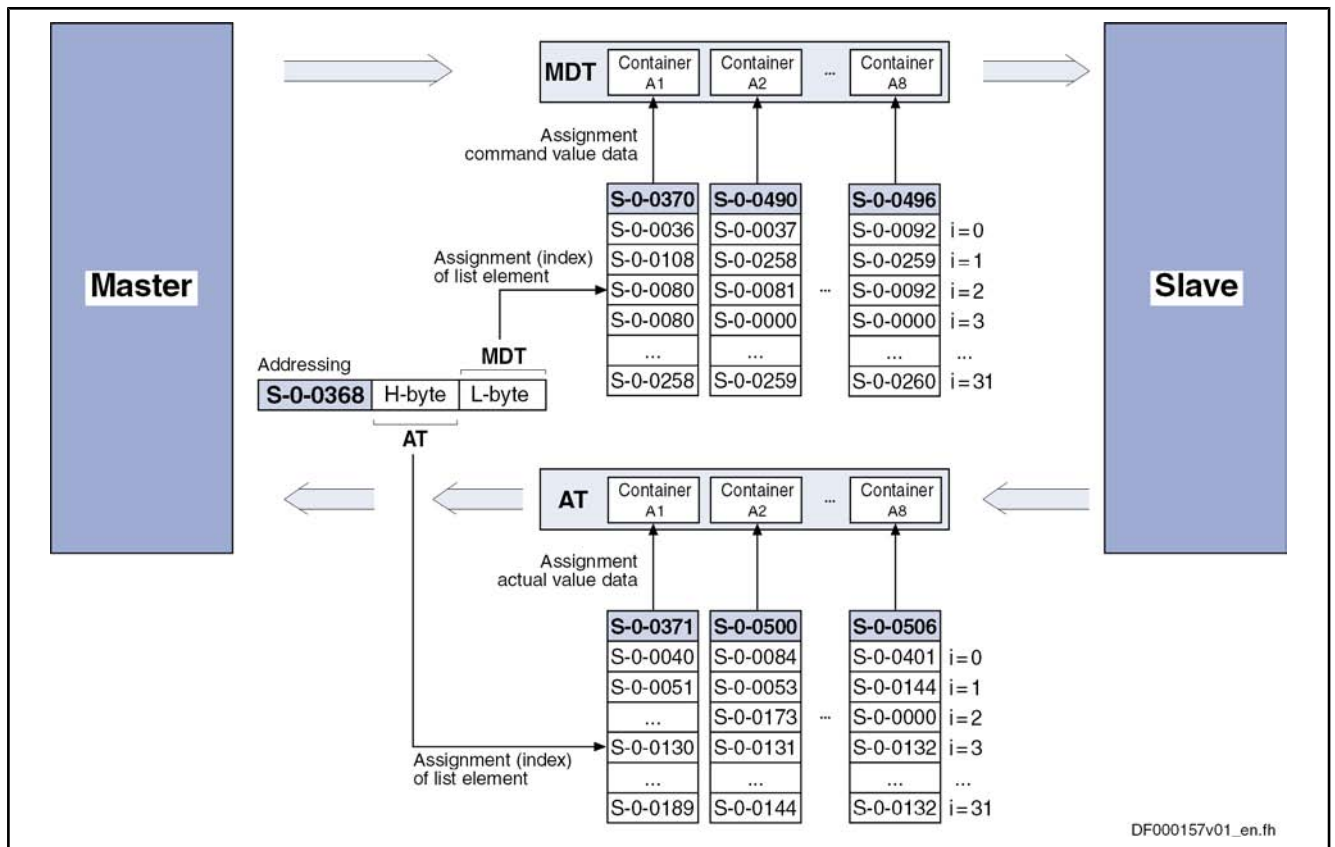
The following assignment applies to S-0-0368:

- Bit 0...4 → addressing for all data containers configured in the cyclic command value telegram (MDT)
- Bit 8...12 → addressing for all data containers configured in the cyclic actual value telegram (AT)



Only bits 0...4 (for MDT) and bits 8...12 (for AT) are used for addressing via parameter S-0-0368. The other bits are ignored. This is why no value greater 31 can be set for addressing!

The figure below illustrates the relationship between addressing and assignment of parameter values to the data containers of the multiplex channel.



i index (= list element no.)  
 S-0-0368 Data Container A: Addressing  
 S-0-0370 Data Container A: configuration list command value -1  
 S-0-0490 Data Container A: configuration list command value -2  
 S-0-0496 Data Container A: configuration list command value -8  
 S-0-0371 Data Container A: configuration list feedback value -1  
 S-0-0500 Data Container A: configuration list feedback value -2  
 S-0-0506 Data Container A: configuration list feedback value -8  
 Fig.4-18: Addressing and Assignment for Multiplex Channel



The parameter "S-0-0368, Data container A: addressing" can, depending on the requirements, be configured in the cyclic command value telegram or write accessed via the non-cyclical data channel or some other interface.

### Assigning Single List Elements

The value (data) transmitted in the data container is written to the determined target parameter; in this case we distinguish between single and list parameters.

In order to allow cyclic transmission or change of single elements in the case of list parameters, there are two more addressing parameters available:

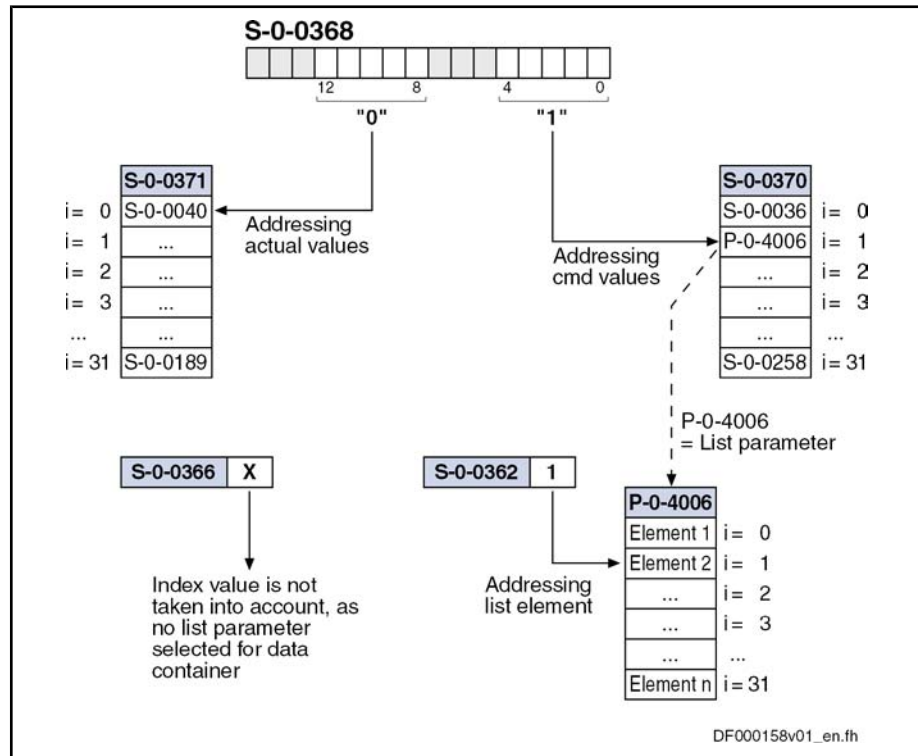
- S-0-0362, Data container A: list index command values  
 → Addressing elements of list parameters that have been entered as target for the content of command value data containers (for **write access**)
- S-0-0366 Data container A: List index feedback values  
 → Addressing elements of list parameters that have been entered as source for the content of actual value data containers (for **read access**)

Master Communication



The parameters S-0-0362 and S-0-0366 only take effect when a list parameter is addressed as target/source for the content of the data container.

The figure below illustrates the access to an element of a list parameter for the multiplex channel.



i index (= list element no.)  
 S-0-0368 Data Container A: Addressing  
 S-0-0362 Data Container A: list index command values  
 S-0-0366 Data Container A: List index feedback values  
 S-0-0370 Data Container A: configuration list command value -1  
 S-0-0371 Data Container A: configuration list feedback value -1  
 P-0-4006 Positioning block target position  
 Fig.4-19: Access to Elements of a List Parameter via Multiplex Channel (Example of Command Values → MDT Data Container)

### 4.3.3 Notes on Commissioning

**Activation** To use the function of the multiplex channel it is not necessary to take any measures for activation.

**Data Container A: Command Value-x** For determining the target parameter to which the content (data) of "Data container A: command value-x" (S-0-0360, ...) is to be written we distinguish between single and list parameter:

- **Single parameters**  
 → The target parameter is determined by means of addressing (S-0-0368) in the respective configuration list (S-0-0370, S-0-0490 to S-0-0496).
- **List parameters**  
 → The element of the target parameter is determined by means of addressing (S-0-0368) in the respective configuration list (S-0-0370, S-0-0490 to S-0-0496) and the parameter "S-0-0362, Data container A: list index command values":



The display format is hexadecimal without decimal places.

If the configuration list contains 16-bit parameters, only the lower 16 bits from the data container are used when a 16-bit parameter is addressed.

#### Data Container A: Feedback Value-x

For determining the source parameter to which the content (data) of "Data container A: Feedback value-x" (S-0-0364, ...) is to be written we also distinguish between single and list parameter:

- **Single parameters**

→ The source parameter is determined by means of addressing (S-0-0368) in the respective configuration list (S-0-0371, S-0-0500 to S-0-0506).

- **List parameters**

→ The element of the source parameter is determined by means of addressing (S-0-0368) in the respective configuration list (S-0-0371, S-0-0500 to S-0-0506) and the parameter "S-0-0366, Data container A: list index feedback values":



The display format is hexadecimal without decimal places.

If the configuration list contains 16-bit parameters, only the lower 16 bits are copied to the data container when a 16-bit parameter is addressed (the H-byte does not contain any useful data).

## 4.3.4 Diagnostic and Status Messages

In conjunction with the multiplex channel, various checks are carried out.

#### Checking the Configured IDN Order

The chronology of the processing of cyclic command value data in the drive has the order in which the parameter IDNs of the configured list have been entered in parameter "S-0-0024, Configuration list of MDT".

If the parameters "data container A, command value-x" (S-0-0360, S-0-0450 to S-0-0456) and the parameter "S-0-0368, Data container A: addressing" were configured in the cyclic command value telegram, the MDT data container is only processed correctly when the addressing had been processed before.

To make sure the correct order is followed when configuring the cyclic command values, the drive during the execution of "S-0-0127, C0100 Communication phase 3 transition check", checks whether IDN S-0-0368 was configured before the IDNs S-0-0360 or S-0-0450 to S-0-0456. If this was not the case, the drive generates the error message "C0118 Order of cyclic command value configuration incorrect"

#### Checking the Configuration Lists

You have to make sure that the IDN contained in the configuration lists are existing and the corresponding parameters can be cyclically configured.

This is why a check is run at the execution of "S-0-0127, C0100 Communication phase 3 transition check" in order to find out whether the entered IDNs are contained in the lists "S-0-0187, List of configurable data in the AT" or "S-0-0188, List of configurable data in the MDT".

There are the following possible error messages:

- If a **command value configuration list** contains one or several IDNs that are not existing or not contained in "S-0-0188, List of configurable data in the MDT", the following error message is generated:
  - C0151 IDN for command value data container not allowed

Master Communication

- If a **actual value configuration list** contains one or several IDNs that are not existing or not contained in "S-0-0187, List of configurable data in the AT", the following error message is generated:
  - C0152 IDN for actual value data container not allowed

Checking the Index

During the runtime, the drive monitors whether the index in parameter "S-0-0368, Data container A: addressing" points to a non-initialized point in the MDT data containers or AT data containers.

According to the case that occurred, one of the following warning messages is generated:

- E4008 Invalid addressing command value data container A
- E4009 Invalid addressing actual value data container A



These warning messages can only occur if less IDNs than possible at maximum are entered in the configuration lists.

## 4.4 Operating Modes of Master Communication

### 4.4.1 Introduction and Overview

#### Overview of Operating Modes and Possibilities of Command Triggering

Command triggering for the drive can take place by an external control master (remote mode) or internally via IndraMotion MLD or the inputs/outputs which are available (local mode).

The figure below contains an overview of the possibilities of drive command triggering.

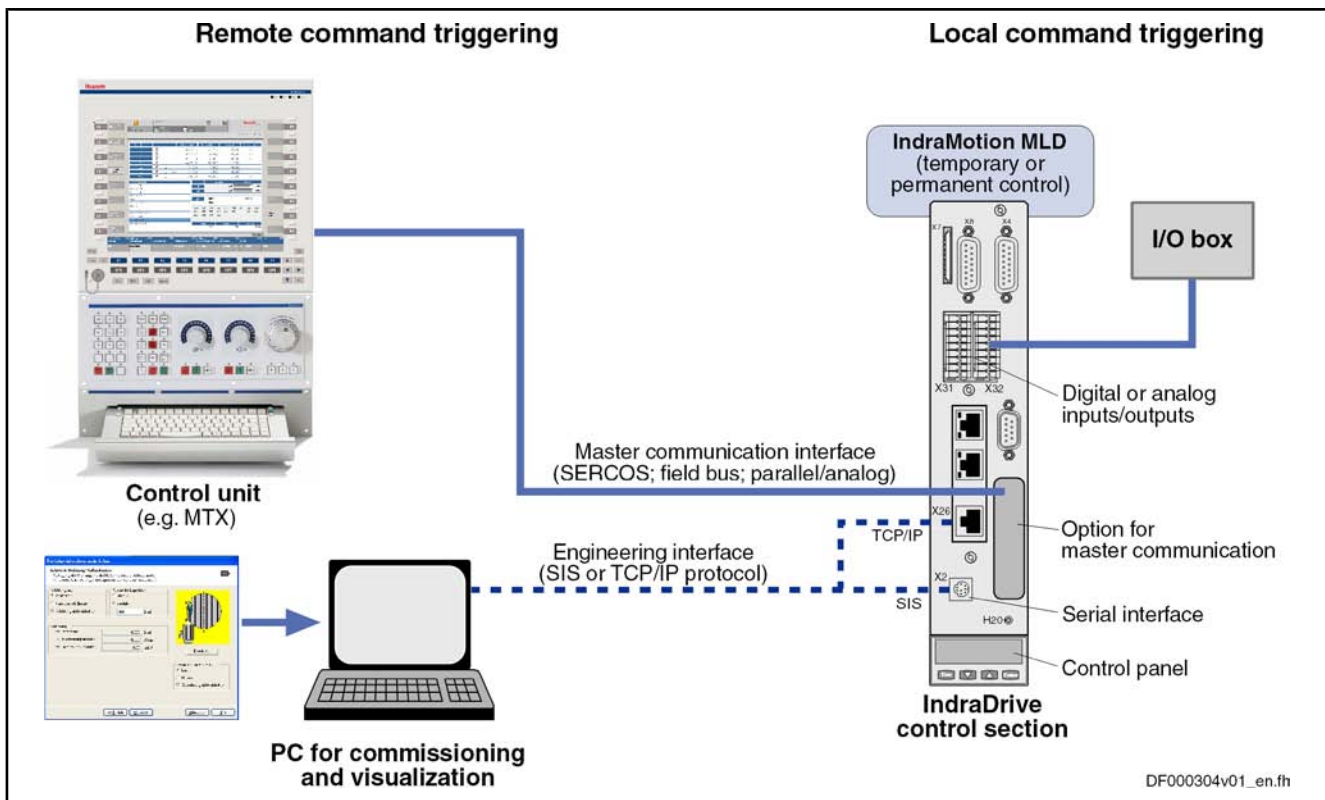


Fig. 4-20: Overview of Possibilities of Command Triggering for an IndraDrive Device

**Operating Modes and Changes of States**

The overview below shows the basically possible operating states and the actions required for change/transition from one operating mode to the other.

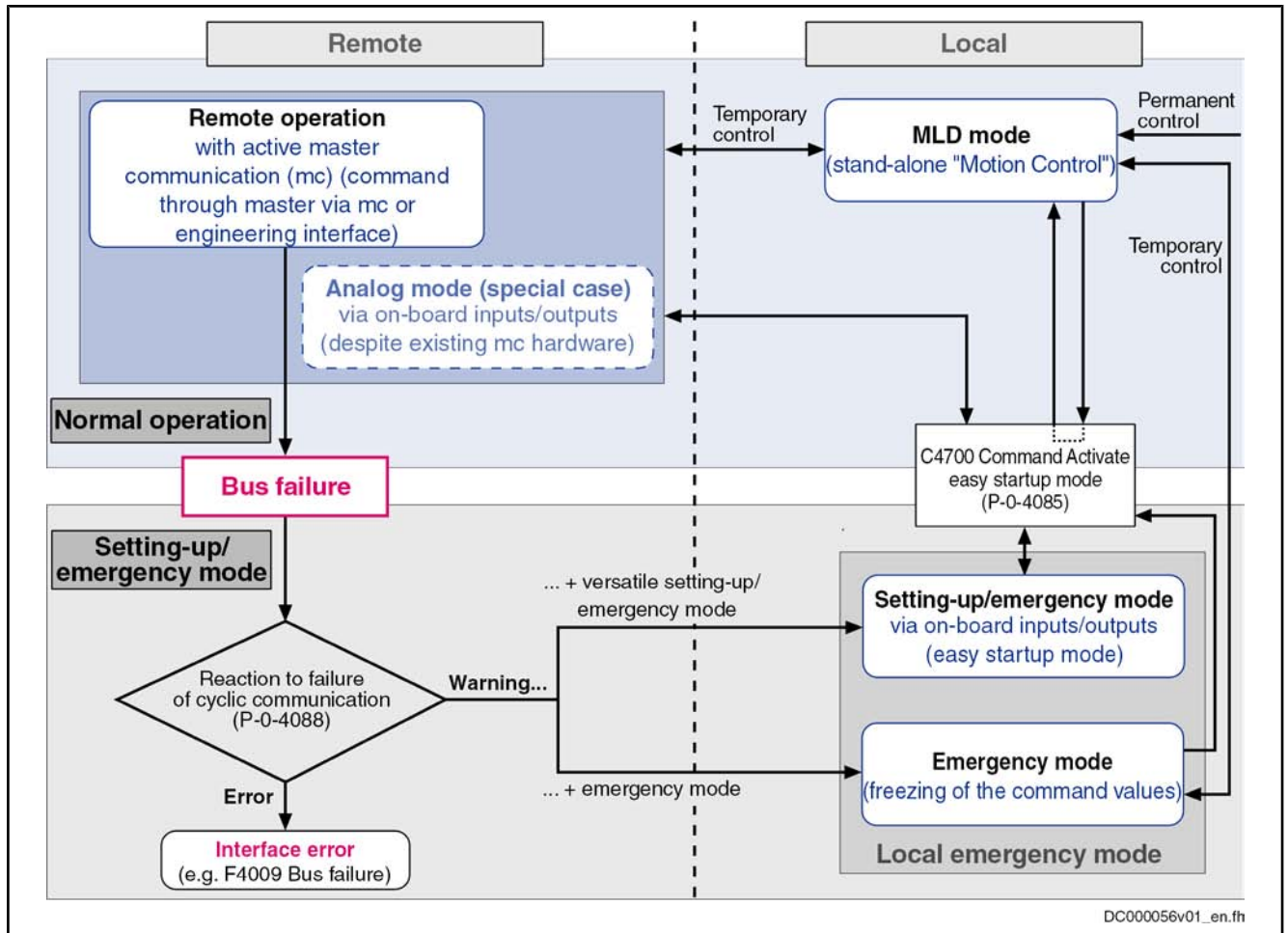


Fig.4-21: Operating States and Operating Modes of Master Communication

**Device Control and State Machine**

According to the kind of master communication or setting of the device control, different control words take effect. Internally, however, all relevant control bits are always displayed in parameter "P-0-0116, Device control: control word".



The actual state machines of master communication are described in section "Device Control and State Machines" !

**Normal Operation (via Internal or External Control Unit)**

In the so-called normal operation, the command triggering for the drive takes place via an internal (IndraMotion MLD) or external control unit (e.g. IndraMotion MTX or MLC); we distinguish the following cases:

- **Remote mode** with active master communication (standard case)
  - Command triggering for the axis takes place via the master communication (SERCOS, field bus, analog/parallel).

**Special cases** (respective configuration via parameter P-0-4088):

- **Analog mode** for SERCOS or field bus devices (master communication has been deactivated and a device with SERCOS or field bus interface is permanently operated via the digital/analog inputs/outputs)
- **EtherNet/IP™ communication** via the engineering interface

## Master Communication

- **MLD mode** (stand-alone "Motion Control")
  - The PLC integrated in the drive (IndraMotion MLD) takes over command triggering of the axis or, in conjunction with cross communication (CCD), of an entire axis group.
  - Configuration via parameter P-0-1367 (see also "Stand-Alone Motion Control" in the separate documentation "IndraMotion MLD, Application Manual")

**Local Setting-Up Mode/Emergency Mode ("Easy Startup Mode")**

During operation, the drive can, **due to the situation**, change to a local mode for setting-up or to remedy an emergency (e.g. bus failure). We distinguish the following operating modes:

- **Setting-up mode** (easy startup mode)
  - For commissioning or the setting-up procedure, the drive can temporarily be moved via the inputs/outputs (digital and analog), independently of the external master (e.g. field bus interfaced PLC or NC) or the the internal control (IndraMotion MLD).
- **Emergency mode** in the case of bus failure (freezing the last command values)
  - Even if the master communication fails, it is possible to continue operating the drive in an emergency mode via the (local) inputs/outputs at the device.



Using the emergency mode requires the corresponding configuration in the parameter "P-0-4088, Master communication: Drive configuration"; the automatic activation of the easy startup mode can be set in this parameter, if necessary.

---

**4.4.2 Normal Mode (Remote or Local)****Remote Mode With External Control Unit and Active Master Communication**

In the standard case, the command triggering for the axis takes place externally via the master communication (remote). In this case, command values and actual values are exchanged with the external control unit via the master communication interface (incl. control word and status word).

See description of the respective master communication:

- SERCOS interface
- SERCOS III
- PROFIBUS-DP
- EtherNet/IP™ interface
- CANopen interface
- DeviceNet™ interface
- Parallel interface
- Analog interface

When using field bus interfaces, also take the profile types for this kind of master communication into account (see "Profile Types (With Field Bus Interfaces)").



EtherNet/IP™ and the analog operation with optional module available for these master communications require specific configuration and handling (see "Notes on Commissioning and Utilization: Special Cases of Operation With External Control Unit").

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## MLD Mode With Permanent Control (Stand-Alone Motion Control)



Using IndraMotion MLD requires the functional firmware package "ML" or "MA" and the corresponding MLD software!

With small, stand-alone subsystems, command triggering often takes place directly in the drive with an integrated PLC (IndraMotion MLD). In this case, IndraMotion MLD can independently communicate with external devices via all interfaces available in the drive (master communication, digital/analog inputs/outputs, serial interface, ...).

Observe the following aspects for **commissioning and utilization**:

- You have to configure the MLD mode with permanent control in parameter "P-0-1367, PLC configuration".
- The configuration can only be changed in the parameter mode (PM) and only takes effect after repeated run-up to the operating mode (OM).
- Command value input by an external control unit is interrupted and has to be freely programmed with IndraMotion MLD.

### 4.4.3 Setting-Up Mode (Easy Startup Mode)

#### Brief Description of Easy Startup Mode

The setting-up mode as so-called "easy startup mode" allows moving the drive without connected or active control unit (or master communication master) or external command value box. When using a Rexroth motor with encoder data memory, this is also possible without using a commissioning PC, because all motor and controller parameters are stored in the encoder data memory.

#### Fields of Application

The easy startup mode is particularly suited for

- **initial commissioning** of individual axes without active master communication
- maintaining a configurable **emergency mode** (local mode) when the internal or external control unit (or master communication) has failed

See also section "Introduction and Overview: Local Setting-Up Mode/Emergency Mode (Easy Startup Mode)"

#### Features

The easy startup mode has the following features:

- **Activation/deactivation** of the easy startup mode:
  - By writing parameter "P-0-4085, Command Activate easy startup mode"
  - Via control panel of controller (incl. switch-off)
- **Command triggering** (axis control) via digital inputs/outputs by
  - Predefined digital I/O configuration in operation mode "**velocity control**" with a velocity command value (default) that can be parameterized
  - Freely configurable I/O configuration and operation mode with active easy startup mode
  - Selection of **travel direction** (positive/negative) via digital input signals
  - Activation of and changes in the fixed velocity command values via standard control panel
- **Switching off command triggering** by master communication interface (see "P-0-4077, Interface status", "S-0-0134, Interface status") and possibly available drive-integrated PLC (IndraMotion MLD)

## Master Communication

- Pertinent Parameters**
- S-0-0014, Interface status
  - P-0-0120, Control word easy startup
  - P-0-0300, Digital I/Os, assignment list
  - P-0-0301, Digital I/Os, bit numbers
  - P-0-0302, Digital I/Os, direction
  - P-0-1200, Control word 1 velocity control
  - P-0-1206, Memory of velocity command values
  - P-0-4085, Command Activate easy startup mode
  - P-0-4086, Master communication status
  - P-0-4088, Master communication: Drive configuration

- Pertinent Diagnostic Messages** When the easy startup mode is used, simple diagnostic texts appear on the display of the control panel in "light writing":
- When the easy startup mode has been activated, the display changes between the drive address and the message "CM" (Commissioning Mode).
  - During commissioning, the relevant messages appear on the display (see fig. "Activating the Easy Startup Mode Via the Control Panel").

## Functional Description of Easy Startup Mode

In the setting-up mode (easy startup mode), the drive can be controlled either via the digital and analog inputs or via the commissioning interface (serial or Ethernet).

- Control via Digital or Analog Inputs** If the drive is to be controlled via the digital or analog inputs, the inputs must have been configured accordingly. The form and point of time of the configuration is set in parameter "P-0-4088, Master communication: Drive configuration":

- Automatically by activating the easy startup mode
- or -
- Manually before or after the easy startup mode has been activated

- Automatic Configuration of the Inputs** For automatic configuration of the inputs, the following actions are performed:

- Deactivation of master communication interface and activation of drive enable in parameter "P-0-0120, Control word easy startup"
- Setting of operation mode "velocity control" with values from memory of fixed command values (P-0-1206)
- Assignment of the command velocity selected via the control panel (in percent) of "S-0-0091, Bipolar velocity limit value" to element 1 or 2 of parameter "P-0-1206, Memory of velocity command values" (with positive sign to element 1, with negative sign to element 2).
- Assignment of allocation of inputs



The actual configuration of the inputs/outputs depends on the available digital inputs of the control section (see tables below).



The automatic configuration of the inputs/outputs for the easy start-up mode takes place **in volatile form**, i.e. any I/O configuration existing before is reestablished when the command is completed. This is not the case, if the I/O configuration was specifically (manually) changed with the command being active.

IndraDrive single-axis control sections (CSB, CSH)			
Connection	Signal	Function	I/O assignment
X31.3	I_1	Motor potentiometer, ramp +	P-0-1200, Control word 1 velocity control (bit 8)
X31.4	I_2	Drive enable	P-0-0120, Control word easy startup (bit 15)
X31.7	I_5	Motor potentiometer, ramp –	P-0-1200, Control word 1 velocity control (bit 9)
X32.7	I/O_9	Selection of memory of fixed command values	P-0-1200, Control word 1 velocity control (bit 0)
X32.8	I/O_10	Selection of memory of fixed command values	P-0-1200, Control word 1 velocity control (bit 1)

Fig.4-22: Automatic I/O Configuration for Easy Startup Mode With Single-Axis Control Sections

IndraDrive double-axis control sections (CDB)				
Connection	Signal	Axis	Function	I/O assignment
X33.4	I_15	1	Motor potentiometer, ramp +	P-0-1200, Control word 1 velocity control (bit 8)
X33.1	I_12	1	Drive enable	P-0-0120, Control word easy startup (bit 15)
X33.5	I_16	1	Motor potentiometer, ramp –	P-0-1200, Control word 1 velocity control (bit 9)
X33.2	I_13	1	Selection of memory of fixed command values	P-0-1200, Control word 1 velocity control (bit 0)
X33.3	I_14	1	Selection of memory of fixed command values	P-0-1200, Control word 1 velocity control (bit 1)
X34.4	I_21	2	Motor potentiometer, ramp +	P-0-1200, Control word 1 velocity control (bit 8)
X34.1	I_18	2	Drive enable	P-0-0120, Control word easy startup (bit 15)
X34.5	I_22	2	Motor potentiometer, ramp –	P-0-1200, Control word 1 velocity control (bit 9)
X34.2	I_19	2	Selection of memory of fixed command values	P-0-1200, Control word 1 velocity control (bit 0)
X34.3	I_20	2	Selection of memory of fixed command values	P-0-1200, Control word 1 velocity control (bit 1)

Fig.4-23: Automatic I/O Configuration for Easy Startup Mode With Double-Axis Control Sections

IndraDrive Mi (KSM)			
Connection	Signal	Function	I/O assignment
X37.2	I/O_3	Drive enable	P-0-0120, Control word easy startup (bit 15)
X37.4	I/O_1	Selection of memory of fixed command values	P-0-1200, Control word 1 velocity control (bit 0)
X38.4	I/O_2	Selection of memory of fixed command values	P-0-1200, Control word 1 velocity control (bit 1)

Fig.4-24: Automatic I/O Configuration for Easy Startup Mode With IndraDrive Mi



IndraDrive Mi (distributed servo drive "KSM") only has a limited number of digital inputs/outputs (4 inputs/outputs), it has no analog input and no control panel!

## Master Communication



See also "Optional Modules for Control Sections" in the separate documentation "Control Sections for Drive Controllers; Project Planning Manual"

### Manual Configuration of the Inputs

**Necessary** manual configuration of the digital/analog inputs (see also "Digital Inputs/Outputs" or "Analog Inputs"):

- Connect 24V/0V power supply to respective terminal connectors
- +24 V for activation of drive enable (P-0-0120, bit 15)

**Alternatively**, you can additionally set the following manual configurations:

- Input of analog speed command value (P-0-1460), if command value input is to take place via analog value
- Setting of source for velocity command values in parameter "P-0-1200, Control word 1 velocity control":
  - Selection of memory of fixed command values, if command value input is to take place via predefined fixed values
  - or -
  - Setting that command value input is to take place via motor potentiometer function

### Operating the Drive via Serial Interface or Ethernet

The drive can also be controlled via the commissioning interface (serial or Ethernet) via which it is possible to write the control word and the command values.

Take the following aspects into account:

- The digital inputs must not have been assigned to the parameter "P-0-1200, Control word 1 velocity control".
- Parameter "P-0-1460, PLC/setting-up mode, velocity command value" must not have been assigned to any analog input
- Drive enable mustn't have been assigned to any digital input (P-0-0120).



**CAUTION**

### Property damage caused by errors when controlling motors and moving parts!

⇒ It is necessary to wire the E-Stop input at the drive so that the drive can be shut down when the commissioning interface fails.

## Notes on Commissioning for Easy Startup Mode

### Requirements

The following requirements and conditions must have been fulfilled for using the easy startup mode:

- For Rexroth motors with encoder data memory there is no commissioning PC required; for motors without encoder data memory, the motor parameters have to be manually written during commissioning.
- Master communication or IndraMotion MLD should not be active, as the easy startup mode switches off any possibly active command triggering via master communication or IndraMotion MLD!
- There mustn't be any error message present in the drive, not even a transition command error (C01xx, C02xx).
- The drive must be ready for operation (bb).
  - In the case of conventional field bus interfaces (e.g. CANopen, PROFIBUS® or DeviceNet™), the drive is automatically ready for operation (bb) after run-up, even if master communication is not active. In this way, the requirements for manual mode basically are always fulfilled!

- With SERCOS interface, Ethernet interface, ..., the drive after run-up is **not ready for operation** if master communication is not active (e.g. communication phase "P-1" with SERCOS).

**Possibilities of Activation**

The easy startup mode is activated by starting "P-0-4085, Command Activate easy startup mode" in one of the following ways:

- Activate the corresponding menu item on **standard control panel**
- **Set a digital input** on which the command parameter P-0-4085 has been configured
- **Write the parameter P-0-4085** via master communication, via serial interface or via EtherNet/IP™ (if available)
- **Automatically by internal command start** in the case of bus failure, if configured accordingly (see P-0-4088)



If the drive already is in the easy startup mode and this mode is activated again, the display reads "easymode active"!

---

**Activation via Control Panel**

The command P-0-4085 can be activated and deactivated via the standard control panel of the IndraDrive controllers.

The figure below shows the sequence for activating the easy startup mode via the control panel:

Master Communication

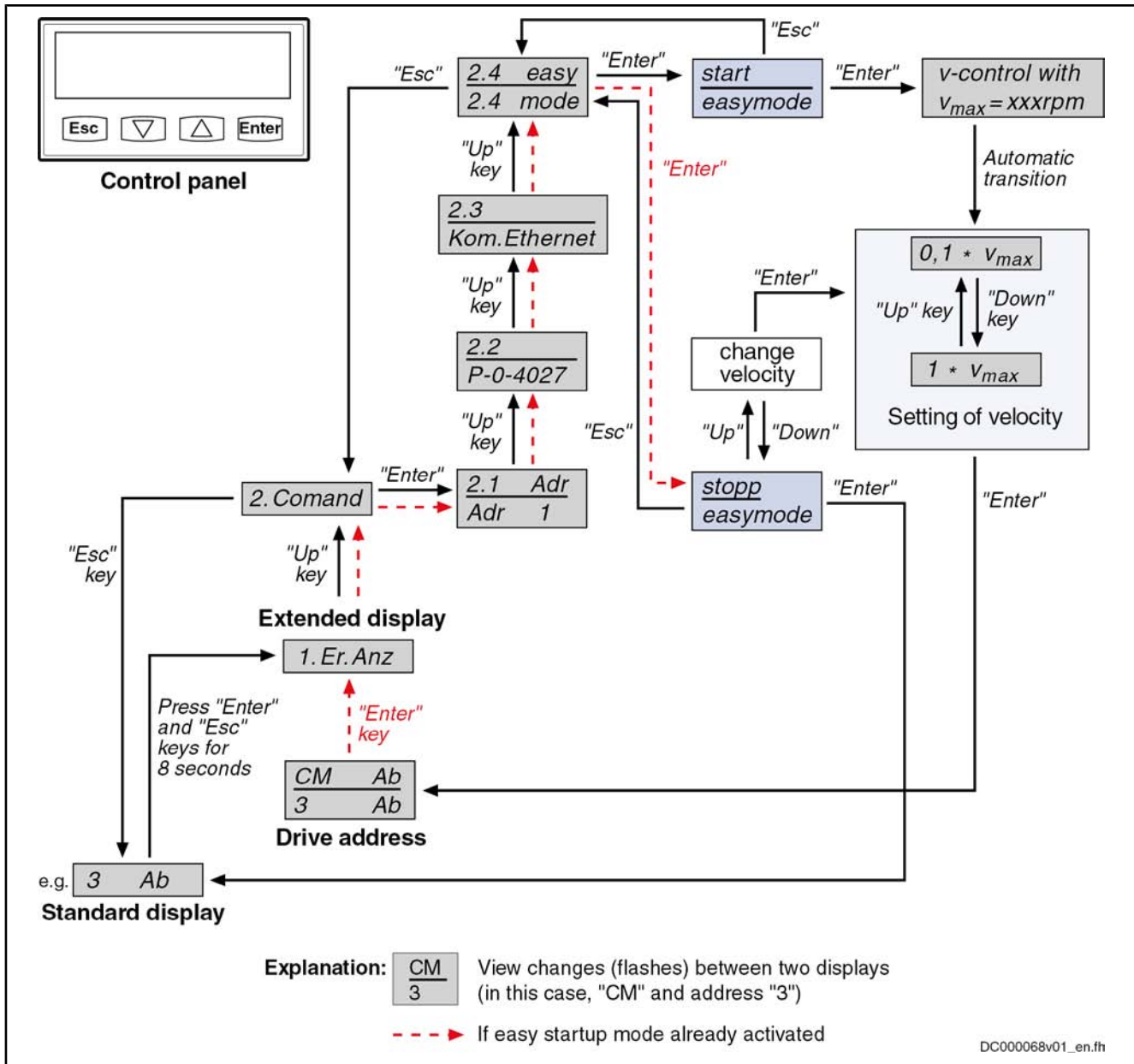


Fig.4-25: Activating the Easy Startup Mode Via the Control Panel

See also "Control Panels of the IndraDrive Controllers"

**Activation via Digital Input**

To activate the easy startup mode via a digital input, bit 0 of parameter P-0-4085 has to be assigned to a digital input.

See "Digital Inputs/Outputs"

**Activation via Serial Interface**

To activate the easy startup mode via the serial interface, parameter P-0-4085 has to be written via SIS telegrams.

See "Serial Communication"



Parameter P-0-4085 can also be directly written via the master communication (e.g. SERCOS or field bus), but in this way the master would deactivate itself!

**Acknowledgment of Activation**

The activation of the easy startup mode is acknowledged by:

- Setting bit 8 in parameter "P-0-4086, Master communication status"
- Changing the display on the control panel between "CM" (Commissioning Mode) and the drive address
- Clearing the bit "drive follows (ext.) command value input" in parameter P-0-0115 (bit 3)



With active easy startup mode, the active operating mode is not acknowledged in the status word (see P-0-0115)!

---

#### Deactivating/Exiting the Easy Start-up Mode

The easy startup mode is switched off by deactivating the command execution. The command can be deactivated by writing parameter P-0-4085 or by confirming the corresponding menu item with the standard control panel.

---



After you have exited the easy startup mode, the previously active status becomes active again. The command triggering of the drive again takes place via the master communication (see P-0-4077, S-0-0134, ...) or IndraMotion MLD and the originally active operation modes are carried out.

---

#### Control Parameter P-0-0120

The control parameter "P-0-0120, Control word easy startup" active in the easy startup mode can be changed or influenced in the following ways:

- Via digital inputs, if they were accordingly configured before
- Via the serial interface by direct writing of parameter P-0-0120  
→ In this case, the parameter has to be actively written at least every 2 s, otherwise the drive will automatically clear drive enable!

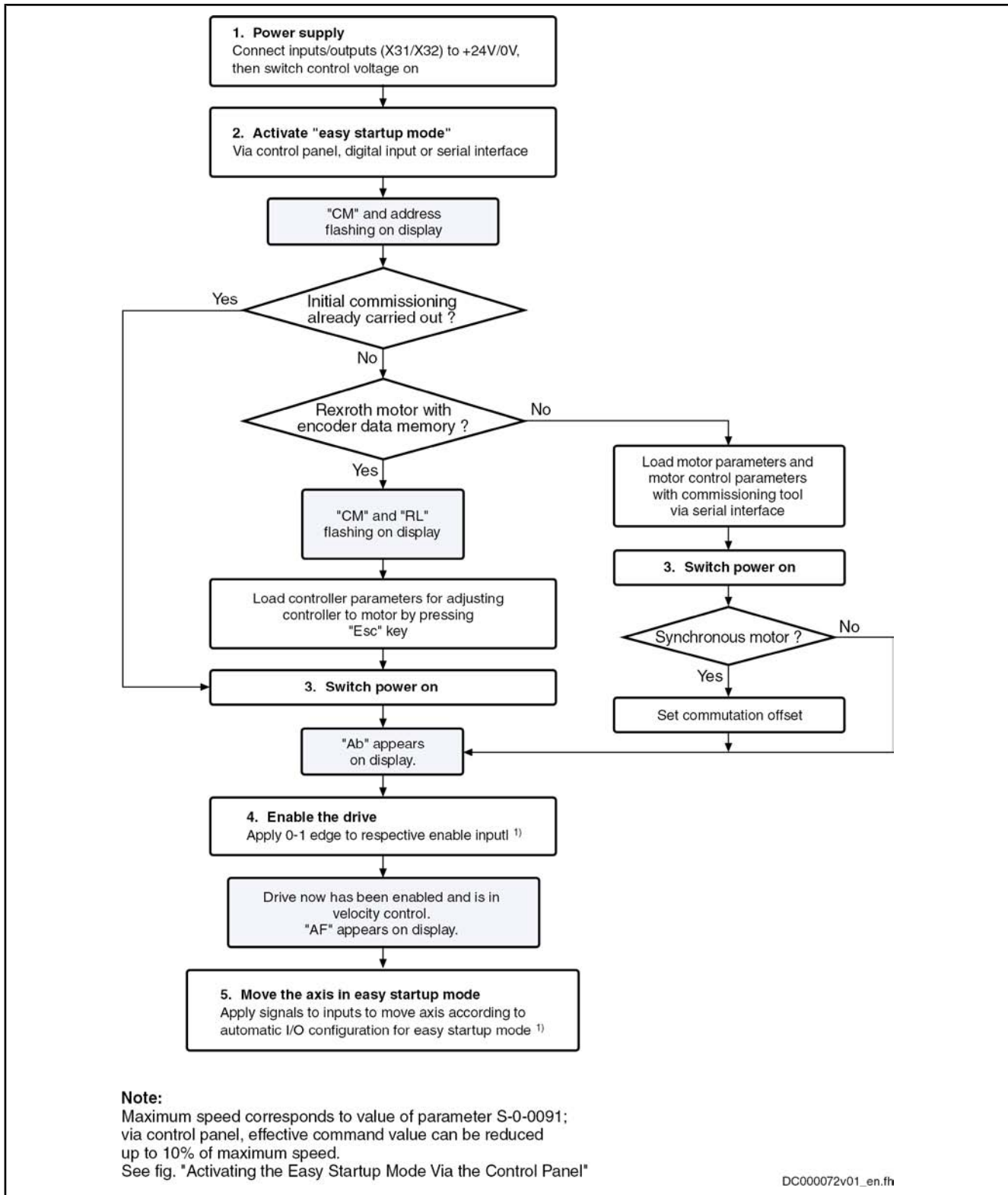
#### Invalid Commands

The commands for backup of working memory ("C2200 Backup working memory procedure command" and "C2400 Selectively backup working memory procedure command") should not be triggered in the easy startup mode, because otherwise the settings of the easy startup mode will be stored in the non-volatile memory and will be active again after the drive is switched on the next time!

#### Commissioning With Easy Startup Mode

The figure below summarizes the commissioning sequence with the easy start-up mode:

Master Communication



1) See assignment tables for the different hardware designs under "Automatic Configuration of the Inputs"

Fig.4-26: Commissioning Sequence With the Easy Startup Mode

For "load defaults procedure" see "Default Settings in the Motor Encoder Data Memory" in "Overview of Drive Control".



**Special Case: Initial Commissioning of Motors Without Encoder Data Memory**

Initial commissioning of Rexroth motors without encoder data memory or of third-party motors is only possible in the manual mode in conjunction with the commissioning tool "IndraWorks Ds/D/MLD", in order to load or enter the values for motor control parameters and motor encoder parameters. For synchronous motors with absolute measuring system, the commutation offset only has to be determined at initial commissioning. For synchronous motors with relative measuring system, the commutation offset is automatically determined every time drive enable is set for the first time after transition "PM → OM".

If for synchronous motors the commutation offset can only be determined by supplying current, this is only possible in the operating status "Ab" with active easy startup mode!

See "Commissioning Motors: Initial Start With the Commissioning Tool"

**CAUTION****Danger of property damage during initial start in the easy startup mode caused by incorrect parameter values!**

⇒ For motors without encoder data memory, the required motor and controller parameters have to be checked before initial start in the easy startup mode!

**Recommissioning**

In the easy startup mode, recommissioning (after initial commissioning having been carried out) of drives is possible without any problem, because the correct values of motor control parameters and motor encoder parameters are already available in the drive.

Only the commutation setting of synchronous motors with relative measuring system is automatically determined again every time drive enable is set for the first time after transition "PM → OM"!

## 4.4.4 Local Mode

### Overview

During operation and in a setting-up or emergency mode, it is possible, **depending on the situation**, to change to **digital and analog inputs/outputs of the controller or to the control panel**:

- **MLD mode** with temporary control by IndraMotion MLD (intelligent servo axis) to carry out, for example, an intelligent error reaction.
- **Emergency run (local mode)** for bus failure → With the corresponding configuration, you can continue using the drive in an emergency mode, even if master communication (field bus, SERCOS, ...) has failed.

### MLD Mode With Temporary Control (Intelligent Servo Axis)

Starting from any status (except for setting-up mode), you can get temporary control (see parameter "P-0-1367, PLC configuration" and function block "MX\_SetControl") over the axis with IndraMotion MLD and thereby interrupt the command value input of an external control unit. As IndraMotion MLD can be freely programmed, this provides high flexibility for drive control which can be used, for example, for realizing an intelligent error reaction.



Using the MLD mode with temporary control requires the functional firmware package "ML" and the corresponding MLD software!

### Emergency Mode (When Master Communication has Failed)

**Behavior in the Case of Bus Failure**

For bus failure (line interruption), bus stop or PLC stop, the reaction of the drive can be set in the parameter "P-0-4088, Master communication: Drive configuration":

- **Bus failure as error**

Master Communication

→ The drive normally switches off, generates the message of an interface error (e.g. "F4009") and carries out the defined **error reaction** (best possible deceleration).

- **Bus failure as warning**

→ In the case of bus failure, the drive does **not** react by switching off and generating an error message, but the status of the last command triggering is maintained (command value and control word are "frozen") or the easy startup mode is automatically activated and the warning "E4005 No command value input via master communication" is output.

See also section "Setting-Up Mode (Easy Startup Mode)"



See also Parameter Description "P-0-4088, Master communication: Drive configuration"



**Property damage caused by errors when controlling motors and moving parts!**

⇒ If bus failure has been configured as a warning, the E-Stop input should be wired at the drive. It is no longer possible to switch the drive off via the master communication.

**Status Display** The parameter "S-0-0014, Interface status" displays the current status of the master communication interface.

## 4.4.5 Notes on Commissioning and Utilization

### Using the Operating Modes

The table below summarizes the different operating modes of master communication, their operation criteria and activation.

Place of command triggering	Mode	Usage	Execution of command triggering	Activation	Operation modes	Notes
Control unit (remote)	<b>Master comm. mode (remote)</b>	Field bus or SERCOS device is operated as usual via existing interface of master communication	Via external control unit (bus or inputs/outputs)	Not required	Standard operation modes 0...7 take effect and can be selected	Standard case
	<b>Special case: analog mode</b>	Field bus device can be permanently operated as analog drive, if master comm. option deactivated (for mounting spare parts or emergency mode without master)	Only via digital onboard inputs/outputs and analog inputs	Configuration of parameter P-0-4088 <b>Note:</b> Activation requires complete booting process	Standard operation modes 0...7 take effect and can be defined according to application, if required	Special case in which master comm. option existing, but not active
Control unit (internal)	<b>MLD mode (permanent control)</b>	For motion solutions with permanent control by MLD over the axis/axes	Internal via MLD with motion function blocks	Configuration of parameter P-0-1367	Standard operation modes are 0...6 automatically configured, operation mode 7 can be freely defined	No access by master communication (only E-Stop is possible)

Master Communication

Place of command triggering	Mode	Usage	Execution of command triggering	Activation	Operation modes	Notes
Local	<b>Setting-up mode</b>	Setting-up and commissioning of axes, even without running master	Via MLD, digital inputs/outputs or acyclic channel with "IndraWorks Ds /D/MLD"	Control panel and command "easy startup mode"	Internal operation modes 8...12 take effect <b>Note:</b> Operation modes 8...12 have been permanently configured	Control via MLD is impossible!
	<b>Emergency mode</b>	Moving the axes when master communication or MLD fails	Via MLD, digital inputs/outputs or acyclic channel with "IndraWorks Ds /D/MLD"	Command "easy startup mode", can be manually started in the case of bus failure	The operation modes last active take effect (0...7)	Control via MLD or activation of easy startup mode is possible
	<b>Special Case:</b> Temporary control for intelligent error reaction	Preferably for use as intelligent servo axis (MLD has control only temporarily, e.g. for carrying out an intelligent error reaction)	Internal via MLD with motion function blocks	With function block "MX_Set-Control"	Internal operation modes 8...12 take effect <b>Note:</b> Operation modes 8...12 have been permanently configured	Access by master communication with SERCOS <b>Note:</b> With field bus, bit 14 in the control word does not take effect.

Master comm. Hardware option for master communication option  
MLD IndraMotion MLD (drive-integrated PLC)  
*Fig.4-27: Operation Criteria of the Operating Modes*

### Control Words of the Operating Modes and Master Communications

According to the operating mode or master communication used, different control words take effect; they are shown in the figure below.

Master Communication

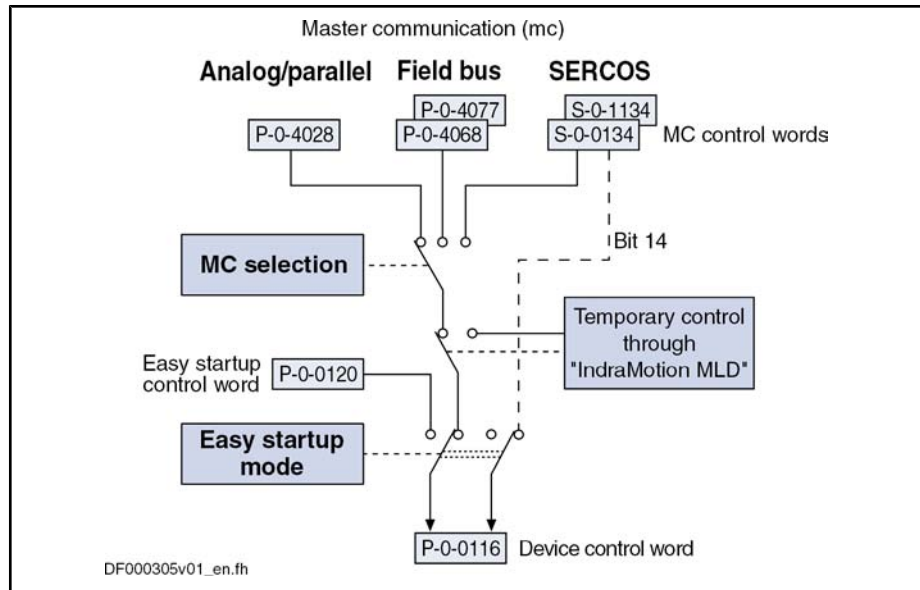


Fig.4-28: Overview of Control Words of Operating Modes and Master Communication

Special Cases of Operation With External Control Unit

There are the following special cases of operation via an external master communication:

- Analog mode (with existing analog optional module)
- EtherNet/IP™ communication via the engineering interface

Analog Mode With Existing Optional Module

You can **permanently** switch off a master communication interface (e.g. SERCOS or field bus) available in the control section and thereby use a SERCOS or field bus device like an analog device. In this case, the axis is controlled via the digital or analog inputs of the control section or a possibly available additional analog optional module (e.g. MA1).



In this operating mode, there aren't any command values and actual values transmitted between the drive and an external control unit!

Observe the following aspects for **commissioning and utilization**:

- Deactivation of master communication and activation of the analog mode take place in the parameter "P-0-4088, Master communication: Drive configuration".
- The configuration will only take effect after repeated booting process, i.e. you have to switch off and on again the control voltage of the drive controller.
- In order to be able to control the device via the digital inputs, you have to assign the drive enable signal (see Parameter Description "P-0-0120, Control word easy startup") to a digital input of the control section.  
See "Digital Inputs/Outputs"
- The operation mode of the axis can be freely selected, but in the analog mode it is only the operation modes "velocity control" and "positioning block mode" which can be practically used.  
See "Velocity Control" and "Positioning Block Mode"
- If analog inputs are available, they can be used for inputting a velocity command value (S-0-0036, S-0-0037) or, in the case of positioning block mode, a "feedrate override" (S-0-0108).

**EtherNet/IP™ via Engineering Interface**

See "Analog Inputs"

It is possible to ignore a master communication interface (e.g. SERCOS or field bus) available in the control section and **operate the drive via the engineering interface**.

Observe the following aspects for **commissioning and utilization**:

- Deactivation of master communication and activation of the analog mode take place in the parameter "P-0-4088, Master communication: Drive configuration".
- The configuration will only take effect after repeated booting process, i.e. you have to switch off and on again the control voltage of the drive controller.
- The axis is controlled via EtherNet/IP™ communication. An optional module for parallel interface is available as I/O extension.

See also "EtherNet/IP™ Interface"



See also Parameter Description "P-0-4088, Master communication: Drive configuration"

## 4.5 Profile Types (With Field Bus Interfaces)

### 4.5.1 Supported Profile Types

#### Overview

When a field bus interface is used for master communication, IndraDrive controllers support the following profile types (modes):

- I/O mode positioning
- I/O mode preset velocity
- Freely configurable mode (IndraDrive profile type)

The tables below contain an overview of the most important properties and features of these 3 profile types:

I/O mode positioning			
Content of "P-0-4084, Field bus: profile type"	Master communication	Field bus or drive operating mode	Features
0xFF82	PROFIBUS® CANopen DeviceNet™	I/O mode positioning (positioning block mode, encoder 1, lagless)	- up to 64 positioning blocks can be controlled via field bus - apart from control and status word, other real-time data can be configured (in P-0-4080 and P-0-4081) - bits can be freely defined in signal status word via function "configurable signal status word"

Fig.4-29: Profile Type "I/O Mode Positioning"

Master Communication

I/O mode preset velocity			
Content of "P-0-4084, Field bus: profile type"	Master communication	Field bus or drive operating mode	Features
0xFF92	PROFIBUS® CANopen DeviceNet™	I/O mode preset velocity	- fixed velocity command values can be controlled and ramp-function generator can be operated via field bus - apart from control and status word, other real-time data can be configured (in P-0-4080 and P-0-4081) - bits can be freely defined in signal status word via function "configurable signal status word"

Fig.4-30: Profile Type "I/O Mode Preset Velocity"

Freely configurable mode			
Content of "P-0-4084, Field bus: profile type"	Master communication	Field bus or drive operating mode	Features
0xFFFFE	PROFIBUS® CANopen DeviceNet™	Freely configurable mode (default assignment is "drive-controlled positioning" with corresponding required cyclic data)	- possible use of complete drive functionality by free configuration of real-time data and operating mode selection - control word and status word have a Rexroth-specific structure - selection suited for operation with analog command values in commissioning phase
0xFFFFD	like profile 0xFFFFE, but reduced field bus control word (relevant for MLD applications, for example)		

Fig.4-31: Profile Type "Freely Configurable Mode"

- Pertinent Parameters**
- S-0-0026, Configuration list for signal status word
  - S-0-0144, Signal status word
  - S-0-0328, Assign list signal status word
  - P-0-4068, Field bus: control word IO
  - P-0-4071, Field bus: length of cyclic command value data channel
  - P-0-4074, Field bus: data format
  - P-0-4077, Field bus: control word
  - P-0-4078, Field bus: status word
  - P-0-4080, Field bus: config. list of cyclic actual value data ch.
  - P-0-4081, Field bus: config. list of cyclic command value data ch.
  - P-0-4082, Field bus: length of cyclic actual value data channel
  - P-0-4083, Field bus: length of parameter channel
  - P-0-4084, Field bus: profile type

Basic Principles and Terms

**Drive Profile** The drive profile defines

- the structure of the field bus control word (P-0-4077) and of the field bus status word (P-0-4078),
- the structure and content of real-time channel (P-0-4080, P-0-4081),
- the active operating mode (S-0-0032, S-0-0033, S-0-0034, S-0-0035),
- the drive states and their transitions (state machine of IndraDrive profile type or I/O mode).

By selecting a profile type, the commissioning of field bus drives becomes very easy for the user. The advantage of the profile selection is that all important basic settings for the desired drive function are thereby made automatically in the drive. As the profile types are defined independently of the bus, the transfer of applications from one field bus to the other is also facilitated.

**State Machine** A status (e.g. Drive Halt, drive error, ...) represents a specific internal and external behavior. The status can be exited by defined events (e.g. drive commands, switching of operating modes, ...). Corresponding status transitions are assigned to the events. The interaction of control and status bits and the status transitions are called state machine.

- Abbreviations**
- **i16**: 16-bit variable with sign (1 word) in Intel format
  - **i32**: 32-bit variable with sign (2 words) in Intel format
  - **u16**: 16-bit variable without sign (1 word) in Intel format
  - **u32**: 32-bit variable without sign (2 words) in Intel format
  - **ZKL1**: Class 1 diagnostics
  - **ZKL2**: Class 2 diagnostics

## 4.5.2 I/O Mode (Positioning and Preset Velocity)

### Brief Description

We distinguish the following variants of the profile type "I/O mode":

- I/O mode positioning (functionality similar to parallel interface)
- I/O mode preset velocity (e.g. for open-loop applications)

**General Features** The I/O mode has the following features:

- Optional parameter channel can be activated, if required, via "P-0-4083, Field bus: length of parameter channel" (max. 8 words)  
Default: P-0-4083 = 0 → Without parameter channel
- Real-time channel consists of at least one word (16 bits), the field bus control word (P-0-4068) and the signal status word (S-0-0144)
- Freely expandable real-time channel by configuration of real-time data:
  - **Master → slave** (drive)  
→ Configuration of "P-0-4081, Field bus: config. list of cyclic command value data ch."
  - **Slave → master** (drive)  
→ Configuration of "P-0-4080, Field bus: Config. list of cyclic actual value data channel"
- Freely configurable field bus status word (cf. S-0-0144)
- Relationship between profile type selection and operating mode which takes effect:
  - In the **I/O modes** there is a determined relationship between profile type (P-0-4084) and predefined primary operation mode (S-0-0032).

Master Communication

- The **freely configurable mode** allows free selection of the operating modes (S-0-0032, S-0-0033, ...).



The respective default settings are activated by selecting the profile type and subsequent action "load default communication parameters" (see also P-0-4090 and S-0-0262).

Structure of the Real-Time Channel

Data direction	Word1	Format
Master → slave	P-0-4068, Field bus: Control word IO	u16 (1 word)
Slave → master	S-0-0144, Signal status word	u16 (1 word)

Fig.4-32: Structure of the Real-Time Channel for the I/O Modes

Features "I/O Mode Positioning"

Specific features of "I/O mode positioning":

- The drive is operated in "positioning block mode, lagless, encoder 1" (see also description of the operation mode "Positioning Block Mode").
- In this operating mode, 64 programmable positioning blocks can be selected and started via 6 bits (in the 16 bit wide control word).
- The jog function can be activated in "P-0-4068, Field bus: control word IO". "Drive-controlled positioning" was set as the 1st secondary operation mode (see also description of the operation mode "Drive-Controlled Positioning").

Features "I/O Mode Preset Velocity"

Specific features of "I/O mode preset velocity":

- The drive is operated in the "velocity control" mode (see also description of the operation mode "Velocity Control").
- In this operating mode you can, for example, select and start 5 programmable fixed velocity command values (in the 16 bit wide control word) and operate the function of the ramp-function generator.

State Machine in I/O Mode

Interaction of control and status bits (state machine):



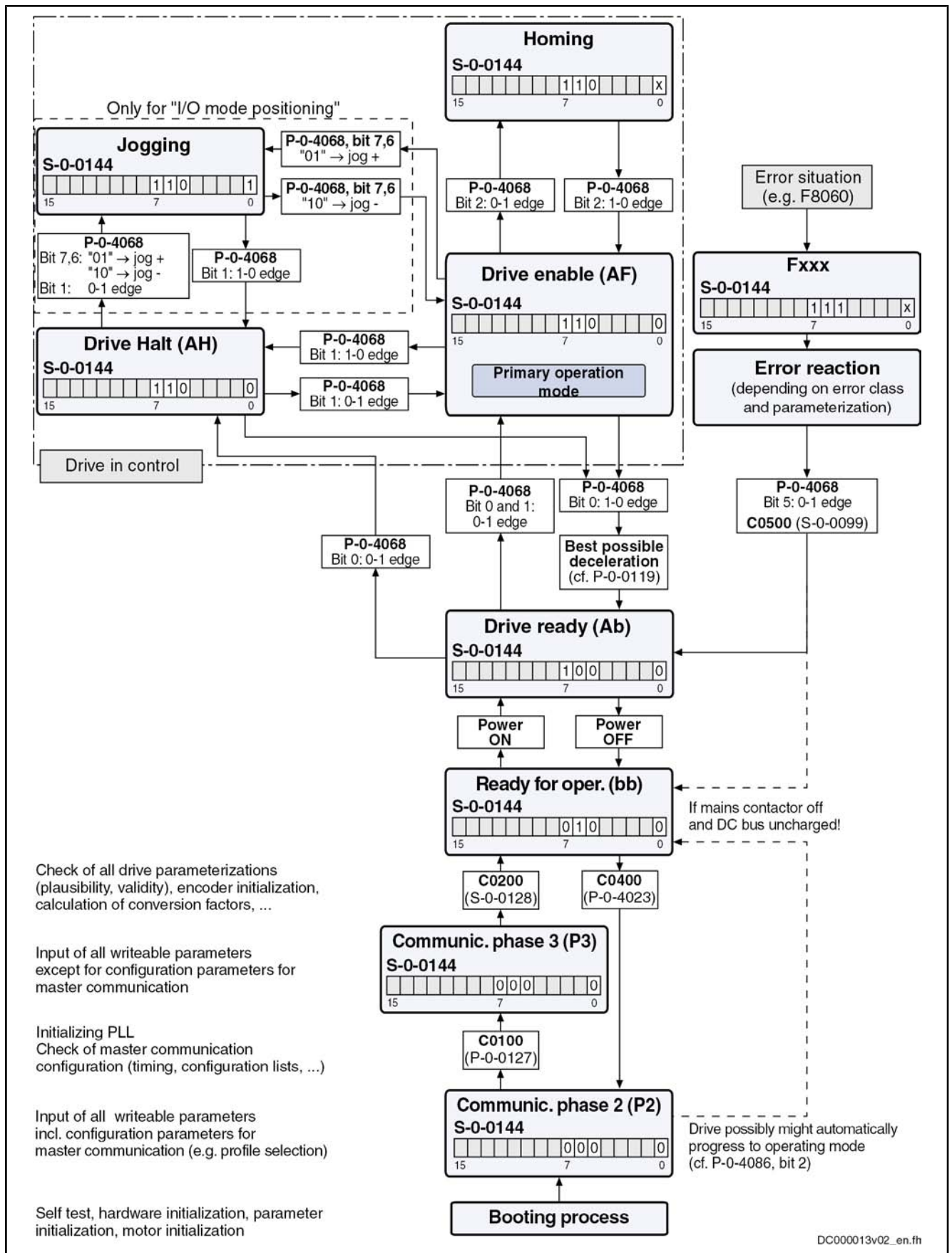


Fig.4-33: Device Control of Variants of I/O Mode (State Machine)

Master Communication



The figure illustrates the status word (S-0-0144) in its default configuration. If required, it can be given any configuration.



**Automatic restart after bus failure!**

In the case of bus failure (message "F4009" or "E4005"), an error reaction must be carried out in the control unit, too, to prevent automatic restart after the bus has been reestablished. This means that the bits "Drive Halt", "drive enable" and "drive ON" (e.g. bits 13, 14 and 15 in parameter "P-0-4077, Field bus: control word") should be reset in the control unit in the case of bus failure.

**Field Bus Control Word in I/O Mode**

The bits in parameter "P-0-4068, Field bus: control word IO" are fixed by Bosch Rexroth and the user cannot change them. If additional control bits should be required, the parameter "S-0-0145, Signal control word" has to be configured accordingly and transmitted to the real-time channel of the field bus.



See Parameter Description "P-0-4068, Field bus: control word IO"



See Parameter Description "S-0-0145, Signal control word"

**Signal Status Word in I/O Mode**

- In the I/O modes (P-0-4084 = 0xFF82 or 0xFF92), the parameter "S-0-0144, Signal status word" is transmitted instead of the field bus status word (P-0-4078). The configuration of S-0-0144 is given by default setting (see below).
- According to the selected I/O profile type, there is a different default configuration for S-0-0144 (see below).

The tables below show the two default configurations for S-0-0144 which depend on the profile type:

Bit	Pin assignment	Significance
0	Active Operating Mode	1: Jogging (S-0-0437) 0: Positioning
1	Position switch point (PSP)	1: To the right of PSP 0: To the left of PSP (S-0-0060)
2	In reference	1: Drive has been homed (S-0-0403)
3	In motion	0: In motion (S-0-0331)
4	In position	1: Drive is in positioning window & no sequential block (P-0-4061)
5	Drive error (error flag)	1: Error (P-0-0115) 0: No error
6	Readiness for operation; display "bb"	1: Ready for operation (P-0-0115)
7	Power switched on; display "Ab"	1: Power has been switched on (P-0-0115)
13...8	Positioning block acknowledgment	P-0-4051, Positioning block acknowledgment
15...14	Not assigned	

Fig.4-34: Default Assignment of Parameter "S-0-0144, Signal Status Word" for "I/O Mode Positioning" (P-0-4084 = 0xFF82)

Bit	Pin assignment	Significance
0	Status of ramp-function generator	1: Run-up stop active (P-0-1210, bit 1)
1	Status of ramp-function generator	1: Acceleration active (P-0-1210, bit 2)
2	Status of ramp-function generator	1: Deceleration active (P-0-1210, bit 3)
3	In motion	1: Message "n_act = 0" (S-0-0331, bit 0)
4	Status of ramp-function generator	1: Cmd value reached (P-0-1210, bit 0)
5	Drive error (error flag)	1: Error (P-0-0115) 0: No error
6	Readiness for operation; display "bb"	1: Ready for operation (P-0-0115)
7	Power switched on; display "Ab"	1: Power has been switched on (P-0-0115)
8	Status of ramp-function generator	1: Cmd value within masking window (P-0-1210, bit 4)
9	Status of ramp-function generator	1: V-ramp within masking window (P-0-1210, bit 5)
15...10	Not assigned	

Fig.4-35: Default Assignment of Parameter "S-0-0144, Signal Status Word" for "I/O Mode Velocity" (P-0-4084 = 0xFF92)



As the parameter "S-0-0144, Signal status word" is already used as field bus status word in the I/O mode, it cannot be configured again in the cyclic channel.



See Parameter Description "S-0-0144, Signal status word"

## Notes on Parameterization/Commissioning

### Features with Default Configuration

The following definitions apply to the default setting the I/O modes:

- Fixed real-time channel length of 2 bytes. Thus the length of the real-time channel corresponds to the length of the cyclic data channel (P-0-4082 = P-0-4071 = 2)!
- "P-0-4068, Field bus: control word IO" und "S-0-0144, Signal status word" have been set to the above-mentioned default configuration.
- In the real-time channel only "P-0-4068, Field bus: control word IO" and "S-0-0144, Signal status word" are transmitted.

### Features/Settings with Free Configuration or Expansion

There are the following possibilities for free configuration/expansion:

- The user can freely expand the length of cyclic data channel P-0-4082 or P-0-4071 up to a maximum of 23 words. In addition to control word and status word, other real-time data can be configured via the parameters "P-0-4080, Field bus: config. list of cyclic actual value data ch." and "P-0-4081, Field bus: config. list of cyclic command value data ch."

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- The content of "S-0-0144, Signal status word" can be freely parameterized via "S-0-0026, Configuration list for signal status word" and "S-0-0328, Assign list signal status word".
- The content of "S-0-0145, Signal control word" can be freely parameterized via "S-0-0027, Configuration list for signal control word" and "S-0-0329, Assign list signal control word".

### 4.5.3 Freely Configurable Mode (IndraDrive Profile Type)

#### Brief Description

To use the extensive and numerous functions of a Rexroth drive with field bus interface it is necessary, in addition to the I/O modes, to define another profile, the freely configurable mode. This implies the use of a specific control and status word ("P-0-4077, Field bus: control word" and "P-0-4078, Field bus: status word").

**Features**

- The structure (content) of the real-time data channel must be defined via the configuration parameters P-0-4080 and P-0-4081. No profile-dependent settings and checks are carried out!
- In this profile type, it is the Rexroth-specific definitions for the field bus control and status words which apply. Some bits in the parameters "P-0-4077, Field bus: control word" and "P-0-4078, Field bus: status word" can only be used in conjunction with certain operation modes.
- This profile type allows using the entire drive functionality (e.g. velocity synchronization, drive-controlled positioning, ...).
- The primary mode of operation and the secondary operating modes can be freely determined in the parameters S-0-0032, S-0-0033 etc.
- The operation mode "drive-controlled positioning" is set as default with the command values S-0-0282, S-0-0259 and twice S-0-0000 and the actual values S-0-0386, S-0-0040, S-0-0390 (see also below "Exemplary Configurations: Drive-Controlled Positioning").



One of the parameters "P-0-4077, Field bus: control word" or "P-0-4078, Field bus: status word" must always be contained in the 1st place in the configuration parameters P-0-4080 and P-0-4081.

**Real-Time Channel**

In the real-time channel of the field bus the data configured in parameters "P-0-4081, Field bus: config. list of cyclic command value data ch." and "P-0-4080, Field bus: config. list of cyclic actual value data ch." are transmitted between master and drive (slave).

Data direction	Word1	Format
<b>Master → slave</b>	P-0-4077, Field bus: control word	u16 (1 word)
	Optional command values	According to selection
<b>Slave → master</b>	P-0-4078, Field bus: status word	u16 (1 word)
	Optional command values	According to selection

Fig.4-36: Structure of the Real-Time Channel in the Freely Configurable Mode



The IDNs of the parameters of the cyclic configurable command and actual values are listed in "S-0-0188, List of configurable data in the MDT" and "S-0-0187, List of configurable data in the AT".

Data direction	Word1	Word2	...	Word_n
Master → slave	P-0-4077	Command value 1	...	
Slave → master	P-0-4078	Feedback value 1	...	

Fig.4-37: Content and Order of Data in Real-Time Channel in the Freely Configurable Mode

### Status Machine in Freely Configurable Mode (IndraDrive Profile Type)

Each field bus drive of Bosch Rexroth, regardless of the command communication interface, is equipped with a uniform "status machine". This includes a continuous structure of the parameters "P-0-4077, Field bus: control word" and "P-0-4078, Field bus: status word".



See Parameter Description "P-0-4077, Field bus: control word"



See Parameter Description "P-0-4078, Field bus: status word"

Interaction of control and status bits (state machine):

Master Communication

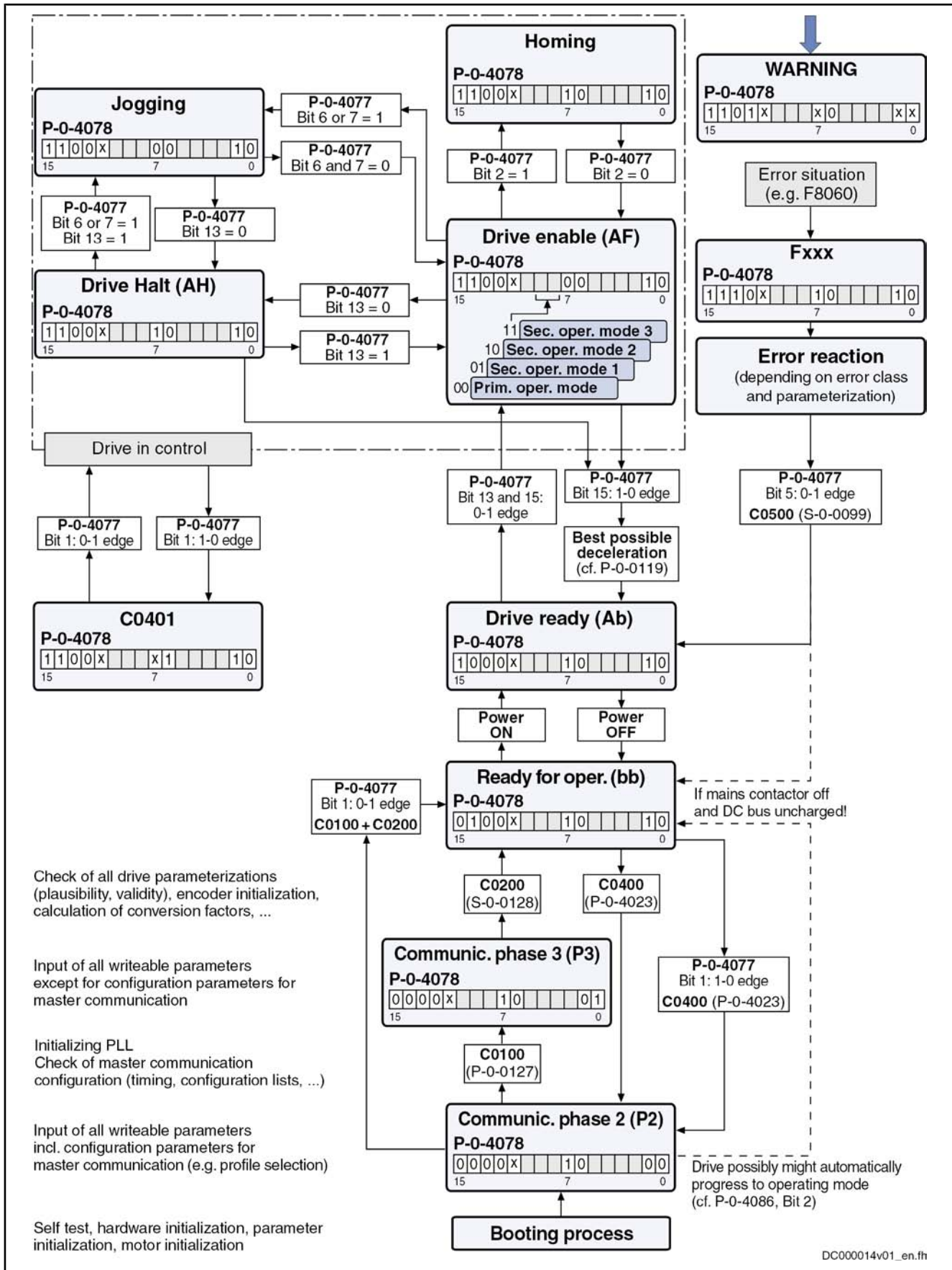


Fig.4-38: Device Control in the Freely Configurable Mode (State Machine)



### Automatic restart after bus failure!

In the case of bus failure (message "F4009" or "E4005"), an error reaction must be carried out in the control unit, too, to prevent automatic restart after the bus has been reestablished. This means that the bits "Drive Halt", "drive enable" and "drive ON" (e.g. bits 13, 14 and 15 in parameter "P-0-4077, Field bus: control word") should be reset in the control unit in the case of bus failure.

#### Field Bus Control Word and Field Bus Status Word

For this profile type the field bus control word and status word are preset by Bosch Rexroth and the user cannot change them. If freely configurable control and status bits are required, the signal control word or signal status word has to be configured in the cyclic channel in addition to the available field bus status word or field bus control word.



See Parameter Description "S-0-0144, Signal status word"



See Parameter Description "S-0-0145, Signal control word"



With field bus drives, the parameters "P-0-0116, Device control: control word" and "P-0-0115, Device control: status word" are only used for diagnostic purposes. The actual control and status information is contained in the parameters "P-0-4077, Field bus: control word" und "P-0-4078, Field bus: status word". These parameters are always an inherent part of the real-time channel.

See also "Device Control and State Machine"

## Exemplary Configurations

### General Information

All of the following examples of configuration refer to the freely configurable mode (**P-0-4084 = 0xFFFE**). This mode provides the highest degree of flexibility and the highest number of possibilities to use the available drive functions of the field bus master communication.

### Velocity Control

#### Features/Settings

- "Velocity control" must have been set as the primary operation mode in parameter S-0-0032 (see also description of the operation mode "Velocity control").
- The contents of parameters "S-0-0036, Velocity command value" are cyclically transmitted via the field bus in the command value data channel and "S-0-0040, Velocity feedback value", "S-0-0051, Position feedback value 1" and "S-0-0393, Command value mode" in the actual value data channel.
- The Rexroth-specific definitions for the field bus control and status words are applying (see also section "Freely Configurable Mode (IndraDrive profile type)"). Some bits in the parameters "P-0-4077, Field bus: control word" and "P-0-4078, Field bus: status word" are irrelevant for this configuration (or operation mode).
- The length of the cyclic data channel has been defined with:
  - P-0-4082 = 14 bytes
  - P-0-4071 = 6 bytes

Master Communication

Structure of the Real-Time Channel

In the real-time channel of the field bus, the velocity data configured in parameter "P-0-4081, Field bus: config. list of cyclic command value data ch." are transmitted from the master to the drive; the data configured in parameter "P-0-4080, Field bus: config. list of cyclic actual value data ch." are transmitted from the drive to the master.

Data direction	Parameters	Format
Master → slave	P-0-4077, Field bus: control word	u16 (1 word)
	S-0-0036, Velocity command value	i32 (2 words)
Slave → master	P-0-4078, Field bus: status word	u16 (1 word)
	S-0-0040, Velocity feedback value	i32 (2 words)
	S-0-0051, Position feedback value 1	i32 (2 words)
	S-0-0390, Diagnostic message number	u32 (2 words)

Fig.4-39: Structure of the Real-Time Channel in Velocity Control (and Freely Configurable Mode)

Data direction	Word1	Word2	Word3	Word4	Word5	Word6	Word7
Master → slave	P-0-4077	S-0-0036 (H)	S-0-0036 (L)				
Slave → master	P-0-4078	S-0-0040 (H)	S-0-0040 (L)	S-0-0051 (H)	S-0-0051 (L)	S-0-0390 (H)	S-0-0390 (L)

Fig.4-40: Content and Order of Data in Real-Time Channel in Velocity Control (and Freely Configurable Mode)

Drive-Internal Interpolation

Features/Settings

- "Drive-internal interpolation, encoder 1, lagless" must have been set as the primary operation mode in parameter "S-0-0032 (see also description of operation mode "Drive-Internal Interpolation").
- The contents of parameters "S-0-0258, Target position" and "S-0-0259, Positioning velocity" as well as "S-0-0051, Position feedback value 1" and "S-0-0040, Velocity feedback value" are cyclically transmitted via the field bus.  
→ The configuration of P-0-4081 or P-0-4080 has to be adjusted accordingly!
- The Rexroth-specific definitions for the field bus control and status words are applying (see also section "Freely Configurable Mode (IndraDrive profile type)"). Some bits in the parameters "P-0-4077, Field bus: control word" and "P-0-4078, Field bus: status word" are irrelevant for this configuration (or operation mode).
- The length of the cyclic data channel has been defined with:
  - P-0-4082 = 14 bytes
  - P-0-4071 = 10 bytes



To use the functional expansion (switching absolute/relative) of the "drive-internal interpolation" mode, it is necessary to configure "S-0-0282, Positioning command value" instead of "S-0-0258, Target position" in the list parameter P-0-4081!

Structure of the Real-Time Channel

In the real-time channel of the field bus, the positioning data configured in parameter "P-0-4081, Field bus: config. list of cyclic command value data ch." are transmitted from the master to the drive; the positioning data configured in pa-



parameter "P-0-4080, Field bus: config. list of cyclic actual value data ch." are transmitted from the drive to the master.

Data direction	Parameters	Format
Master → slave	P-0-4077, Field bus: control word	u16 (1 word)
	S-0-0258, Target position	i32 (2 words)
	S-0-0259, Positioning velocity	i32 (2 words)
Slave → master	P-0-4078, Field bus: status word	u16 (1 word)
	S-0-0051, Position feedback value 1	i32 (2 words)
	S-0-0040, Velocity feedback value	i32 (2 words)
	S-0-0390, Diagnostic message number	u32 (2 words)

Fig.4-41: Structure of the Real-Time Channel in Drive-Internal Interpolation (and Freely Configurable Mode)

Data direction	Word1	Word2	Word3	Word4	Word5	Word6	Word7
Master → slave	P-0-4077	S-0-0258 (H)	S-0-0258 (L)	S-0-0259 (H)	S-0-0259 (L)		
Slave → master	P-0-4078	S-0-0051 (H)	S-0-0051 (L)	S-0-0040 (H)	S-0-0040 (L)	S-0-0390 (H)	S-0-0390 (L)

Fig.4-42: Content and Order of Data in Real-Time Channel in Drive-Internal Interpolation (and Freely Configurable Mode)

### Drive-Controlled Positioning

#### Features/Settings

- "Drive-controlled positioning, encoder 1, lagless" must have been set as the primary operation mode in parameter S-0-0032 (see also description of operation mode "Drive-Controlled Positioning").
- The Rexroth-specific definitions for the field bus control and status words are applying (see also section "Freely Configurable Mode (IndraDrive profile type)").
- By configuring the content of "S-0-0282, Positioning command value" as a cyclic command value, the bits 0, 3, 4 in "P-0-4077, Field bus: control word" can be used to directly switch between relative to absolute positioning (functionally compatible with position target setting).
- In this configuration a drive functionality is achieved which corresponds to the position target setting of DRIVCOM (functionally compatible).

#### Structure of the Real-Time Channel

In the real-time channel of the field bus, the positioning data configured in parameter "P-0-4081, Field bus: config. list of cyclic command value data ch." are transmitted from the master to the drive; the positioning data configured in parameter "P-0-4080, Field bus: config. list of cyclic actual value data ch." are transmitted from the drive to the master.

Data direction	Parameters	Format
Master → slave	P-0-4077, Field bus: control word	u16 (1 word)
	S-0-0282, Positioning command value	i32 (2 words)
	S-0-0259, Positioning velocity	i32 (2 words)

Master Communication

Data direction	Parameters	Format
<b>Slave → master</b>	P-0-4078, Field bus: status word	u16 (1 word)
	S-0-0051, Position feedback value 1	i32 (2 words)
	S-0-0040, Velocity feedback value	i32 (2 words)
	S-0-0390, Diagnostic message number	u32 (2 words)

Fig.4-43: Structure of the Real-Time Channel in Drive-Controlled Positioning (and Freely Configurable Mode)

Data direction	Word1	Word2	Word3	Word4	Word5	Word6	Word7
<b>Master → slave</b>	P-0-4077	S-0-0282 (H)	S-0-0282 (L)	S-0-0259 (H)	S-0-0259 (L)		
<b>Slave → master</b>	P-0-4078	S-0-0051 (H)	S-0-0051 (L)	S-0-0040 (H)	S-0-0040 (L)	S-0-0390 (H)	S-0-0390 (L)

Fig.4-44: Content and Order of Data in Real-Time Channel in Drive-Controlled Positioning (and Freely Configurable Mode)

**Using the Signal Control Word and the Signal Status Word**

By using the parameters "S-0-0145, Signal control word" and "S-0-0144, Signal status word", the user has the option to freely configure control and status bits in the drive which are also transmitted along with the field bus control word and field bus status word in real time via the field bus.

See also "Configurable Signal Control Word" and "Configurable Signal Status Word"

- Features**
- By using the parameters S-0-0144 and S-0-0145 there are 16 more freely configurable control and status bits available.
  - This allows, among other things, to start commands that are contained in parameter "S-0-0399, IDN-list of configurable data in signal control word" (see "Configurable Signal Control Word").
  - It is possible to read any bit in any parameter (see "Configurable Signal Status Word").

- Settings** The following settings are required:
- To configure the bit lists, the list parameters S-0-0026 (for "S-0-0144, Signal status word") and S-0-0027, S-0-0329 (for "S-0-0145, Signal control word") can be used.
  - To use the function, select profile type "freely configurable mode" (P-0-4084 = 0xFFFE).
  - Set "drive-controlled positioning, encoder 1, lagless", for example, in parameter "S-0-0032, Primary mode of operation".
  - Parameterize the configuration lists P-0-4080 and P-0-4081 as follows:

**Structure of the Real-Time Channel**

In the real-time channel of the field bus, the positioning data configured in parameter "P-0-4081, Field bus: config. list of cyclic command value data ch." are transmitted from the master to the drive; the positioning data configured in parameter "P-0-4080, Field bus: config. list of cyclic actual value data ch." are transmitted from the drive to the master.

Data direction	Parameters	Format
<b>Master → slave</b>	P-0-4077, Field bus: control word	u16 (1 word)
	S-0-0282, Positioning command value	i32 (2 words)
	S-0-0259, Positioning velocity	i32 (2 words)
	S-0-0145, Signal control word	u16 (1 word)

Data direction	Parameters	Format
Slave → master	P-0-4078, Field bus: status word	u16 (1 word)
	S-0-0051, Position feedback value 1	i32 (2 words)
	S-0-0040, Velocity feedback value	i32 (2 words)
	S-0-0390, Diagnostic message number	u32 (2 words)
	S-0-0144, Signal status word	u16 (1 word)

Fig. 4-45: Structure of the Real-Time Channel When Using Signal Control Word and Signal Status Word (and Freely Configurable Mode)

Data direction	Word1	Word2	Word3	Word4	Word5	Word6	Word7	Word8
Master → slave	P-0-4077	S-0-0282 (H)	S-0-0282 (L)	S-0-0259 (H)	S-0-0259 (L)	S-0-0145		
Slave → master	P-0-4078	S-0-0051 (H)	S-0-0051 (L)	S-0-0040 (H)	S-0-0040 (L)	S-0-0390 (H)	S-0-0390 (L)	S-0-0144

Fig. 4-46: Content and Order of Data in Real-time Channel When Using Signal Control Word and Signal Status Word (and Freely Configurable Mode)



See also Parameter Description "P-0-4074, Field bus: data format"

## 4.6 SERCOS Interface (SERCOS II)

### 4.6.1 Brief Description

**General Features**

- Cyclical data exchange of command and actual values in equal time intervals
- Data transfer via fiber optic cables; except for converter in motor (in this case, copper conductor)
- Service channel for parameterization and diagnosis
- Free configuration of telegram contents
- Synchronization between time command value takes effect and measurement starting time of the actual values for all drives on a ring
- Overall synchronization of all connected drives to the control unit

**Firmware-Specific Features**

- Cycle time Min. 250/500 μs, max. 65 ms (multiples of position clock 250 μs or 500 μs can be set)
- SERCOS compatibility class C
- Baud rate: Optionally 2, 4, 8 or 16 MBaud
- Automatic baud rate detection; active baud rate displayed in a parameter
- Transmission power can be set via indication of transmission length (setting via control panel)
- Max. quantity of configurable data in the MDT: 48 bytes
- Max. quantity of configurable data in the AT: 48 bytes

## Master Communication



The number of configurable bytes in the MDT/AT depends on the relation of the position cycle time (P-0-0556, bit 2) to the SERCOS cycle time.

SERCOS cycle time = position cycle time → max. length 24 bytes

SERCOS cycle time > position cycle time → max. length 48 bytes



For more detailed information, see SERCOS specification.

**Pertinent Parameters**

- S-0-0001, NC cycle time (TNcyc)
- S-0-0002, SERCOS cycle time (TScyc)
- S-0-0003, Minimum AT transmit starting time (T1min)
- S-0-0004, Transmit/receive transition time (TATMT)
- S-0-0005, Minimum feedback acquisition time (T4min)
- S-0-0006, AT Transmission starting time (T1)
- S-0-0007, Feedback acquisition starting time (T4)
- S-0-0008, Command value valid time (T3)
- S-0-0009, Position of data record in MDT
- S-0-0010, Length of master data telegram
- S-0-0014, Interface status
- S-0-0015, Telegram type parameter
- S-0-0016, Configuration list of AT
- S-0-0024, Configuration list of MDT
- S-0-0028, MST error counter
- S-0-0029, MDT error counter
- S-0-0088, Receive to receive recovery time (TMTSY)
- S-0-0089, MDT Transmit starting time (T2)
- S-0-0090, Command value proceeding time (TMTSG)
- S-0-0096, Slave arrangement (SLKN)
- S-0-0097, Mask class 2 diagnostics
- S-0-0098, Mask class 3 diagnostics
- S-0-0134, Master control word
- S-0-0135, Drive status word
- S-0-0143, Sercos interface version
- S-0-0185, Length of the configurable data record in the AT
- S-0-0186, Length of the configurable data record in the MDT
- S-0-0187, List of configurable data in the AT
- S-0-0188, List of configurable data in the MDT
- S-0-0301, Allocation of real-time control bit 1
- S-0-0303, Allocation of real-time control bit 2
- S-0-0305, Allocation of real-time status bit 1
- S-0-0307, Allocation of real-time status bit 2
- S-0-0413, Bit number allocation of real-time control bit 1
- S-0-0414, Bit number allocation of real-time control bit 2

- S-0-0415, Bit number allocation of real-time status bit 1
  - S-0-0416, Bit number allocation of real-time status bit 2
  - P-0-4027, Transmission length SERCOS interface
  - P-0-4029, Diagnostic report SCSB module
  - P-0-4087, Baud rate SERCOS interface
- Pertinent Diagnostic Messages**
- C0104 Config. IDN for MDT not configurable
  - C0105 Maximum length for MDT exceeded
  - C0106 Config. IDNs for AT not configurable
  - C0107 Maximum length for AT exceeded
  - C0108 Time slot parameter > Sercos cycle time
  - C0109 Telegram offset unsuitable
  - C0110 Length of MDT (S-0-0010) odd
  - C0111 ID9 + Record length - 1 > length MDT (S-0-0010)
  - C0112 TNcyc (S-0-0001) or TScyc (S-0-0002) error
  - C0113 Relation TNcyc (S-0-0001) to TScyc (S-0-0002) error
  - C0114 T4 > TScyc (S-0-0002) - T4min (S-0-0005)
  - C0115 T2 too small
  - C0116 T3 (S-0-0008) within MDT (S-0-0089 + S-0-0010)
  - C0139 T2 (S-0-0089)+length MDT (S-0-0010)>TScyc (S-0-0002)
  - F4001 Sync telegram failure
  - F4002 RTD telegram failure
  - F4003 Invalid communication phase shutdown
  - F4004 Error during phase progression
  - F4005 Error during phase regression
  - F4006 Phase switching without ready signal

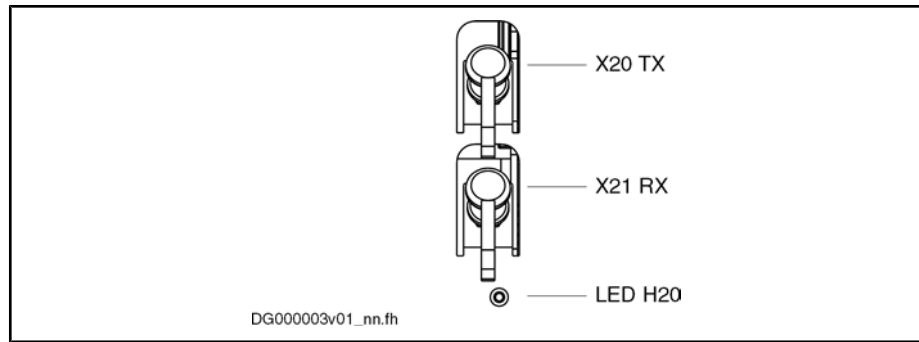
## 4.6.2 Commissioning the SERCOS interface

### Steps of Commissioning

To commission the interface, you basically have to carry out the following steps:

- Connect the fiber optic cables
- Set the drive address
- Set the transmission length (transmitting power)
- Check the distortion indicators

## Master Communication



X20 TX	Optical output (transmitter)
X21 RX	Optical input (receiver)
H20	Distortion indicator LED
<i>Fig.4-47:</i>	<i>SERCOS interface</i>

## Settings of the SERCOS interface

For settings or display for communication via SERCOS interface, the following parameters are available:

- P-0-4025, Drive address of master communication
- P-0-4027, Transmission length SERCOS interface
- P-0-4087, Baud rate SERCOS interface

For information on these parameters, see the following sections!

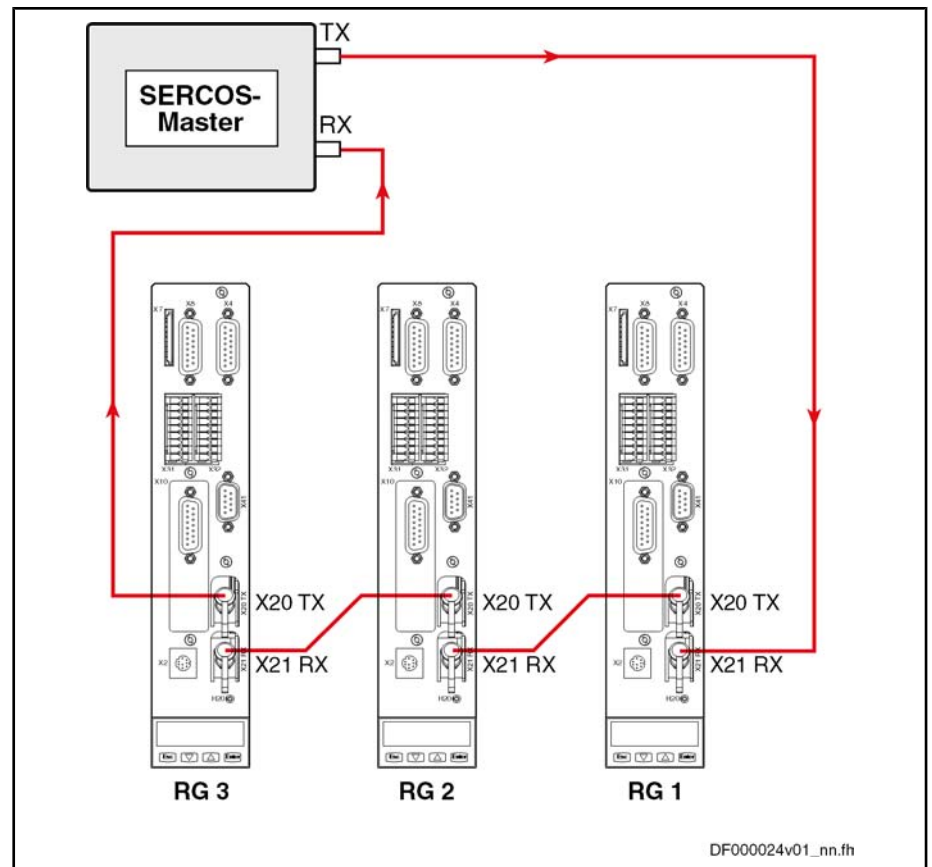


The settings must be made via the SERCOS ring before communication is built up.

## Connecting the Fiber Optic Cables

The connection between the master (control unit) and the drive controllers is established with fiber optic cables.

To do this, it is necessary to set up a ring structure according to SERCOS interface (IEC 1491).



RG Controller

Fig.4-48: Connecting the Fiber Optic Cables (Example)

The fiber optic cable ring starts and ends at the SERCOS master (control unit).

The optical output of the master is connected to the optical input of the first drive (X21). The output of this drive (X20) is connected to the input of the next drive etc.

The output of the last drive is connected to the optical input of the master.

## Setting the Drive Address

The drive address is set in parameter "P-0-4025, Drive address of master communication" (instead of the address selector switch which was used before). A drive address set or changed in this parameter is only activated at the next change of communication phase from "0" to "1".

The drive address is independent of the order of drive connections via the fiber optic cables.

## Setting the Transmission Length (Transmitting Power) of the SERCOS interface

The length of the fiber optic cable connected to X20 (TX) is entered in parameter "P-0-4027, Transmission length SERCOS interface" .

Depending on the entered fiber optic cable length, the required optical transmitting power of the light source is automatically set. The controller classifies the entered length in one of four ranges.

Ranges of length for the connected fiber optic cable:

- Up to 15 m
- 15 m to 30 m
- 30 m to 45 m

## Master Communication

- More than 45 m and glass fiber

**Transmission Rate of the SERCOS interface**

The transmission rate is preset by the master, automatically recognized by the drive, set accordingly and displayed in the parameter "P-0-4087, Baud rate SERCOS interface".



Baud rates of 2, 4, 8 and 16 MBaud are supported.

---

**Using the Distortion Indicator "H20"**

**Checking the Optic Signal Level** After the drive address has been set, it is necessary to check whether the optic signal levels available at every node are sufficient, i.e. whether the receiver is neither underloaded nor overloaded. The optic signal level is checked by means of the distortion indicator at the front of the controllers (LED "H20").

The distortion indicator LED normally stays dark.

To check the optic signal level, the distortion indicators of all drives in the ring are checked in signal flow direction, starting from the transmitter output of the master (control unit) (see figure in section "Connecting the Fiber Optic Cables").

Check the distortion indicators in the "direction of the light", i. e. at first, check the first drive in the ring. If its distortion indicator is dark, go to the next drive. Do this up to the last drive and then at the master (control unit).



The distortion indicator must not be lit nor glow!

---

The distortion indicator "H20" will be lit in the following cases:

- Fiber optic cable leading to the preceding drive is defective
- Transmission rate is not supported
- Transmission length (transmitting power) is incorrectly set

**What to do when the distortion indicator is lit:**

- Check the Fiber Optic Cable** Check the fiber optic cable and its connectors from the physical predecessor in the ring to the affected drive (see below).
- Check the Transmission Rate** Compare the transmission rate of the master to the supported baud rates of the drive.
- Check the Transmission Length** At the physical predecessor of the affected drive, check the transmission length (length of the fiber optic cable at the optical output X20) set in parameter "P-0-4027, Transmission length SERCOS interface".

**Checking the Fiber Optic Cables**

The fiber optic cable may be defective, if the preset transmission rate is supported and the transmission lengths were correctly set, but communication nevertheless is not established. In this case, the "H20" distortion indicator will be lit.

The reason for a defective fiber optic cable can be mechanical damage or bad assembly (connector mounting, ...).

Sometimes it is possible to recognize a defective fiber optic cable by the fact that hardly any light comes out at its end or that the optical fiber was "drawn back" into the connector (check the "face of the connector"). Further checks of the fiber optic cable cannot be carried out with simple means.

Defective fiber optic cables must be replaced.



## 4.6.3 Cyclic Data Transfer

### General Information

To synchronize the drives in a ring, the master synchronization telegram (MST) is sent at the beginning of every SERCOS cycle. The only information the MST contains is the communication phase preset by the master.

The content of master data telegram (MDT) and drive telegram (AT = Antriebstelegramm) can be configured.

Once per SERCOS cycle time, a collective master data telegram for all drives is sent from the control unit to the drives. The master data telegram contains the master control word, the service channel and a configurable data block. This data block mostly contains the command and limit values the control unit wants to transmit to the drive to operate the corresponding operating mode. The content of this data block can be configured by means of the telegram settings.

The master data telegram is received by all drives in the ring at the same time.

In addition, a separate drive telegram is sent once per SERCOS cycle time from every drive to the control unit. The drive telegram contains the drive status word, sections of the service channel and a configurable data block. This data block mostly contains the actual and status values the control unit needs from the drive to operate the corresponding operating mode.

### Master Control Word

The master control word is part of the master data telegram. The master control word contains all important control information for the drives, such as:

- Drive on
- Drive enable
- Drive Halt
- Interpolator clock
- Command operation mode
- Real-time control bits 1 and 2
- Control information for the service channel



The master control word is mapped to parameter S-0-0134. The exact structure of this parameter is described in the separate Parameter Description.

See Parameter Description "S-0-0134, Master control word"

The master control word is cyclically transmitted to the drive with every master data telegram in the SERCOS clock (see "S-0-0002, SERCOS cycle time (TScyc)"). For diagnostic purposes, the master control word can be read via parameter "S-0-0134, Master control word".

### Drive Enable

The drive is activated by a positive edge of the drive enable signal. In the case of drive controllers with SERCOS interface, the drive enable signal corresponds to bit 15 in the master control word of the master data telegram (MDT).

The controller enable signal is accepted, i.e. the drive switches from its de-energized status to its energized status, when the following conditions have been fulfilled:

- SERCOS interface ready for operation (communication phase 4)

## Master Communication

- No drive error
- Power section switched on

In this status the display of the drive reads "Ab", the diagnostic message via parameter S-0-0095 is "A0012 Control and power sections ready for operation".

When drive enable signal is set, the display changes to "AF", the diagnostic message then shows the activated mode of operation (e.g. "A0101 Velocity control").

## Drive Halt

The "Drive Halt" signal is status-controlled and active when the signal = 0 V; this means that for signal =0 V the drive is in status "Drive Halt" The input signal is mapped to the master control word bit 13.

## Drive Status Word

The drive status word is part of the drive telegram (AT). It contains all important status information from the drive, such as:

- Readiness for operation of control and power sections
- Drive errors
- Change bits class 2 and 3 diagnostics
- Current operation mode
- Real-time status bits 1 and 2
- Status information for the service channel



The drive status word is mapped to parameter S-0-0135. The exact structure of this parameter is described in the separate Parameter Description.

See Parameter Description "S-0-0135, Drive status word"

The drive status word is cyclically transmitted to the control unit with every drive telegram in the SERCOS clock (see Parameter Description "S-0-0002, SERCOS cycle time (TScyc)"). For diagnostic purposes, the drive status word can be read via parameter "S-0-0135, Drive status word".

## Acknowledging Drive Enable

The drive acknowledges the drive enable setting in the drive status word of the drive telegram. Bits 14 and 15 change from "10" (control and power section ready for operation, torque-free) to "11" (in operation, under torque) after drive enable is activated and has been accepted.

The time that passes between the setting of drive enable and its acknowledgment is needed by the drive to establish its complete readiness for operation. For example, in the case of asynchronous motors this time is used to magnetize the motor.

If drive enable is disabled, the drive performs the reaction parameterized by parameter "P-0-0119, Best possible deceleration". In this case, too, time passes between the resetting and acknowledgment of the reset. This time depends on

- the setting of parameter P-0-0119,
- the existence of a motor brake and its parameterization,
- the velocity of the axis at the time drive enable is reset.

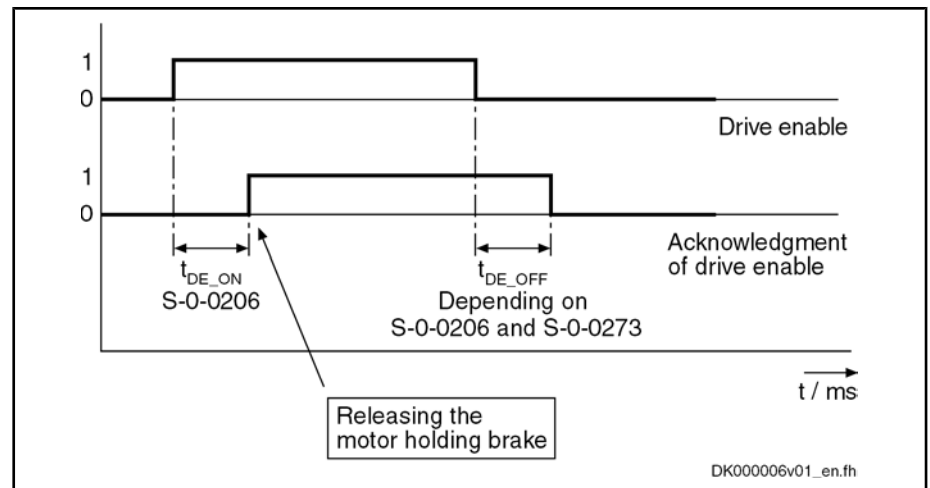


Fig.4-49: Acknowledging Drive Enable (DE)

Typical values for  $t_{DE\_ON}$  (S-0-0206) are about 8 ms for synchronous motors or 300 ms for asynchronous motors.



During the  $t_{DE\_ON}$  time, the command value set by the control unit should be such that the command velocity is zero. Releasing the possibly available motor holding brake only takes place at the time drive enable is acknowledged (positive edge of "drive enable acknowledgement")!

#### 4.6.4 Transmission of Non-Cyclical Data

Non-cyclical data are parameters that are not transmitted cyclically, but via the service channel. The service channel is therefore used for parameterization and diagnosis.

The transmission via the service channel is done in sections in the MDT and AT, and per transmitted element can last several SERCOS cycles.

#### 4.6.5 Interface Errors and Diagnostic Possibilities

##### Possible Error Messages

If conditions are detected in the drive that no longer allow the correct operation of the interface, or if incorrect preset values are detected during the initialization phase, the drive reacts by going back to communication phase 0. No more drive telegrams will be sent, the drive automatically carries out the programmed error reaction (see Parameter Description "P-0-0119, Best possible deceleration") and waits for the reinitialization of the SERCOS ring by the master.

Possible error messages could be:

- F4001 Sync telegram failure
- F4002 RTD telegram failure
- F4003 Invalid communication phase shutdown
- F4004 Error during phase progression
- F4005 Error during phase regression
- F4006 Phase switching without ready signal

##### Diagnostic Parameters for Interface Status

The parameter "S-0-0014, Interface status" is used to diagnose existing interface errors and the current communication phase.

## Master Communication

## Error Counter for Telegram Failures

The drive checks every received master synchronization and master data telegram for

- the correct receive time,
- the assigned telegram length,
- the correct CRC checksum.

The failure of a telegram is registered by incrementing an error counter. For this purpose, the parameters "S-0-0028, MST error counter" and "S-0-0029, MDT error counter" are used.

The content of parameter S-0-0028 is cleared when switching from communication phase 2 to 3, the content of parameter S-0-0029 is cleared when switching from communication phase 3 to 4.

## 4.6.6 Real-Time Control Bits and Real-Time Status Bits

### Brief Description

The master control word and the drive status word contain 2 configurable real-time bits each. To configure these binary signals there are the following parameters:

- S-0-0301, Allocation of real-time control bit 1
- S-0-0303, Allocation of real-time control bit 2
- S-0-0305, Allocation of real-time status bit 1
- S-0-0307, Allocation of real-time status bit 2
- S-0-0398, IDN-list of configurable data in signal status word
- S-0-0399, IDN-list of configurable data in signal control word
- S-0-0413, Bit number allocation of real-time control bit 1
- S-0-0414, Bit number allocation of real-time control bit 2
- S-0-0415, Bit number allocation of real-time status bit 1
- S-0-0416, Bit number allocation of real-time status bit 2

These parameters contain the information of which parameter bit 0 (LSB) is mapped to the corresponding real-time status bit and therefore is sent cyclically to the master, or to which parameters the real-time control bits are mapped.

### Notes on Commissioning

**Selection List S-0-0399**

Only parameters contained in the list parameter "S-0-0399, IDN-list of configurable data in signal control word" can be assigned to the parameters S-0-0301 or S-0-0303 (allocation of real-time control bit 1 or 2). Assigning command parameters that are possibly contained in the list parameter S-0-0399, however, is not possible!

**Selection List S-0-0398**

Only parameters contained in the list parameter "S-0-0398, IDN-list of configurable data in signal status word" can be assigned to the parameters S-0-0305 or S-0-0307 (allocation of real-time status bit 1 or 2).



The real-time status bits are configured in every master communication cycle at the point of time defined in parameter "S-0-0007, Feedback acquisition starting time (T4)".

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## 4.7 PROFIBUS-DP

### 4.7.1 Brief Description

It is possible to operate IndraDrive controllers with a PROFIBUS interface as master communication module. Via this module it is possible to exchange real-time data with a PROFIBUS-DP master.

We distinguish the following communication channels:

- **Cyclic data channel** (PROFIBUS-DP)

The field bus provides data containers in which useful data can be cyclically transmitted. This section is referred to as cyclic data channel. The cyclic data channel is divided into:

- One (optional) device-specific **parameter channel** for reading and writing all parameters via PROFIBUS-DP.

**Note:** This parameter channel does not fulfill "real-time properties"!

- One (optional) **safe**, axis-specific **process data channel** (PROFIsafe) which enables the transmission of safety-relevant signals, depending on the firmware and hardware (see also section "Integrated Safety Technology").
- One axis-specific **process data channel** (real-time channel) which contains fixed, selected information that can be directly interpreted by the receiver.

- **Acyclic data channel** (DPV1 parameter communication)

The following are supported:

- One class-1 connection
- Two class-2 connections

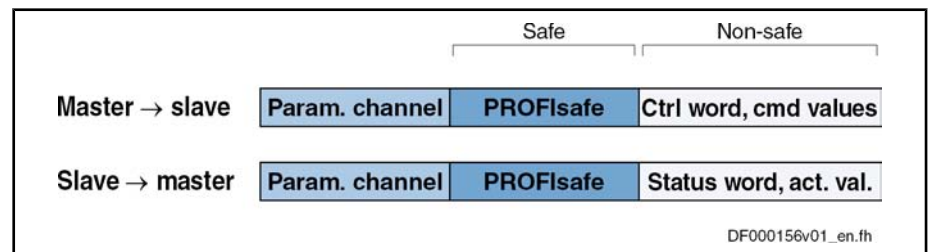


Fig.4-50: Overview of Cyclic Data Channel



To simplify field bus communication, Bosch Rexroth makes available function blocks for different programmable logic controllers (PLCs). The principles applied can be easily used for other field bus masters.

**Features** The slave PROFIBUS-DP circuit with master communication module PL has the following functional features:

- Support of **RS485 interfaces according to IEC 61158-2**
- Support of all **data rates according to IEC 61158-2**, with exclusive use of PROFIBUS-DP (9.6 kBaud, 19.2 kBaud, 45.45 kBaud, 93.75 kBaud, 187.5 kBaud, 500 kBaud, 1.5 MBaud, 3 MBaud, 6 MBaud, 12 MBaud)
- Automatic baud rate detection
- Configurable cyclic data up to 15 parameters (incl. field bus control word and field bus status word) in both data directions (max. 48 bytes or 24 words)

## Master Communication

- Additional optional parameter channel in the cyclic channel with up to 16 bytes (8 words)
- Monitoring of the cyclical data exchange (watchdog function)
- LED for diagnosing the PROFIBUS interface
- Supported DPV0 services:
  - Slave\_Diag (read diagnostic data)
  - Get\_Cfg (read configuration data)
  - Set\_Prm (send parameterization data)
  - Chk\_Cfg (check configuration data)
  - Data Exchange (transfer I/O data)
  - Global Control (synchronization)
  - RD\_Outp (read output data)
  - RD\_Inp (read input data)
- Parameter access with DPV1-class-1 services
  - DDLM\_Initiate (establishment of connection)
  - DDLM\_Read (acyclic read access)
  - DDLM\_Write (acyclic write access)
  - DDLM\_Abort (abortion of connection)
  - DDLM\_Idle (connection monitoring)
- Support of up to two DPV1-class-2 connections
- Supported field bus profiles:
  - 0xFF82: I/O mode "positioning" with configurable real-time data
  - 0xFF92: I/O mode " preset velocity" with configurable real-time data
  - 0xFFFE: Freely configurable mode
- Access to all device parameters according to PROFIdrive specification

**Hardware Requirements**

Using the master communication "PROFIBUS-DP" requires the following control section design:

- Single-axis BASIC PROFIBUS (not configurable) (CSB01.1N-PB)

In addition, communication via "PROFIBUS-DP" is possible with the following configurable control sections, if they are equipped with the optional module "PB":

- Single-axis BASIC UNIVERSAL (CSB01.1C)
- Single-axis ADVANCED (CSH01.1C)
- Double-axis BASIC UNIVERSAL (CDB01.1C)

**Pertinent Parameters****Communication parameters**

Specific parameters for communication via PROFIBUS-DP:

- P-0-3290, PROFIsafe: F\_Destination\_Address
- P-0-4069, Field bus: module diagnosis

Parameters for general communication via field bus interfaces:

- P-0-4073, Field bus: diagnostic message
- P-0-4074, Field bus: data format
- P-0-4075, Field bus: watchdog
- P-0-4076, Field bus: cycle time (T<sub>cyc</sub>)

- P-0-4079, Field bus: baud rate

#### Profile type parameters

Apart from mere communication parameters, we use parameters in conjunction with the profile types.

See "Profile Types (With Field Bus Interfaces)"

#### Parameters for extended communication

We use additional parameters for extended communication.

See following sections:

- "Configurable Signal Control Word"
- "Configurable Signal Status Word"
- " Multiplex Channel"

#### Pertinent Diagnostic Messages

- C0154 Field bus: IDN for cycl. command val. not configurable
- C0155 Field bus: max. length for cycl. command val. exceeded
- C0156 Field bus: IDN for cycl. actual val. not configurable
- C0157 Field bus: length for cycl. actual values exceeded
- C0158 Field bus: Tcyc (P-0-4076) incorrect
- C0159 Field bus: P-0-4077 missing for cycl. command values
- F4009 Bus failure
- F4012 Incorrect I/O length

## 4.7.2 Configuring the PROFIBUS-DP Slave

### Device Data Sheet for IndraDrive

Like every other PROFIBUS slave, IndraDrive controllers have to be configured in the field bus master. This requires the corresponding device data sheet "RX\*\*0107.GSD" that has to be included in the project ("\*\*" represents the version number of the GSD file). This GSD-file, when configuring the bus master, is required for each node.



The device data sheet (GSD) for IndraDrive controllers supports all hardware types and enabling of functional packages.

IndraDrive controllers assign their data to four modules (for single-axis devices), seven modules (for double-axis devices) or up to 31 modules for devices operated via CCD group (1 CCD master + 9 CCD slaves) which possibly have to be configured. Each drive in the CCD group has an F-module, one input module and one output module:

- Module 1: Parameter channel
- Module 2: F-module axis 0 (optional for PROFIsafe)
- Module 3: Inputs axis 0
- Module 4: Outputs axis 0
- Module 5: F-module axis 1 (optional for PROFIsafe, double-axis devices or devices operated at the CCD group)
- Module 6: Inputs axis 1 (only for double-axis devices or devices operated at the CCD group)
- Module 7: Outputs axis 1 (only for double-axis devices or devices operated at the CCD group)

## Master Communication

- Module X: F-module axis X (optional for FROFIsafe, according to number of CCD drives)
- Module Y: Inputs axis X (according to number of CCD drives)
- Module Z: Outputs axis X (according to number of CCD drives)

The default configuration stored in the device data sheet is "Input 1 Word" and "Output 1 Word" (single-axis device) without safety technology and without parameter channel. For configurators that are supporting the GSD version 03 or higher, this default configuration is automatically set. For IndraDrive this setting is active after the load defaults procedure.

The device data sheet also contains the IDN assigned to the IndraDrive controller by the PROFIBUS User Organization:

- **Ident. no. 107 hex**



During the installation of "IndraWorks Ds/D/MLD", the device data sheet is stored in the "Indramat\DeviceDataSheets" directory.

**Module 1: Parameter Channel**

The module 1 is marked with "ParamCh" and of the input/output module type. If no parameter channel is required, the module "ParamCh not used" has to be selected. For a parameter channel with the standard length of 5 words, the module "ParamCh 5 Words" has to be included.



The standard length provides the optimum between the required I/O length and transmission rate. If possible, it should always be selected for the parameter channel. The function blocks available for IndraDrive use this length, too.

The drive automatically recognizes the configuration of the master and adjusts accordingly. Parameterization by the master is therefore always possible even in the case of incorrect configuration of the command values/actual values. This allows parameter download from the master after a device was replaced.



This active setting is displayed in parameter "P-0-4083, Field bus: length of parameter channel" in bytes.

**Module 2: F-Module**

The (optional) module 2 is used to configure a safe process data channel (with the corresponding hardware and enabling of functional packages). When the optional module is not used, the blank module "F-Modul not used" has to be assigned to it.

**Module 3: Inputs**

In module 3 the length of the input data in words is set. The module identifier is "Input". For successful data exchange, the length that was set has to equal the value in parameter "P-0-4082, Field bus: length of cyclic actual value data channel" which indicates the length in bytes.



If the configuration of the master does not correspond with the one of the IndraDrive controller, the IndraDrive device will generate the error message "F4012 Incorrect I/O length".

**Module 4: Outputs**

Module 4 corresponds to module 3 but defines the outputs. The module identifier is "Output". The length of the output data that was set has to correspond with the value of parameter "P-0-4071, Field bus: length of cyclic command value data channel":





If the configuration of the master does not correspond with the one of the IndraDrive controller, the IndraDrive device will generate the error message "F4012 Incorrect I/O length".

**Modules 5 to 7**

The modules 5 to 7 are provided for double-axis devices or for 5 to 31 devices operated at the CCD group. In the case of single-axis devices, the blank modules "F-Modul not used", "Input not used" or "Output not used" should be assigned to these modules.

**Configuring the Process Data Channel****Standard Process Data Channel  
(Non-Safe)**

The user can freely configure the cyclic data in the standard process data channel according to the process requirements.



For the profile types "freely configurable mode" (P-0-4084 = 0xFFFE) or "I/O mode" (P-0-4084 = 0xFF82), there is a default configuration that the user can change at any time. See also "Profile Types (With Field Bus Interfaces)"

**Configuration List Cyclic Actual  
Value Data Channel**

The structure and therefore the number of words and their assigned objects (indices) for the process input data (slave → master) are mapped in parameter "P-0-4080, Field bus: config. list of cyclic actual value data ch.". The master can use this configuration in order to localize the individual real-time data in the field bus.

**Configuration List Cyclic Command  
Value Data Channel**

The structure of the process output data (master → slave) is mapped in parameter "P-0-4081, Field bus: config. list of cyclic command value data ch.". This allows reading the current structure and thus the assignments in the field bus via the parameter channel.



It is possible to configure up to 15 real-time parameters (incl. control or status word) on the bus in each data direction.

**PROFIsafe Process Data Channel  
(Safe)**

The safe channel is configured in the master using the safety module (F-module 2 or module 5). The drive automatically recognizes the control configuration during the run-up (→ "CheckConfig").



Drives operated via the CCD group do not support PROFIsafe. In this case, use the blank module "F-Modul not used".

As a result thereof the individual modules (module 2 and modules 5) have to be supported, too!



In order to use the safe channel in the drive, a value unequal zero has to be set in parameter "P-0-3290, PROFIsafe: F\_Destination\_Address". This activates the safe process data channel (PROFIsafe) and deactivates the safety inputs/outputs on the optional safety technology card (except for input for safe homing procedure).

Per direction of transmission, the safe process data channel contains 2 bytes useful data (safety technology control and status word) and 4 bytes header for backing up the transmission of useful data.

## Master Communication



The control word gets to parameter "P-0-3212, Safety technology control word, channel 1" in inverted form; the status word corresponds to the content of parameter "P-0-3214, Safety technology status word, channel 1".

See also Parameter Description P-0-3212 and P-0-3214

**Length of the Process Data Channel (Real-Time Data Channel)****Standard Process Data Channel  
(Non-Safe)**

Within the cyclic channel, the parameter channel (optional) and the process data channel, in which the real-time data of the drive controller are transmitted, are arranged.

The PROFIBUS slave circuit allows flexible configuration of the process data channel, the length of the process data channel is thereby changing accordingly.



The length currently effective is contained in the parameters "P-0-4082, Field bus: length of cyclic actual value data channel" and "P-0-4071, Field bus: length of cyclic command value data channel".

The process data channel (real-time data channel) can only have words or double words, but not bytes, as data types. Length, however, is specified in bytes for the sake of compatibility with other bus systems.

The length of the process data channel can range between 1...24 words or 2...48 bytes in either direction.

The length of the process data channel is determined by the contents of the configuration lists "P-0-4080, Field bus: config. list of cyclic actual value data ch." or "P-0-4081, Field bus: config. list of cyclic command value data ch." and can be taken from the following parameters:

- P-0-4071, Field bus: length of cyclic command value data channel (master → slave)
- P-0-4082, Field bus: length of cyclic actual value data channel (slave → master)

The setting is calculated from the contents of the parameters P-0-4080 and P-0-4081 and takes effect as the drive controller runs up to the operating mode.



Note that a change in the length of the process data channel also requires a change in the master configuration. The length of the process data channel that was set has to be in accordance with the projected length in the master. Otherwise the error message "F4012 Incorrect I/O length" is generated.

**PROFIsafe Process Data Channel  
(Safe)**

The length of this safe process data channel cannot be modified! There are always 2 bytes available for useful data and 4 bytes header for data backup.

**4.7.3 Cyclic Communication via Process Data Channel****Communication Cycle Time**

Cyclic communication via the process data channel takes place in the so-called communication cycle (cf. "P-0-4076, Field bus: cycle time (T<sub>cyc</sub>)"). The possible quantity of cyclic data depends on the setting of parameter P-0-4076.

Min. cycle time	Max. quantity of process data ↔ setting P-0-4076	Notes
0,5 ms ( $T_{A\_pos}$ )	16 bytes → P-4076 = 0.5 ms 32 bytes → P-4076 = 1 ms 48 Bytes → P-4076 > 1 ms	Additionally a maximum of 16 bytes parameter channel for PROFIBUS and PROFINET

Fig.4-51: Quantity of Cyclic Data Depending on P-0-4076

Valid values for P-0-4076: 0.5 ms, 1 ms, 2 ms, 3 ms, 4 ms, 5 ms, ...



When the safe channel (PROFIsafe) is used, the minimum allowed cycle time is limited to 2 ms!

### Axis-Specific Process Data Channel



Fig.4-52: Position of the Non-Safe Process Data Channel in the Cyclic Data Channel

#### Processing the Cyclic Data

The internal processing of the command values and actual values is carried out synchronously with the control clock. As the communication via PROFIBUS-DP is not carried out in a synchronous way, this type of master communication is not suited for synchronous operation modes such as "position control with cyclic command value input", but only for positioning modes and the "velocity control" mode.

In the drive, only a limited quantity of cyclic data can be processed (Basic: 32 bytes; Advanced: 40 bytes).



There is no limit value check for the cyclically transmitted command values and they are stored in volatile form.

#### Configuring the Cyclic Data

The cyclic data have to be configured in the parameter mode. It is described in section "Configuring the PROFIBUS-DP Slave" (see above).

### Safe, Axis-Specific Process Data Channel (PROFIsafe)

#### General Information



Using the safe process data channel (PROFIsafe) with the firmware version MPx-07 requires the optional safety technology module "S2"!

## Master Communication

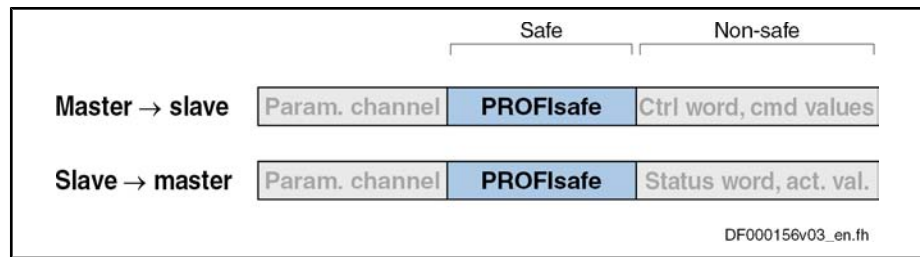


Fig. 4-53: Position of the Safe Process Data Channel (PROFIsafe) in the Cyclic Data Channel



When the safe channel (PROFIsafe) is used, the minimum allowed cycle time is limited to 2 ms!

The internal processing of the command values and actual values is carried out synchronously with the control clock. The safe channel allows selecting the integrated safety functions via Profibus or transmitting the corresponding feedback signals (acknowledgements).

The available safety functions and mechanisms are described in the Application Manual on integrated safety technology.



See separate documentation "Rexroth IndraDrive - Integrated Safety Technology"



A check (→ safe transmission) is carried out for the cyclically transmitted, safe command values (2 bytes) and they are stored in volatile form.

### PROFIsafe Configuration



Drives operated via the CCD group do not support PROFIsafe. In this case, use the blank module "F-Modul not used".

#### Configuration of IndraDrive

PROFIsafe is activated by entering the PROFIsafe destination address in parameter "P-0-3290, PROFIsafe: F\_Destination\_Address". Entering the value "0" deactivates PROFIsafe.

When PROFIsafe has been activated, the value from the control unit configuration must be applied to parameter "P-0-3291, PROFIsafe: F\_Source\_Address":

The PROFIsafe parameters which have to be set via the PLC configuration are displayed in parameter "P-0-3292, PROFIsafe: F\_Parameters".

#### Configuration of the Control Unit

To use PROFIsafe in the drive, you have to include the PROFIsafe modules in the control unit configuration according to the required functionality. The following PROFIsafe modules (F-modules) are available for this purpose:

- **F-Modul not used**

This axis does not exchange any data via PROFIsafe. PROFIsafe must be deactivated for the axis (P-0-3290 = 0).

- **F-Module I/O**

16 safe control bits (P-0-3216) are transmitted to the drive in inverted form. The drive transmits 16 safe status bits (P-0-3214 of channel 1, channel 2 must supply the same value). The "destination address" set in the PLC configuration must be entered in parameter P-0-3290.



See separate documentation "Rexroth IndraDrive - Integrated Safety Technology"

### Parameter Channel in the Cyclic Channel (Device-Specific)



Fig.4-54: Position of the Parameter Channel in the Cyclic Data Channel

Since it must be possible to parameterize the drive via the field bus, a configurable parameter channel was implemented in the cyclic channel of the IndraDrive the length of which can be set to 4...16 bytes. The parameter channel consists of a control or status word and up to a maximum of 7 words for data.



The parameter channel is always at the beginning of the cyclical data channel. The length of the parameter channel is configured in the master and taken over by the drive to parameter "P-0-4083, Field bus: length of parameter channel".

#### Structure of the Parameter Channel:

- Control word: 2 bytes
- Data: 2 to 14 bytes

#### Object Directory for PROFIBUS-DP via the Parameter Channel

For PROFIBUS-DP there wasn't any object directory defined. Acyclic access to drive parameters is only possible via the parameter channel.

In order to make cyclic parameter access as easy as possible (without SIS telegrams), objects were assigned to drive parameters.

The data of an object are accessed via:

- Index
- Subindex
- Index = 0x2000 + IDN (S-0-XXXX) → **S-parameters**
- Index = 0x2000 + IDN (S-0-XXXX) → **P-parameters**

#### Generating Law for Object Index

#### Generating Law for Object Subindex

**Example 1:** Accessing data of S-0-0051

- Index = 0x2000 + IDN (S-0-0051) = 0x2000 + 51 = 0x2033
- Subindex = 7, since access to data desired

**Example 2:** Accessing data of P-0-0051

- Index = 0x3000 + IDN (P-0-0051) = 0x3000 + 51 = 0x3033
- Subindex = 7, since access to data desired

#### Structure of Control Word in Parameter Channel

The control word is transmitted from the master to the slave. Its width is 16 bits and the individual bits have the following significance:

Master Communication

15	14	13	12	11 ... 8	7 ... 0
res	G	L	T	FL	GL

res Reserved (always 0)  
 G No basic setting  
 L Load bit  
 T Toggle bit  
 FL Length of user data in fragment (4 bits)  
 GL Length of data still to be transmitted including the data in the current fragment (8 bits)

Fig.4-55: Structure of Control Word in Parameter Channel

Structure of Status Word in Parameter Channel

The status word is transmitted from the slave to the master. Its width is 16 bits and the individual bits have the following significance:

15	14	13	12	11 ... 8	7 ... 0
res	F	L	T	FL	GL

res Reserved (always 0)  
 F Error  
 L Load bit  
 T Toggle bit  
 FL Length of user data in fragment (4 bits)  
 GL Length of data still to be transmitted including the data in the current fragment (8 bits)

Fig.4-56: Structure of Status Word in Parameter Channel

Configuration of the Parameter Channel

The parameter channel consists of:

- Control word / status word
- User data

Without considering a fragmentation or an error, the parameter channel when **writing a parameter** consists of:

	Control word	Index	Subindex	Data
<b>M → S</b>	2 bytes	2 bytes	2 bytes	Max. 80 bytes
	<b>Status word</b>			
<b>S → M</b>	2 bytes			

Fig.4-57: Parameter Channel When Writing a Parameter

Without considering a fragmentation, the parameter channel when **reading a parameter** consists of:

	Control word	Index	Subindex	
<b>M → S</b>	2 bytes	2 bytes	2 bytes	
	<b>Status word</b>	<b>Data</b>		
<b>S → M</b>	2 bytes	Max. 80 bytes		

Fig.4-58: Parameter Channel When Reading a Parameter

Basic Setting

The control unit defines the basic setting and the drive responds with the identifier (2 bytes) of the supported parameter channel format; in this case with 01V00.

	Control word / status word						User data								
	Res	G/F	L	T	FL	GL	B2	B3	B4	B5	B6	B7	B8	B9	
<b>M → S</b>	0	1	1	0/1	0	0	-	-	-	-	-	-	-	-	
<b>S → M</b>	0	0	1	0/1	2	2	01h	00h	-	-	-	-	-	-	

Fig.4-59: Basic Setting for Parameter Channel

**Non-Fragmented Reading**

The control unit reads the operating data of parameter S-0-0057. It is a double word, fragmentation therefore is not necessary.

The value is 100.

**Parameter mapping:**

- Index = 2039h
- Subindex = 7h

	Control word / status word						User data								
	Res	G/F	L	T	FL	GL	B2	B3	B4	B5	B6	B7	B8	B9	
<b>M → S</b>	0	1	1	1/0	4	4	20h	39h	00h	07h	-	-	-	-	
<b>S → M</b>	0	0	1	1/0	4	4	00h	00h	00h	64h	-	-	-	-	

Fig.4-60: Non-Fragmented Reading

**Non-Fragmented Writing Without Error**

The control unit writes a new operating data to parameter S-0-0057. It is a double word, fragmentation therefore is not necessary.

The value is 200. The drive returns an acknowledgement that mirrors the length.

**Parameter mapping:**

- Index = 2039h
- Subindex = 7h

	Control word / status word						User data								
	Res	G/F	L	T	FL	GL	B2	B3	B4	B5	B6	B7	B8	B9	
<b>M → S</b>	0	1	1	0/1	8	8	20h	39h	00h	07h	00h	00h	00h	C8h	
<b>S → M</b>	0	0	1	0/1	0	0	-	-	-	-	-	-	-	-	

Fig.4-61: Non-Fragmented Writing Without Error Message

**Non-Fragmented Writing With Error Message**

The control unit writes a new operating data to parameter P-0-0032.

The value is "8193" and above the allowed maximum. The drive returns an error message, in this case 7007h.

**Parameter mapping:**

- Index = 3020h
- Subindex = 7h

	Control word / status word						User data								
	Res	G/F	L	T	FL	GL	B2	B3	B4	B5	B6	B7	B8	B9	
<b>M → S</b>	0	1	1	0/1	6	6	30h	20h	00h	07h	20h	01h	-	-	
<b>S → M</b>	0	1	1	0/1	2	2	70h	07h	-	-	-	-	-	-	

Fig.4-62: Non-Fragmented Writing With Error Message

**Fragmented Reading**

The control unit reads the operating data of parameter S-0-0016. It is a list of words. In the example below, it contains 40 (28h), 51 (33h), 53 (36h), 84 (54h),

Master Communication

95 (5F), 130 (82h) and 131 (83h). First the list pointer (subindex 10) is set to zero.

**Parameter mapping:**

- Index = 2010h
- Subindex = 11h → 17 → 7 elements

	Control word / status word						User data								
	Res	G/F	L	T	FL	GL	B2	B3	B4	B5	B6	B7	B8	B9	
<b>M → S</b>	0	1	1	1/0	8	8	20h	10h	00h	0Ah	00h	00h	00h	00h	
<b>S → M</b>	0	0	1	1/0	0	0	-	-	-	-	-	-	-	-	
<b>M → S</b>	0	1	1	0/1	4	4	20h	10h	00h	11h	-	-	-	-	
<b>S → M</b>	0	0	0	0/1	8	14	00h	28h	00h	33h	00h	36h	00h	54h	
<b>M → S</b>	0	1	1	1/0	0	6	-	-	-	-	-	-	-	-	
<b>S → M</b>	0	0	1	1/0	6	6	00h	5Fh	00h	82h	00h	83h	-	-	

*Fig.4-63: Fragmented Reading*

**Fragmented Writing**

The control unit writes data to parameter P-0-4006. It is a list of double words. In the example below, it is to contain 100 (64h), 200 (C8h), 300 (12Ch), 400 (190h), 500 (1F4) and 600 (258h). First the list pointer (subindex 10) is set to zero.

**Parameter mapping:**

- Index = 3FA6h
- Subindex = 10h → 16 → 6 elements

length: 4 bytes header + (6 x 4 bytes of data) = 28 bytes

	Control word / status word						User data								
	Res	G/F	L	T	FL	GL	B2	B3	B4	B5	B6	B7	B8	B9	
<b>M → S</b>	0	1	1	0/1	8	8	3Fh	A6h	00h	0Ah	00h	00h	00h	00h	
<b>S → M</b>	0	0	1	0/1	0	0	-	-	-	-	-	-	-	-	
<b>M → S</b>	0	1	0	1/0	8	28	3Fh	A6h	00h	10h	00h	00h	00h	64h	
<b>S → M</b>	0	0	1	1/0	0	20	-	-	-	-	-	-	-	-	
<b>M → S</b>	0	1	0	0/1	8	20	00h	00h	00h	C8h	00h	00h	01h	2Ch	
	0	0	1	0/1	0	12	-	-	-	-	-	-	-	-	
	0	1	0	1/0	8	12	00h	00h	01h	90h	00h	00h	01h	F4h	
	0	0	1	1/0	0	4	-	-	-	-	-	-	-	-	
	0	1	1	0/1	4	4	00h	00h	02h	58h	-	-	-	-	
<b>S → M</b>	0	0	1	0/1	0	0	-	-	-	-	-	-	-	-	

*Fig.4-64: Fragmented Writing*

**Requesting the Next Fragment**

For requesting the next fragment of a fragmented transmission, it is necessary to calculate GL with the data received from the control word / status word:



$$GL_{\text{TRANSMIT}} = GL_{\text{RECEPTION}} - FL_{\text{RECEPTION}}$$

GL Length of data still to be transmitted including the data in the current fragment (8 bits)

FL Length of user data in fragment (4 bits)

Fig.4-65: *GL Calculation*

## 4.7.4 Acyclic Parameter Access (PROFIdrive via DPV1)

### General Information

As of firmware version MPx-03VRS, the field bus independent parameter access via DPV1 is no longer supported, but access according to **PROFIdrive**. The following has been taken as a basis:

- PROFIdrive → Profile Drive Technology version 3.1 / Nov. 2002
- PROFIBUS → Profile Order-No. 3.172



This modification does not have any effect on the parameter channel!

### Overview of Acyclic Communication

**DP Master Class-1** An acyclic communication relationship of type MSAC\_C1 to a DP master class-1 (MSAC\_C1) is supported. The following DP services are available for this communication relationship:

- DDLM\_Read (MSAC1\_Read)
- DDLM\_Write (MSAC1\_Write)

**DP Master Class-2** A maximum of two acyclic communication relationships of type MSAC\_C2 to a DP master class-2 (MSAC\_C2) are supported. The following DP services are available for this communication relationship:

- DDLM\_Initiate (MSAC2\_Initiate)
- DDLM\_Abort (MSAC2\_Abort)
- DDLM\_Read (MSAC2\_Read)
- DDLM\_Write (MSAC2\_Write)

### Parameter Exchange via DPV1 Services

The parameter exchange described below is executed via DPV1 telegram frame. The following sequence is run:

Master Communication

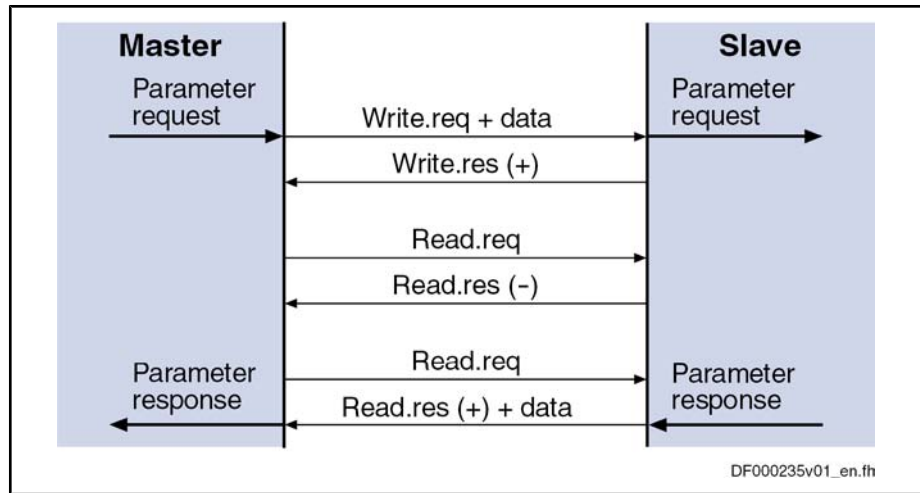


Fig.4-66: Sequence of the Parameter Exchange via DPV1 Services

The individual parameters are accessed with the services "request parameter" or "change parameter".

Request Parameter

<b>Request header</b>	Request reference 1 to 255	Request ID 1 = request parameter
	Axis	Number of parameters
<b>Parameter address</b>	Attribute	Number of elements
	Parameter number	
	Subindex	

Fig.4-67: PROFdrive Parameter Request via DPV1

<b>Response header</b>	Request reference mirrored 1 to 255	Response ID 1 = positive acknowledgement 129 = negative acknowledgement
	Axis mirrored	Number of parameters
<b>Parameter value(s)</b>	Format	Number of values
	Value(s) or error value	
	...	

Fig.4-68: PROFdrive Parameter Response

Change Parameter

<b>Request header</b>	Request reference 1 to 255	Request ID 2 = change parameter
	Axis	Number of parameters
<b>Parameter address</b>	Attribute	Number of elements
	Parameter number	
	Subindex	

<b>Parameter value(s)</b>	Format	Number of values
	Value(s)	
	...	

Fig.4-69: PROFIdrive Parameter Request via DPV1

<b>Response header</b>	Request reference mirrored 1 to 255	Response ID 2 = positive acknowledgement 130 = negative acknowledgement
	Axis mirrored	Number of parameters

Fig.4-70: DPV1 Parameter Response

## Parameter Structure

A parameter structure is accessed via a 16-bit index and a 16-bit subindex. Each parameter has the following attributes:

- Parameter Value
- Parameter Description
- Parameter Text
- Manufacturer Specific



The attribute valid for access is indicated in the header of the request.

**Index** The index corresponds to the SERCOS IDN:

SERCOS IDN	Index (hex)	Index (dec)
S-0-0001 to S-0-4095	0x0001 to 0x0FFF	1 to 4095
S-1-0001 to S-1-4095	0x1001 to 0x1FFF	4097 to 8191
S-2-0001 to S-2-4095	0x2001 to 0x2FFF	8193 to 12287
S-3-0001 to S-3-4095	0x3001 to 0x3FFF	12289 to 16383
S-4-0001 to S-4-4095	0x4001 to 0x4FFF	16385 to 20479
S-5-0001 to S-5-4095	0x5001 to 0x5FFF	20481 to 24575
S-6-0001 to S-6-4095	0x6001 to 0x6FFF	24577 to 28671
S-7-0001 to S-7-4095	0x7001 to 0x7FFF	28672 to 32767
P-0-0001 to P-0-4095	0x8001 to 0x8FFF	32769 to 36863
P-1-0001 to P-1-4095	0x9001 to 0x9FFF	36865 to 40959
P-2-0001 to P-2-4095	0xA001 to 0xAFFF	40961 to 45055
P-3-0001 to P-3-4095	0xB001 to 0xBFFF	45057 to 49151
P-4-0001 to P-4-4095	0xC001 to 0xCFFF	49153 to 53247
P-5-0001 to P-5-4095	0xD001 to 0xDFFF	53249 to 57343
P-6-0001 to P-6-4095	0xE001 to 0xEFFF	57345 to 61439
P-7-0001 to P-7-4095	0xF001 to 0xFFFF	61441 to 65535

Fig.4-71: Relationship Between SERCOS Parameter IDN and Index

## Master Communication

<b>Subindex</b>	The subindex is the element number. Its significance depends on the attribute.
<b>Parameter Value (0x10)</b>	Access to the parameter value takes place in the attribute "Parameter Value". For single parameters or commands, there is only subindex 0 existing. In the case of lists, the subindex ranges from 0 to "list length – 1". All elements are of the same data type.
<b>Parameter Description (0x20)</b>	<p>The description of the parameter via the attribute "Parameter Description" is divided into different elements which are accessed by means of the subindex:</p> <ul style="list-style-type: none"> <li>• <b>Complete description (0)</b> <ul style="list-style-type: none"> <li>→ Complete description (subindex 1 to 12, always with a length of 46 bytes)</li> </ul> </li> <li>• <b>Identifier (1)</b> <ul style="list-style-type: none"> <li>→ 16-bit value for the basic description of the parameter with the following significance of the individual bits (if set): <ul style="list-style-type: none"> <li>– Bit 0 to 7 → Data type</li> <li>– Bit 8 → "Standardiz. factor" + "variable attribute" not relevant</li> <li>– Bit 9 → Parameter write-protected</li> <li>– Bit 10 → Parameter text available</li> <li>– Bit 11 → Reserved (always 0)</li> <li>– Bit 12 → Parameter value does not correspond to default value</li> <li>– Bit 13 → Parameter can only be reset, cannot be used</li> <li>– Bit 14 → List parameter</li> <li>– Bit 15 → Reserved (always 0)</li> </ul> </li> </ul> </li> <li>• <b>Number of array elements or length of string (2)</b> <ul style="list-style-type: none"> <li>→ 16-bit value with number of list elements or length of string</li> <li>In the case of a string, each character is assigned to a subindex. <b>Only element of the description that might possibly be changed!</b></li> </ul> </li> <li>• <b>Standardization factor (3)</b> <ul style="list-style-type: none"> <li>→ 32-bit floating point number by means of which it is possible to calculate the physical value from the parameter value (number for IndraDrive normally is a power of ten)</li> </ul> </li> <li>• <b>Variable attribut (4)</b> <ul style="list-style-type: none"> <li>→ Two 8-bit values for determining the unit and its prefix</li> <li>The standard value is 0x00FE, as not all of the units used for IndraDrive can be mapped.</li> </ul> </li> <li>• <b>Reserved (5)</b> <ul style="list-style-type: none"> <li>→ 32-bit reserved data</li> </ul> </li> <li>• <b>Name (6)</b> <ul style="list-style-type: none"> <li>→ Name of the parameter with maximum number of 16 characters</li> <li>As the IndraDrive parameter names normally are longer, the SERCOS IDN is stored as string (e.g. "S-0-0158").</li> </ul> </li> <li>• <b>Low limit (7)</b> <ul style="list-style-type: none"> <li>→ Minimum possible parameter value</li> <li>If this parameter value does not exist for IndraDrive, the lower value range limit of the data type is entered.</li> </ul> </li> <li>• <b>High limit (8)</b> <ul style="list-style-type: none"> <li>→ Maximum possible parameter value</li> </ul> </li> </ul>

If this parameter value does not exist for IndraDrive, the upper value range limit of the data type is entered.

- **Reserved (9)**  
→ 16-bit reserved data
- **ID extension (10)**  
→ 16-bit reserved data
- **PCD reference parameter (11)**  
→ 16-bit value with number or the reference parameter  
If there is no reference parameter, the value "0" is entered.
- **PCD normalization (12)**  
→ 16-bit value with additional information on normalization:
  - Bit 0 to 5 → Normalization bit 0 to 31
  - Bit 6 to 14 → Reserved
  - Bit 15 → Normalization valid

#### Parameter Text (0x30)

The attribute "Parameter Text" is not supported.

#### Manufacturer Specific (0x80)

In the attribute "Manufacturer Specific", there is such information stored that cannot be mapped to standard elements of PROFIdrive:

- **Complete structure (0)**  
→ All elements of this structure (a total of 84 bytes)
- **Maximum number of elements (1)**  
→ 32-bit value with maximum possible number of elements  
In the case of single-parameters and commands, this value always is "1".
- **Parameter name (2)**  
→ 64-byte string with the characters of the parameter name  
Zero is written to unused characters after the end of the name.
- **SERCOS attribute (3)**  
→ 32 bits of the SERCOS attribute
- **Unit (4)**  
→ 16-byte string with the characters of the unit  
Zero is written to unused characters after the end of the unit.

## Error Codes

Error No.	Significance	Extended information
0x00	Parameter not available (previously 0x1001)	0
0x01	Parameter cannot be written (previously 0x7004)	Subindex
0x02	Value outside of limit values (previously 0x7006/0x7007)	Subindex
0x03	Subindex not available	Subindex
0x04	List access to single parameter	0
0x05	Access with incorrect data type (previously 0x7002/0x7003)	0

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Error No.	Significance	Extended information
0x07	Write access to write-protected element of description	Subindex
0x0B	Access not possible due to operating status (previously 0x7005)	0
0x0F	No parameter text available	0
0x15	Response data too long for telegram	0
0x17	Error in format	0
0x18	Writing beyond end of list	0
0x19	Access to nonexistent axis	0
0x65	Manufacturer-specific error code	SIS error code

Fig.4-72: Error Codes at Acyclic Parameter Access

Data Types

Data type	Code	SERCOS type
Integer 16	0x03	Decimal number with sign <sup>1)</sup>
Integer 32	0x04	Decimal number with sign <sup>1)</sup>
Unsigned 16	0x06	Binary, IDN, decimal number without sign <sup>1)</sup> , hexadecimal, command
Unsigned 32	0x07	Decimal number without sign <sup>1)</sup> , hexadecimal
Floating Point	0x08	
Visible String	0x09	Text
Error code	0x44	

1) Depending on bits 16 and 17 of SERCOS attribute

Fig.4-73: Data Types at Acyclic Parameter Access

### 4.7.5 Monitoring Functions and Diagnostic Functions

#### Monitoring Functions

**Watchdog for Cyclic Communication**

As a standard, the time required for the watchdog monitoring function is automatically calculated and configured by the configuration program of the master. It is displayed in parameter "P-0-4075, Field bus: watchdog" (in ms).



The entry

"0" in parameter "P-0-4075, Field bus: watchdog" means that the watchdog monitoring function has been deactivated!

**F4012 Incorrect I/O Length**

If the error message "F4012 Incorrect I/O length" is generated, the drive is in PROFIBUS status "Data\_Exchange"; the LED display "H30" is active. The parameter channel is working, but the data of the input and output module are not processed internally.

#### Diagnostic Possibilities

The status of the field bus master communication of an IndraDrive device is diagnosed via:

- LED display "H30" at the front panel of the controller

- and -

- Diagnostic parameter "P-0-4073, Field bus: diagnostic message".

**Diagnostic LED "H30"**

The LED display "H30" is active when the drive is in PROFIBUS status "Data\_Exchange". This means that the real-time data are exchanged between IndraDrive device and master.

**Parameter for Field Bus Diagnostic Message**

In parameter "P-0-4073, Field bus: diagnostic message" the status of the field bus master communication is stored in plain text. The contents of parameter P-0-4073 have the following significance:

Text	Significance
"OFFLINE"	Initialization value of the diagnostic message
"Power-On"	A PROFIBUS-DP card has been recognized as master communication and the hardware is checked.
"Baud-Search"	The hardware is okay; the PROFIBUS interface is monitored in order to recognize the baud rate used.
"Wait-Prm"	The baud rate has been found, the drive waits for a parameterization telegram of the master that contains its IDN (contained in the device data sheet).
"Wait-Cfg"	The IndraDrive device has received a valid parameterization telegram and now waits for the configuration telegram in which the master tells the drive which modules it is expecting for input/output configuration.
"Data-Exch WD+"	The drive has received a valid configuration, it exchanges real-time data with the master. The communication is monitored by a watchdog.
"Data-Exch WD-"	The drive has received a valid configuration. It exchanges real-time data with the master without the communication being monitored by a watchdog.

Fig.4-74: Significance of the Entries in Parameter P-0-4073

**Error Codes of PROFIBUS Communication**

**Parameter Channel Errors**

The table below contains an overview of the possible parameter channel error messages and their significances:

Error code	Significance
0x0082	Quantity of all transmitted data is too low, i.e. less than 4 bytes
0x0083	Quantity of data still to be transmitted is greater than the internal buffer
0x0088	The length of the valid data indicated in the control word is longer than the parameter channel
0x008C	Status conflict, a new request was sent although there are still data to be transmitted
0x008D	Length of data that are still to be transmitted indicated in the control word is incorrect

Fig.4-75: Overview Parameter Channel Errors

**DPV1 Errors**

The table below contains an overview of the possible DPV1 error messages and their significances:

Master Communication

Error code	Significance	Designation acc. to DPV1 standard
0x80 0xA0 0x00	The read request has a length of more than 10 bytes.	DPV1, access, read error
0x80 0xA1 0x00	The write request has a length of less than 11 bytes.	DPV1, access, write error
0x80 0xA9 0x00	DPV1 service not supported	DPV1, application, feature not supported
0x80 0xB0 0x00	No access to index 47.	DPV1, access, invalid index
0x80 0xB1 0x00	There isn't any DPV1 header available.	DPV1, access, write length error
0x80 0xB2 0x00	No access to slot 0.	DPV1, access, invalid slot
0x80 0xB3 0x00	Access is only allowed to the value of the object.	DPV1, access, type conflict
0x80 0xB5 0x00	Parameter request not yet received, therefore response not yet available.	DPV1, access, state conflict
0x80 0xB6 0x00	The parameter cannot be written.	DPV1, access, access denied
0x80 0xB8 0x00	It is only allowed to process one parameter in one access.	DPV1, access, invalid parameter
0x80 0xC0 0x00	The request is still processed, the read request has to be repeated.	DPV1, resource, read constrain conflict

Fig.4-76: Overview DPV1 Errors

Parameter Access Errors

The table below contains an overview of the possible parameter access errors and their significances; the error values are transmitted in word format:

Error No. (hex)	Significance
0x1001	No IDN
0x1009	Invalid access to element 1
0x2001	No name
0x2004	Name cannot be changed (read only)
0x3004	Attribute cannot be changed (read only)
0x4001	No units
0x4004	Unit cannot be changed (read only)
0x5001	No minimum input value
0x5004	Minimum input value cannot be changed (read only)
0x6001	No maximum input value
0x6004	Maximum input value cannot be changed (read only)
0x7002	Operation data transmission too short
0x7003	Operation data transmission too long
0x7004	Operation data cannot be changed (read only)



Error No. (hex)	Significance
0x7005	Operation data is write-protected at this time (e.g. communication phase)
0x7006	Operation data is smaller than minimum input value
0x7007	Operation data is greater than maximum input value
0x7008	Invalid operation data: Configured IDN will not be supported, invalid bit number or bit combination
0x7009	Operation data write protected by a password
0x700A	Operation data is write protected, it is configured cyclically
0x700B	Invalid indirect addressing (e.g. data container, list handling)
0x700C	Operation data is write protected, due to other settings (e.g., parameter, operation mode, drive enable, drive on etc.)
0x7010	Procedure command already active
0x7011	Procedure command not interruptible
0x7012	Procedure command at this time not executable (e.g., in this phase the procedure command cannot be activated)
0x7013	Procedure command not executable (invalid or false parameters)
0x9001	Input cannot be identified as application
0x9002	Parameter type error
0x9003	Invalid data set number
0x9004	Invalid data block number
0x9005	Data element number invalid
0x9006	Error in R/W flag
0x9007	Invalid character in the data

Fig. 4-77: Overview Parameter Access Errors

## 4.8 CANopen Interface

### 4.8.1 Brief Description

It is possible to operate IndraDrive controllers with a CANopen interface as master communication module. This requires the control section with the optional module "CANopen/DeviceNet" (CO). Via this optional module, it is possible to exchange real-time data with a CANopen master. The "CANopen" protocol (according to Draft Standard DS301, version 4.0.2) has been implemented in the drive controller.

#### Communication Channels

We distinguish the following communication channels:

- **Cyclic data channel** (process data objects → PDO)  
The field bus provides data containers in which useful data can be cyclically transmitted in real time (process data objects).
- **Acyclic data channel** (service data objects → SDO)  
The field bus provides data containers in which useful data (service data objects) can be acyclically transmitted.

## Master Communication




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The process data are always transmitted via PDOs.

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- Features**
- Simple configuration through use of "Predefined Connection Set" and "Minimal Boot-Up" according to DS301
  - Baud rates of 20, 50, 125, 250, 500, 800 and 1000 kbit/s specified by CANopen according to DS301 are supported
  - Configurable cyclic data up to 12 parameters (incl. field bus control word and field bus status word) in both data directions (max. 24 bytes or 12 words)
  - Functional compatibility with EcoDrive functions through profile selection (I/O mode)
  - Node monitoring (heartbeat function and node guard function)
  - LED displays at the front panel of the master communication module for simple diagnosis of bus functions and most important communication relationships between drive and field bus (2 LEDs: "Run" status and "Error" status)
  - All parameters of the drive can be directly read via SDO and, if permitted, can be written
  - Upload/download function for all parameters of the drive possible with SDO services
  - Event-controlled or synchronous transmission of process data
  - CANopen Device profile DSP402 is not supported; field bus profiles according to DSP402 are partly supported (see "Profile Types (With Field Bus Interfaces)")

**Hardware Requirements** The optional module with CANopen interface is available for the following configurable control sections:

- Single-axis BASIC UNIVERSAL (CSB01.1C)
- Single-axis ADVANCED (CSH01.xC)

**Pertinent Parameters** **Communication parameters**

Specific parameters for CANopen communication:

- P-0-3610, CANopen: Heartbeat/NodeGuard Configuration
- P-0-3611, CANopen: COB-IDs
- P-0-3612, CANopen: Transmission Types
- P-0-3613, CANopen: List of the Event Parameters

Parameters for general field bus communication:

- P-0-4025, Drive address of master communication
- P-0-4073, Field bus: diagnostic message
- P-0-4074, Field bus: data format
- P-0-4075, Field bus: watchdog
- P-0-4076, Field bus: cycle time (T<sub>cyc</sub>)
- P-0-4079, Field bus: baud rate

**Profile type parameters**

Apart from mere communication parameters, we use parameters in conjunction with the profile types.

See "Profile Types (With Field Bus Interfaces)"

**Parameters for extended communication**

We use additional parameters for extended communication.

See following sections:

- "Configurable Signal Control Word"
  - "Configurable Signal Status Word"
- Pertinent Diagnostic Messages**
- F4001 Sync telegram failure
  - F4002 RTD telegram failure
  - F4009 Bus failure
  - F4012 Incorrect I/O length

**4.8.2 Configuration CANopen Slave****EDS File**

Due to the object directory, there is an individual EDS file for each firmware. These files comply with the specifications according to DSP306 and are checked according to versions V3.01, V3.02 and V4.01. Their names consist of the firmware designation and "...\_Co.EDS":

- MPB05\_Co.EDS
- MPH05\_Co.EDS

**Setting the Node Address of the Slave**

The bus address can be set within the range of 1 to 99. This range is smaller than the range allowed for CANopen, as only 2 digits can be displayed.

- Setting is either made via the display or by means of the "IndraWorks Ds/D/MLD" commissioning tool.
- The node address is stored in parameter "P-0-4025, Drive address of master communication".
- A new node address can only be set during baud rate search and in the CANopen states "Initialized" (with CAN warning present) and "Stopped". The corresponding diagnostic messages in parameter "P-0-4073, Field bus: diagnostic message" are:
  - "CANopen: Auto Baudrate Detection"
  - "CANopen: Initialized CAN-Warning"
  - "CANopen: Stopped"
  - "CANopen: Stopped CAN-Warning"

See also section "Setting the Axis Address"

**Baud Rate Search/Baud Rate Input****Supported Transmission Rates**

All transmission rates specified by CANopen are supported. The bit timing corresponds to DS301 (version 4.0.2) and must have been implemented accordingly in the master.

Baud rate	Max. network dimension	Description
10 kBaud	5,000 m	
20 kBaud	2,500 m	Supported by baud rate search
50 kBaud	1,000 m	
125 kBaud	500 m	Supported by baud rate search

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Baud rate	Max. network dimension	Description
250 kBaud	250 m	Supported by baud rate search
500 kBaud	100 m	Supported by baud rate search
800 kBaud	50 m	
1000 kBaud	25 m	Supported by baud rate search

Fig.4-78: CANopen Transmission Rates

**Baud Rate Search**

The automatic baud rate search is activated by writing the value "0" to parameter "P-0-4079, Field bus: baud rate" or by the command "load defaults procedure". The search is carried out directly after switch-on. The first baud rate with which searching takes place after switching on again is the last one found. Baud rate search is signaled by both LED displays flickering. Baud rates which were found by baud rate search are displayed as negative numbers in parameter P-0-4079.

If baud rate search is not desired, it can be deactivated by writing the baud rate as a positive number to parameter P-0-4079. During operation it is possible to activate the baud rate search again or deactivate it after having switched on.

**Baud Rate Input**

Manual input of a different baud rate is possible during baud rate search and in the CANopen states "Initialized" (with CAN warning present) and "Stopped".

**Configuring the Cyclic Data**

The parameters for configuring the cyclic data (P-0-4080 and P-0-4081) contain 12 elements each of which four each have been reserved for each PDO. The data length of the configured PDOs may be 8 bytes as a maximum. "S-0-0000, Dummy parameter" as empty parameter must be assigned to entries which are not used. If a PDO only consists of empty parameters, it is deactivated.

Element in P-0-4080	PDO (tx)		Element in P-0-4081	PDO (rx)
0	PDO1 (tx)		0	PDO1 (rx)
1			1	
2			2	
3			3	
4	PDO2 (tx)		4	PDO2 (rx)
5			5	
6			6	
7			7	
8	PDO3 (tx)		8	PDO3 (rx)
9			9	
10			10	
11			11	

Fig.4-79: Configuring the Cyclic Data

## 4.8.3 Specifying the CANopen Interface

### General Information

There are 11 bits "CAN Identifier" used for transmission.

### Network Management Services

The network knows the following states:

- Initialising
- Pre-operational
- Operational
- Stopped

A change of status is triggered by reception of an NMT telegram or a reset. The current status is transmitted in the NMT error telegram and displayed by the "Run" LED (H4) at the drive. In addition, it can be read from the parameter for the diagnostic field bus message (P-0-4073).

After having been switched on, the drive is in status "Initializing". After initialization has been completed, the drive transmits an NMT error telegram (boot-up telegram) and automatically goes to status "Pre-Operational".

Overview of Network States  
(Allowed Telegrams)

Telegram type	Initialising	Pre-operational	Operational	Stopped
NMT	--	■	■	■
SYNC	--	■	■	--
NMT_Error	■	■	■	■
EMCY	--	■	■	--
SDO	--	■	■	--
PDO	--	--	■	--

Fig.4-80: Network States and Telegrams for CANopen

### NMT Telegrams

The NMT telegram consists of 2 bytes. The first byte contains the command, the second byte the address. The node accepts all telegrams which either contain "0" (the command is destined for all nodes) or its own node ID in the second byte.

- Start Remote Node (command byte = 1)  
→ Node is brought to status "Operational".
- Stop Remote Node (command byte = 2)  
→ Node is brought to status "Stopped".
- Enter Pre-Operational (command byte = 128)  
→ Node is brought to status "Pre-Operational"
- Reset Node (command byte = 129)  
Reset Communication (command byte = 130)  
→ Node is brought to status "Initializing" and after initialization goes to status "Pre-Operational"

Master Communication

Node Monitoring

**Types of Node Monitoring**

Node monitoring is carried out by heartbeat telegrams or the so-called "Node-Guarding".

**Heartbeat Mechanism**

With the heartbeat mechanism, each node transmits an NMT error telegram in intervals which have been set. Monitoring takes place independently of the master, as the node number of the node it monitors can be set in each node.

The heartbeat mechanism used ensures the following conditions:

- The physical availability of the transmitter.
- The bus load, as transmission takes place with the lowest priority.
- The network status of the transmitter.
- The availability of the transmitter and its data (watchdog).

The heartbeat telegrams transmit a 1-byte data:

- 0 → Boot-up message
- 4 → Node is in status "Stopped"
- 5 → Node is in status "Operational"
- 127 → Node is in status "Pre-Operational"

**Heartbeat Interval**

The calculation of the heartbeat interval uses the number of nodes at the bus and the baud rate. As an estimated value, 1500 bit times can be provided for each node (including master). The interval is calculated according to the following relationship:

$$T = \frac{1500 \times n}{f}$$

T interval  
 n number of nodes in network (incl. master)  
 f baud rate

*Fig.4-81: Calculating the Heartbeat Interval*

An interval should have a minimum duration of 10 ms. At least the double value should be selected as monitoring time for received heartbeat telegrams (consumer). The table below contains some combinations of node number and baud rate to determine the transmission interval.

Number of nodes	Baud rate (in kBaud)				
	20	125	250	500	1000
2	150 ms	24 ms	12 ms	10 ms	10 ms
3	225 ms	36 ms	18 ms	10 ms	10 ms
4	300 ms	48 ms	24 ms	12 ms	10 ms
5	375 ms	60 ms	30 ms	15 ms	10 ms
10	750 ms	120 ms	60 ms	30 ms	15 ms
15	1125 ms	180 ms	90 ms	45 ms	23 ms
20	1500 ms	240 ms	120 ms	60 ms	30 ms
30	2250 ms	360 ms	180 ms	90 ms	45 ms

Number of nodes	Baud rate (in kBaud)				
	20	125	250	500	1000
40	3000 ms	480 ms	240 ms	120 ms	60 ms
50	3750 ms	600 ms	300 ms	150 ms	75 ms
60	4500 ms	720 ms	360 ms	180 ms	90 ms
70	5250 ms	840 ms	420 ms	210 ms	105 ms
80	6000 ms	960 ms	480 ms	240 ms	120 ms
90	6750 ms	1080 ms	540 ms	270 ms	135 ms
100	7500 ms	1200 ms	600 ms	300 ms	150 ms
127	9525 ms	1524 ms	762 ms	381 ms	191 ms

Fig.4-82: Combinations of Node Number, Baud Rate and Transmission Interval

When the drive has been configured as heartbeat consumer and the transmitter is not in status "Operational", this is signaled by the "Error" LED (H5) flashing twice.

If after the Heartbeat Consumer Time there has not any NMT error telegram been received from the node to be monitored, a "Heartbeat Event" is triggered which in most cases results in the error message "F4009 Bus failure" (see Troubleshooting Guide for F4009).

### Node Guarding

With the Node Guarding method, the master queries the individual nodes one after the other with an RTR request with regard to the NMT error telegram. The node replies with a Node Guard Telegram (NMT error).

The Node Guarding mechanism used ensures the following conditions:

- For the master:
  - Physical availability of the node which has been queried
  - Bus load, as transmission takes place with the lowest priority
  - Network status of the node which has been queried
  - Availability of the node which has been queried and its data (watchdog)
- For the node which has been queried:
  - Physical availability of the master
  - Bus load, as the request takes place with the lowest priority
  - Availability of the master and its data (watchdog)

The Node Guard Telegrams transmit a 1-byte data to the master with the following significance:

- 0 → Boot-up message
- 4 → Node is in status "Stopped"
- 5 → Node is in status "Operational"
- 127 → Node is in status "Pre-Operational"

### Configuring the Node Monitoring

The behavior of node monitoring is configured in parameter "P-0-3610, CANopen: Heartbeat/NodeGuard Configuration". The required data are stored in this parameter as a 2-byte list containing 5 elements:

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- element 0  
→ Heartbeat Producer Time (in ms); function is switched off with default value "0"
- element 1  
→ Heartbeat Consumer Time (in ms); monitoring is switched off with default value "0"
- element 2  
→ Node ID of the node to be monitored (valid values are 1 to 127); default value is "127"
- element 3  
→ Node Guard Time (in ms); function is switched off with default value "0"
- element 4  
→ Life Time Factor (valid values 1 to 255); default value is "3"

Only one of the two monitoring types may have been activated. Therefore, a check is run when writing data to the parameter P-0-3610 to find out whether either "Heartbeat" was switched off (elements 0 and 1 at "0") or "Node Guarding" was deactivated (element 3 at "0").

### 4.8.4 Cyclic Communication via Process Data Channel (PDO)

#### Characteristics of PDO Communication

The drive firmware supports 3 PDO(tx) and 3 PDO(rx) which can be freely configured:

- PDO1(tx) to PDO3(tx)  
→ Data length 2 to 8 bytes; can be configured via P-0-4080
- PDO1(rx) to PDO3(rx)  
→ Data length 2 to 8 bytes; can be configured via P-0-4081

#### List of Transmission Types

The transmission types are set in parameter "P-0-3612, CANopen: Transmission Types". The individual bits of the list parameter have the following significance:

Element	Description	Valid values
0	PDO1 (tx)	0, 1, 252, 253 and 254
1	PDO1 (rx)	0, 1, 252, 253 and 254
2	PDO2 (tx)	0, 1, 252, 253 and 254
3	PDO2 (rx)	0, 1, 252, 253 and 254
4	PDO3 (tx)	0, 1, 252, 253 and 254
5	PDO3 (rx)	0, 1, 252, 253 and 254
6	--	Reserved
7	--	Reserved

Fig.4-83: List of Transmission Types in Parameter P-0-3612

#### Transmission Type "254"

The transmission type corresponding to value "254" has the following characteristics:



- PDO(rx) is applied with every "command value copying cycle" on the time base of the field bus cycle time (P-0-4076)
- PDO(tx) is updated with every "actual value copying cycle" on the time base of the field bus cycle time (P-0-4076); current data can be queried by means of RTR
- PDO(tx) is transmitted, when:
  - Data of an event parameter was changed (see "P-0-3613, CANopen: List of the Event Parameters")
  - or -
  - Fourfold heartbeat or node guard time has passed since last transmission (heartbeat or node guard time must have been set greater than zero)

**Transmission Type "253"** The transmission type corresponding to value "253" has the following characteristics:

- PDO(rx) is applied with every "command value copying cycle" on the time base of the field bus cycle time (P-0-4076)
- PDO(tx) is updated with every "actual value copying cycle" on the time base of the field bus cycle time (P-0-4076)
- PDO(tx) is transmitted as soon as data are queried by means of RTR

**Transmission Type "252"** The transmission type corresponding to value "252" has the following characteristics:

- See transmission type "253"
- **Additionally**, SYNC telegram tries to synchronize internal clock of the drive controller

**Transmission Type "1"** The transmission type corresponding to value "1" has the following characteristics:

- SYNC telegram tries to synchronize internal clock of the drive controller; in the case of double telegram failure, error message "F4001 Sync telegram failure" is generated
- PDO(rx) is applied with every "command value copying cycle" (is in last position loop clock before SYNC telegram) on the time base of the field bus cycle time (P-0-4076)
- PDO(rx) reception is monitored
  - In the case of one-time failure, new command values are calculated from the previous values; In the case of double failure, the error message "F4002 RTD telegram failure" is generated.
- PDO(tx) is updated with every "actual value copying cycle" (is in first position loop clock after SYNC telegram) on the time base of the field bus cycle time (P-0-4076)
- PDO(tx) is transmitted in interval of field bus cycle time; transmission starting time is directly after update of data
- Only PDO1 is supported

**Transmission Type "0"** The transmission type corresponding to value "0" has the following characteristics:

- See transmission type "1" but PDO(rx) reception is **not monitored**



With IndraDrive devices, the last position loop clock is considered as blocking time in which it is not allowed to transmit any synchronous process data object (PDO).

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**Minimum Supported Cycle Time (Bus Cycle Time)**

Depending on the position loop clock, the IndraDrive firmware supports the following minimum cycle times:

Position loop clock (in ms)	Min. bus cycle time (in ms)
0,125	1
0,250	1
0,500	2
1	4

Fig.4-84: Bus Cycle Time Depending on Position Loop Clock

**List of the Event Parameters**

All parameters of the drive which are suited for event-controlled transmission are listed in parameter "P-0-3613, CANopen: List of the Event Parameters". If one of these parameters has been configured as actual value, the corresponding PDO is immediately transmitted when the data is changed. The minimum possible interval between two telegrams is determined with the field bus cycle time (P-0-4076).

**List of COB-IDs**

The COB-IDs used (the CAN identifiers used by these telegrams) are stored in parameter "P-0-3611, CANopen: COB-IDs". When the most significant bit (inactivity bit) has been set, the telegram is deactivated. This bit is set depending on the PDOs required for cyclic communication.

Element of parameter	PDO	Standard value
0	PDO1 (tx)	0x180 + node ID
1	PDO1 (rx)	0x200 + node ID
2	PDO2 (tx)	0x280 + node ID
3	PDO2 (rx)	0x300 + node ID
4	PDO3 (tx)	0x380 + node ID
5	PDO3 (rx)	0x400 + node ID
6	--	Reserved
7	--	Reserved
8	EMCY	0x080 + node ID
9	SYNC	0x080 (rx) or 40000080 (tx)

Fig.4-85: Assignment of Elements of Parameter P-0-3611

The drive can work both as SYNC consumer (rx) and as SYNC producer (tx).

**SYNC Consumer**

As soon as a synchronous transmission type has been selected and SYNC-COB-ID is at "0x80" (rx), the drive during the transition "PM → OM" switches to synchronous operation and tries to synchronize to a SYNC telegram. As soon as this has happened, the drive switches to operating status "bb".

If a different IndraDrive device is used as SYNC producer in the network, the bus runtime of the SYNC telegram can be corrected with a PLL offset. This PLL offset is activated via bit 8 of parameter "P-0-4088, Master communication: Drive configuration".

If the jitter of the SYNC telegram is too big, you can activate a "smoother" PLL control via bit 7 of parameter P-0-4088.

For synchronous operation the baud rates displayed in the tables below are supported by means of the corresponding PLL controls.

Baud rate (in kBaud)	PLL control	
	"Hard"	"Soft"
1000	■	■
800	■	■
500	■	■
250	--	■

Fig.4-86: xxx

#### SYNC Producer

If the SYNC-COB-ID is at "0x40000080" (tx) and a synchronous transmission type has been selected, the drive during the transition "PM → OM" switches to synchronous operation and transmits a SYNC telegram to synchronize the other bus nodes to itself. As the drive itself is a SYNC producer, it immediately switches to the operating status "bb".



In the network, only one node may have been configured as "SYNC producer".

## 4.8.5 Acyclic Parameter Access (SDO)

All parameters of the drive can be reached by means of SDO access. The following COB-IDs are assigned in a fixed way (standard conform):

- SDO(tx) → 0x580 + Node-ID
- SDO(rx) → 0x600 + Node-ID

The following SDO services are supported:

- **SDO Download**  
→ To write a maximum of 4 bytes of data to the drive
- **Initiate SDO Download**  
→ To write more than 4 bytes of data to the drive (with "Initiate" the length of the data is transmitted)
- **Download SDO Segment**  
→ To transmit a fragment with data to the drive
- **SDO Upload**  
→ To transmit a maximum of 4 bytes of data from drive to master
- **Initiate SDO Upload**  
→ To transmit more than 4 bytes of data from drive to master (drive informs master of length of response data)
- **Upload SDO Segment**  
→ To transmit a fragment with data from drive to master
- **Abort SDO Transfer**  
→ To report errors and abort SDO accesses

## 4.8.6 CANopen Objects

### Communication Objects (0x1000 to 0x1FFF)

The communication objects are described in the CANopen standard DS301. Within the CANopen communication, these objects have one of the following functions:

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- Access to Drive Parameters
- Constants
- Read-only objects

The table below contains an overview of the **objects specified** for CANopen communication:

Index	Subindex/ SubNumber	Description	Parameters
0x1000	0x00	ParameterName = Device Type ObjectType = 0x7 DataType = 0x7 DefaultValue = 0x00000192 AccessType = ro	0x00FF0192
0x1001	0x00	ParameterName = Error Register ObjectType = 0x7 DataType = 0x5 AccessType = ro	
0x1018	5	ParameterName = Identity Object ObjectType = 0x9	
	0x00	ParameterName = Number Of Entries DataType = 0x5 DefaultValue = 4 AccessType = ro	
	0x01	ParameterName = Vendor ID DataType = 0x7 DefaultValue = 0x24 AccessType = ro	36
	0x02	ParameterName = Product Code DataType = 0x7 DefaultValue = 0x4 AccessType = ro	4
	0x03	ParameterName = Revision Number DataType = 0x7 AccessType = ro	P-0-1509: element 5 (release)
	0x04	ParameterName = Serial Number DataType = 0x7 AccessType = ro	P-0-1509: element 3 (serial no.)

Fig.4-87: Specified CANopen Objects



Other communication objects of the CANopen interface are listed in the annex of the separate documentation "Rexroth IndraDrive, Parameter Description" and in the corresponding EDS file.

## Manufacturer-Specific Objects (0x2000 to 0x3FFF)

**Manufacturer-Specific Object** All parameters of the drive can be reached via the manufacturer-specific objects. The S-parameters are addressed via the objects 0x2000 to 0x2FFF, the P-parameters via the objects 0x3000 to 0x3FFF. The manufacturer-specific objects have the following structure:

Subindex	Description
0	Number of parameter sets (1 or 8)
1	Operating data block 0
2	Operating data block 1 (if available)
3	Operating data block 2 (if available)
4	Operating data block 3 (if available)
5	Operating data block 4 (if available)
6	Operating data block 5 (if available)
7	Operating data block 6 (if available)
8	Operating data block 7 (if available)
10	Index of list pointer
11	List element to which element 10 points (only for list parameter)
12...18	List element to which element 10 points (if 8 parameter sets available); only for list parameter
21	Name of parameter
22...28	Name of parameter (if 8 parameter sets available)
31	Attribute of parameter
32...38	Attribute of parameter (if 8 parameter sets available)
41	Unit of parameter
42...48	Unit of parameter (if 8 parameter sets available)
51	Minimum value of parameter
52...58	Minimum value of parameter (if 8 parameter sets available)
61	Maximum value of parameter
62...68	Maximum value of parameter (if 8 parameter sets available)
71	Maximum length of list parameter
72...78	Maximum length of list parameter (if 8 parameter sets available)
81	Actual length of list parameter
82...88	Actual length of list parameter (if 8 parameter sets available)

Fig. 4-88: Structure of Manufacturer-Specific Objects

**List Access** The complete list of a list parameter can be read or written by accessing the operating data of the parameter.

To access individual list elements, it is possible to set a list index (subindex 10) and access the respective list element of the list index via subindex 11 (to subindex 18). With each access via subindex 11 (to subindex 18), the list index is

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incremented by one element. This allows processing a continuous part of a list in the case of repeated access to subindex 11 (to subindex 18).

With one of the following actions, the list index is reset to the first element:

- Change of parameter set
- Change of parameter
- Abortion of connection

For each list element access which does not start from the first element, it is therefore necessary to set the list index.

If the length of the list has to be changes, this can be corrected by changing the actual length of the list parameter (subindex 81...88).

The maximum list length can be read via the subindices 71...78.

With one of the following actions, the parameter value is stored:

- Writing to last element
- Change to a different parameter
- Change of parameter set
- Reading the same parameter
- Abortion of connection

The changes are discarded when the control voltage fails.

### 4.8.7 Notes on Commissioning

Commissioning the CANopen interface requires the following individual steps:

1. Before switching drive on, set switch above CAN connector to "CAN". After that you can switch drive on.
2. To set address (see also section "Setting the Axis Address") it is advantageous not yet to connect CAN connector to drive controller. In this case, drive always is in status in which address may be changed.
3. If baud rate is known, it should be preset in parameter P-0-4079. Drive thereby establishes communication faster. In addition, this helps avoid possible problems of master with nodes of automatic baud rate detection in network.
4. Configure cyclic data (see also section "Profile Types (With Field Bus Interfaces)").
5. If node monitoring is desired, it should be configured (see above "Node Monitoring").
6. Transmit telegram "Start Remote Node" (see above "NMT Telegrams") for drive or for all nodes. After that, cyclic data are exchanged by PDOs.

### 4.8.8 Diagnostic Messages and Monitoring Functions

#### Diagnostic LED

The diagnostic LED displays are controlled according to standard DS303-3 V1.2. There are two LEDs at the front of the optional module CO; with master communication "CANopen" their displays have the significances described below.

**LED Display "Run" (H4, Green)** Behavior of "Run" LED (H4; green) according to DS303-3:

Behavior of LED "H4"	Status	Significance
LED flickers	Auto-baudrate	Drive searches baud rate.
LED flashes	Pre-operational	Drive is in CANopen status "Pre-Operational".
LED flashes shortly	Stopped	Drive is in CANopen status "Stopped"
LED permanently lit	Operational	Drive is in CANopen status "Operational".

Fig.4-89: Behavior and Significance of "Run" LED (H4)

LED Display "Error" H5 (H5, Red)

Behavior of "Error" LED (H5; red) according to DS303-3:

Behavior of LED "H5"	Status	Significance
LED off	No error	CANopen interface works without error.
LED flickers	Auto-baudrate	Drive searches baud rate.
LED flashes once	Warning	CAN controller detected many errors during transmission or reception of telegrams.
LED flashes twice	Node Monitoring	Master no longer transmits heartbeat telegram (or no longer transmits NodeGuard request) or is not in status "Operational" while drive is in "Operational".
LED permanently lit	Bus-Off	CAN controller detected too many errors during transmission or reception of telegrams and has switched off.

Fig.4-90: Behavior and Significance of "Error"-LED (H5)

CANopen - Diagnostic Messages

Depending on the CANopen status and the transmission errors on the CAN bus, a diagnostic message is generated which can be read via parameter "P-0-4073, Field bus: diagnostic message".

Diagnostic message	Significance
CANopen: Offline	CANopen task is initialized.
CANopen: Auto Baudrate Detection	Drive searches baud rate (see "Baud Rate Search/Baud Rate Input").
CANopen: Initialised	Initialization was run after switch-on or after a reset, a boot-up telegram is to be transmitted.
CANopen: Initialised CAN-Warning	In status "Initialized" too many errors were detected on CAN bus, CAN interface is in status "Warning". This status mostly means that boot-up telegram could not be transmitted.  Possible causes: Drive (currently) is only node at bus or there is node with different baud rate at bus.
CANopen: pre-operational	Boot-up telegram was sent, drive now is in status "Pre-Operational". Parameters can be read and written by means of SDO.

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Diagnostic message	Significance
CANopen: Pre-Operational CAN-Warning	In status "Pre-Operational", too many errors were detected on CAN bus, CAN interface is in status "Warning".
CANopen: operational	Drive exchanges cyclic data (see "List of Transmission Types").
CANopen: Operational (only producer)	By received heartbeat telegram, master detected that heartbeat transmitter does not send any PDO due to network status.
CANopen: Operational CAN-Warning	In status "Operational", too many errors were detected on CAN bus, CAN interface is in status "Warning".
CANopen: stopped	Drive is in status "Stopped". In this status, drive only receives NMT commands. It is now possible to change basic communication parameters, such as baud rate or address.
CANopen: Stopped CAN-Warning	In status "Stopped", too many errors were detected on CAN bus, CAN interface is in status "Warning".
CANopen: BUS-OFF	CAN interface detected too many transmission errors and received incorrect telegrams. Possible causes are, among other things, disturbances on bus cable, short circuits, interruptions of bus cable or nodes with different baud rates at bus.
CANopen: BUS-OFF (RxCounter = 0)	CAN interface detected too many transmission errors. Most likely there wasn't any telegram received or received telegrams were not error-free.

Fig.4-91: Overview of Diagnostic Messages for CANopen Communication

Emergency Object

When an error occurs or is cleared, an EMCY telegram is transmitted. The EMCY telegram transports 8-byte data.

0	1	2	3	4	5	6	7
0xFF00		0x81	P-0-0009		S-0-0390 (three least significant bytes)		

Fig.4-92: Error Telegram

0	1	2	3	4	5	6	7
0x0000		0x00	P-0-0009		S-0-0390 (three least significant bytes)		

Fig.4-93: Error-Cleared Telegram

IndraDrive - Diagnostic Error Messages

IndraDrive's diagnostic error messages and their significances in conjunction with CANopen master communication:

- F4001 Sync telegram failure  
→ In two successive cycles, there hasn't any SYNC telegram been received.
- F4002 RTD telegram failure



- In two successive cycles, there hasn't any cyclic PDO telegram been received.
- F4009 Bus failure
  - Within the "Heartbeat Consumer Time" there was not heartbeat telegram received.
  - or -
  - Within the "Life-Time-Counter"-fold "Node-Guarding-Time" there was no Node Guarding request received.
- Note:** With the corresponding setting in parameter "P-0-4088, Master communication: Drive configuration" (bits 1 and 2) this error message can be replaced by the warning "E4005 No command value input via master communication" (see also "Emergency Mode (When Master Communication has Failed)").
- F4012 Incorrect I/O length
  - A PDO telegram was received which had a different length than the configured length.

## 4.9 DeviceNet Interface

### 4.9.1 Brief Description

It is possible to operate IndraDrive controllers with a DeviceNet interface as master communication module. This requires the control section with the optional module "CANopen/DeviceNet" (CO). Via this optional module, it is possible to exchange real-time data with a DeviceNet master. The drive supports the protocol "DeviceNet" according to ODVA version 2.0.

We distinguish the following communication channels:

- **Cyclic data channel** (polled I/O)
 

The field bus provides data containers in which useful data can be cyclically transmitted in real time.
- **Acyclic data channel** (Explicit Message)
 

The field bus provides an object directory of the device. The objects can be acyclically read and, if allowed, can be written.



The process data are always transmitted via "polled I/O".

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To achieve the highest possible system flexibility, all parameters of the drive are accessible via objects. With DeviceNet, these objects can be addressed through class, instance and attribute. Some of these objects can be assigned to the "polled I/O" as real-time data and thus be cyclically transmitted. There is also the option of transmitting via "Explicit Message", but no objects defined in the real-time channel (P-0-4081) may be written by the master via "Explicit Message".

- Features**
- DeviceNet interface completely galvanically decoupled
  - "Open Pluggable Connector" according to specification 2.0 (Phoenix COMBICON connector)
  - "DeviceNet Generic Device" according to specification ODVA 2.0
  - Easy configuration by implementing "Group 2 only Server"
  - All data rates supported:
    - 125 kbit/s (up to a distance of 500 m)

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- 250 kbit/s (up to a distance of 250 m)
- 500 kbit/s (up to a distance of 100 m)
- Freely configurable process data channel (max. 24 words, max. 15 IDN) in both data directions via drive parameters P-0-4080 and P-0-4081
- Monitoring of the process data channel (watchdog function)
- All parameters of the drive can be acyclically read via "Explicit Message" and, if allowed, can be written
- LED displays at the front panel of the master communication module for simple diagnosis of bus functions and most important communication relationships between drive and field bus (2 LEDs: module status and network status)

- Hardware Requirements** The optional module with DeviceNet interface is available for the following configurable control sections:
- Single-axis BASIC UNIVERSAL (CSB01.1C)
  - Single-axis ADVANCED (CSH01.1C)

**Pertinent Parameters** **Communication parameters**

Parameters for general field bus communication (incl. DeviceNet):

- P-0-4025, Drive address of master communication
- P-0-4073, Field bus: diagnostic message
- P-0-4074, Field bus: data format
- P-0-4075, Field bus: watchdog
- P-0-4076, Field bus: cycle time (T<sub>cyc</sub>)
- P-0-4079, Field bus: baud rate

**Profile type parameters**

Apart from mere communication parameters, we use parameters in conjunction with the profile types.

See "Profile Types (With Field Bus Interfaces)"

**Parameters for extended communication**

We use additional parameters for extended communication.

See following sections:

- "Configurable Signal Control Word"
- "Configurable signal status word"
- " Multiplex channel"

- Pertinent Diagnostic Messages**
- F4009 Bus failure
  - F4012 Incorrect I/O length

## 4.9.2 Configuration DeviceNet Slave

### EDS File

For each DeviceNet device it is necessary to have an EDS file (\*.EDS) which contains the data required for operating the device on the field bus. This file, when configuring the bus master, is required for each node.

The EDS file for IndraDrive is an ASCII file with the name "IndraDrive\_DVN.EDS".

## Setting the Node Address of the Slave

The address determines the priority of data sent by of the slave, with the lowest address having the highest priority. Usually, the master has the highest priority and therefore the lowest address. Each DeviceNet node has to transmit data on the bus unequivocally assigned to it. According to the DeviceNet specification, this requires a slave address (MAC ID) that is unequivocal for the whole bus.

This address is set in parameter "P-0-4025, Drive address of master communication".

According to ODVA 2.0, the address can be set within the range of 1 to 63.

The node address of the slave in parameter P-0-4025 can only be changed, when the 24V supply voltage of the DeviceNet interface (Sense bus) has been switched off!

See also section "Setting the Axis Address"

## Baud Rate Search/Baud Rate Input

The baud rate used by the DeviceNet field bus is set in parameter "P-0-4079, Field bus: baud rate" (in kBaud). Possible baud rates are 125 kBaud, 250 kBaud and 500 kBaud.

### Baud Rate Search

The automatic baud rate search is activated by writing the value "0" to parameter P-0-4079 or by the command "load defaults procedure". The search is carried out directly after switch-on. The LEDs "module status" (H4) and "network status" (H5) are switched off. The parameter "P-0-4073, Field bus: diagnostic message" displays the status "BAUD SEARCH". Baud rates which were found by baud rate search are displayed as negative numbers in parameter P-0-4079. The baud rate which was found is at the same time the start value for repeated baud rate search after the control section has been switched on again.

If baud rate search is not desired, it can be deactivated by writing the baud rate as a positive number to parameter P-0-4079. During operation it is possible to deactivate the baud rate search after having switched on.



With low bus load, the baud rate search might possibly fail. The baud rate should therefore be set to a fixed value, if possible.

## Configuring the Cyclic Data

The parameters for configuring the cyclic data (P-0-4080 and P-0-4081) can contain a maximum of 15 elements each. The maximum length is limited to 24 words.

These parameters are set via the commissioning tool "IndraWorks Ds/D/MLD".



Changes in the settings are only applied by reinitializing the DeviceNet card (switching 24V bus voltage off), or by restarting the drive.

## 4.9.3 Specifying the DeviceNet Interface

The module uses the "Predefined Master/Slave Connection Set" and works as Group-2-Only Server.

The implemented DeviceNet object directory contains the objects "Identity Object" (class 1), "Message Router Object" (class 2), "DeviceNet Object" (class 3),

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"Assembly Object" (class 4), "Connection Object" (class 5), as well as a vendor-specific object (class 100), which are obligatory for a Generic Device.

Addressing takes place with 8-bit values for class and attribute and 16-bit values for the instance.

### 4.9.4 Cyclic Communication via Process Data Channel (Polled I/O)

The cyclic channel (polled I/O) is generated by parameterization of "P-0-4080, Field bus: config. list of cyclic actual value data ch." und "P-0-4081, Field bus: config. list of cyclic command value data ch."

On the DeviceNet level, a static Output Assembly Object (class 4, instance 101) and a static Input Assembly Object (class 4, instance 102) are transmitted in the cyclic channel.

### 4.9.5 Acyclic Parameter Access (Explicit Message)

#### Addressing the Objects

For DeviceNet communication the objects are addressed according to the following scheme:

Class → instance → attribute

- Class** All parameters of the drive are mapped to the manufacturer-specific class 100.
- Instance** The instance number is identical to the IDN of the drive parameter.

Bit	Significance
15	0: Standard data (standardized) 1: Product data (specified by the manufacturer)
14 ... 12	Parameter sets from 0 to 7
11 ... 0	Data block number from 0 to 4095

Fig.4-94: Structure of the IDN

- Attribute** The attribute number depends on the format of the drive parameter.

The operating data can have four different formats:

- Data length 2 bytes → **W**
- Data length 4 bytes → **L**
- ASCII text with max. length of 64 bytes → **T**

There are three types of parameters:

- Single parameters
- Command parameters
- List parameters

Independent of its type, each parameter has these attributes (read-only):

No.	Name	Function	Format
0	Number of elements	Number of supported elements	W
1	IDN	SERCOS IDN	T[8]
2	Name	Parameter name	T[60]
3	Attribute	Display mode of the parameter	L
4	Unit	Parameter unit	T[12]

No.	Name	Function	Format
5	Min. input value	Min. possible value of the data	W/L/T
6	Max. input value	Max. possible value of the data	W/L/T

Fig.4-95: Basic Attributes of a Drive Parameter

Depending on its type, each parameter has other attributes of different significance:

No.	Name/function	Format
7	Operating data	W/L/T
8	Max. number of list elements / length of text	L
9	Actual number of list elements / length of text	L
10	Pointer to the data which is processed at the next access to element 7	L
11	Action for 1 list element	W/L/T
12	Action for 2 list elements	W/L/T
13	Action for 3 list elements	W/L/T
14	Action for 4 list elements	W/L/T
15	Action for 5 list elements	W/L/T
16	Action for 6 list elements	W/L/T
17	Action for 7 list elements	W/L/T
18	Action for 8 list elements	W/L/T
19	Action for 9 list elements	W/L/T
20	Action for 10 list elements	W/L/T

Fig.4-96: Type-Dependent Attributes of a Drive Parameter

### Accessing Single Parameters

The value can be accessed by writing and reading the operating data of the parameter. For single parameters, the number of attributes is the value "7".

### Accessing Texts

The value can be accessed by writing and reading the operating data of the parameter. The maximum length of the text and the actual length of the text can be read with attributes 8 and 9. With access to parameter texts, the number of attributes is the value "9".

### Accessing Command Parameters

A command can be started by writing "3" to the operating data, the command status is obtained by read-accessing the operating data. With access to command parameters, the number of attributes is the value "7".

### Accessing List Parameters

The maximum list size can be determined by reading the maximum quantity of data of the parameter (attribute 8). The real size is stored in the actual quantity of data of the parameter (attribute 9) and can be modified unless the list is write-protected. All data refer to the parameter format. The pointer to the data (attribute 10) determines which data in the list is processed. If it points to zero,

## Master Communication

the first element is accessed. To simplify access the pointer is automatically modified in the following situations:

- Zero is loaded when changing from another parameter to this parameter.
- After each access to the operating data, the pointer is incremented by the number of elements which were read.

By access to attribute 11 one element is processed, to attribute 12 two elements are processed etc. up to attribute 20 for processing 10 elements. With access to list parameters, the number of attributes is the value "20".



For successful access to the operating data, the pointer must be smaller than the actual length.

**Example** Parameter P-0-0072 has 18 list elements and is to be read:

- Read: class 100, instance 8048h, attribute 9h = 12h (actual length)
- Write: class 100, instance 8048h, attribute Ah = 0h (list pointer)
- Read: class 100, instance 8048h, attribute Bh = element 0  
→ List pointer now automatically pointing to 1
- Read: class 100, instance 8048h, attribute 14h = elements 1 to 10  
→ List pointer now automatically pointing to 11
- Read: class 100, instance 8048h, attribute Ch = elements 11, 12  
→ List pointer now automatically pointing to 13
- Read: class 100, instance 8048h, attribute Fh = elements 13 to 17  
→ List pointer now automatically pointing to 18 (12h)
- Read: class 100, instance 8048h, attribute Ah = 12h (pointer)

Another access to the operating data would not supply any data without loading the list pointer again (list pointer = actual length). The number of attributes supplies the value "20".

## Storing List Elements

List elements are not directly stored in permanent form. Storage takes place by one of the following actions:

- Writing the last element of the list
- Read-accessing the list
- Accessing a different parameter
- Abortion of connection

When the control voltage fails, all changes which were not stored are cleared!

## Error Codes at Parameter Access

When a vendor-specific error occurs at parameter access, the additional error code provides hints at the cause of the error.

Error number (hex)	Significance
0x02	Parameter transmitted too short
0x03	Parameter transmitted too long
0x04	Parameter cannot be changed
0x05	Parameter is write-protected at this time
0x06	Value is smaller than minimum input value

Error number (hex)	Significance
0x07	Value is greater than maximum input value
0x08	Incorrect value
0x09	Parameter is password-protected
0x0A	Parameter write-protected, as cyclically configured in MDT
0x0B	Invalid indirect addressing
0x0C	Parameter is write protected at this time, due to other settings (parameter, operation mode, drive enable...)
0x10	Procedure command already active
0x11	Procedure command not interruptible
0x12	Procedure command at this time not executable (e.g., in this phase procedure command cannot be activated)
0x13	Procedure command not executable (invalid or false parameters)

Fig.4-97: Error Codes and Their Significances at Parameter Access

## 4.9.6 Notes on Commissioning

Commissioning the DeviceNet interface requires the following individual steps:

1. Before switching drive on, set switch above bus connector to "DVN". After that you can switch drive on.
2. To set address (see also "Setting the Axis Address") it is advantageous not yet to connect DeviceNet connector to drive. In this case, drive always is in status in which address may be changed.
3. If baud rate is known, it should be preset in parameter P-0-4079. Drive thereby establishes communication faster. In addition, this helps avoid possible problems of master with nodes of automatic baud rate detection in network.
4. Configure cyclic data (see also section "Profile Types (With Field Bus Interfaces)").



The communication parameters "P-0-4025, Drive address of master communication" and "P-0-4079, Field bus: baud rate" can only be changed, when the 24V supply voltage of the DeviceNet interface (Sense bus) has been switched off. The parameter "P-0-4075, Field bus: watchdog" is for display only and corresponds to the 4-fold "Expected Packet Rate" set by the DeviceNet master.

## 4.9.7 Diagnostic Messages and Monitoring Functions

### Diagnostic LED

#### LED Display "Module Status" (H4)

There are two LEDs at the front of the optional module CO; with master communication "DeviceNet" their displays have the significances described below.

The LED display "module status" (H4) displays the status of the "DeviceNet Identity Object":

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Behavior of LED "H4"	Significance/status
LED off	No control voltage available
LED flashes green/red	Device self test active
LED flashes green	Device "Standby"
LED permanently lit green	Device "Operational"
LED flashes red	Device "Major Recoverable Fault"
LED permanently lit red	Device "Major Unrecoverable Fault"

Fig.4-98: Behavior and Significance of Module Status LED

LED Display "Network Status" (H5)

The LED display "network status" (H5) displays the network status of the DeviceNet master communication:

Behavior of LED "H5"	Significance/status
LED off	Device "Offline"
LED flashes green	"Online" but no connection to master
LED permanently lit green	"Online" and connection to master
LED flashes red	Polled I/O connection "Timed Out"
LED permanently lit red	Critical connection error

Fig.4-99: Behavior and Significance of Network Status LED

DeviceNet - Diagnostic Messages

The parameter "P-0-4073, Field bus: diagnostic message" displays the current status of the DeviceNet master communication:

Diagnostic message	Significance
BAUD SEARCH	Automatic baud rate search is active.
DEVICE_SELF_TESTING	Automatic self test is active.
OPERATIONAL	"Operational", no connection to master
POLLED IO	"Operational" and connection to master, real-time data are processed.
POLLED IO IDLE	"Operational" and connection to master, real-time data are <b>not</b> processed.
RECOVERABLE_FAULT	A recoverable error is present.
UNRECOVERABLE_FAULT	An <b>unrecoverable</b> error is present.

Fig.4-100: Overview of Diagnostic Messages for DeviceNet Communication

In case an unrecoverable error occurs and its cause can be determined, one of the following possible error messages is displayed in parameter P-0-4073 instead of "UNRECOVERABLE\_FAULT":

Diagnostic message	Significance
DUP_MAC_ERROR	Duplicate MAC Check error
RX_QUEUE_OVERRUN	Overflow of Rx queue
TX_QUEUE_OVERRUN	Overflow of Tx queue
IO_SEND_ERROR	Error when transmitting the cyclic data



Diagnostic message	Significance
CAN_BUS_OFF	CAN controller in status "BUS-OFF"
CAN_OVERRUN	Overflow in CAN controller
BUS_POWER_FAIL	24V error

Fig.4-101: Concrete Error Messages in Status "UNRECOVERABLE\_FAULT"

## IndraDrive - Diagnostic Error Messages

IndraDrive's diagnostic error messages and their significances in conjunction with DeviceNet master communication:

- F4009 Bus failure** → Within the "field bus watchdog time" there hadn't any polled I/O telegram been received.
 

**Note:** The "field bus watchdog time" corresponds to the fourfold "Expected Packet Rate" set by the DeviceNet master.
- F4012 Incorrect I/O length** → The length of the configured cyclic data of master does not match data length of slave.
 

**Note:** This situation can arise when the configuration of parameter "P-0-4080, Field bus: config. list of cyclic actual value data ch." or "P-0-4081, Field bus: config. list of cyclic command value data ch." was changed in running bus operation. The established polled I/O connection persists. The received cyclic data, however, are not accepted by IndraDrive. The configuration of the cyclic data also has to be adjusted in the master and the bus has to be started again to allow clearing the diagnostic error message F4012 which is present.

## 4.10 Parallel Interface

### 4.10.1 Brief Description

It is possible to operate IndraDrive controllers with a parallel interface as master communication module. This requires the control section design with the optional module "parallel interface" (PL), with 16 digital inputs and 16 digital outputs.

- Features**
- Free configuration of the total of 16 digital inputs by means of the signal control word function (see S-0-0145)
  - Free configuration of the total of 16 digital outputs by means of the signal status word function (see S-0-0144)

**Hardware Requirements** The optional module with parallel interface is available for the following configurable control sections:

- Single-axis BASIC UNIVERSAL (CSB01.1C)
- Single-axis ADVANCED (CSH01.1C)

- Pertinent Parameters**
- S-0-0026, Configuration list for signal status word
  - S-0-0027, Configuration list for signal control word
  - S-0-0144, Signal status word
  - S-0-0145, Signal control word
  - S-0-0328, Assign list signal status word
  - S-0-0329, Assign list signal control word
  - S-0-0346, Positioning control word

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- S-0-0398, IDN-list of configurable data in signal status word
- S-0-0399, IDN-list of configurable data in signal control word
- S-0-0437, Positioning status
- P-0-0115, Device control: status word
- P-0-0116, Device control: control word
- P-0-4026, Positioning block selection
- P-0-4028, Device control word
- P-0-4060, Positioning block control word
- P-0-4061, Positioning block status word

Pertinent Diagnostic Messages

- F2044 External power supply X15 error

## 4.10.2 Functional Description

### Control

**Drive Enable** Activating the drive requires a positive edge of the "drive enable" signal.



The "drive enable" signal is mapped to parameter "P-0-4028, Device control word".

See also "Device Control and State Machines"

The enable signal is accepted, i.e. the drive switches from its de-energized status to its energized status, when the following conditions have been fulfilled:

- There mustn't be any drive error present.
- The drive must be in operating mode (phase 4).
- Power must have been switched on and the DC bus voltage must be above the defined minimum threshold.

The drive displays this status on the control panel with "Ab". The diagnostic drive message in parameter "S-0-0095, Diagnostic message" is "A0012 Control and power sections ready for operation".

- The signal "Ready" in parameter "P-0-0115, Device control: status word" must have been set (P-0-0115, bit 1 = 1).

**"Drive HALT"Signal** When drive enable is set and the "Drive HALT" signal is active (P-0-4028, bit 13 = 0),

- the display of the control panel changes to "AH" and
- the diagnostic drive message then is "A0010 Drive HALT" and thereby signals the activation of "Drive Halt".

If the "Drive HALT" signal is then deactivated (P-0-4028, bit 13 = 1),

- the display of the control panel changes to "AF" and
- the diagnostic drive message then is A0206, A0207, A0210 or A0211 (positioning block mode) and thereby signals the activation of the operating mode.



The "Drive HALT" signal is status-controlled and active when the signal = 0 V; this means that for signal =0 V the drive is in status "Drive HALT"

**Clear error** A positive edge at the "clear error" input starts the command for error clearing. By default setting the command for error clearing "C0500 Reset class 1

diagnostics, error reset" has been assigned to a digital input on the parallel interface.



All drive errors are cleared by activating the command for error clearing!

## Configurable Digital Inputs

### Cycle time

The signal control word for IndraDrive devices is cyclically generated or cyclically transmitted to the I/O module:

- Cycle time "Advanced" → T = 250µs
- Cycle time "Basic" → T = 500µs



The digital inputs of the parallel interface are mapped to those of parameter "S-0-0145, Signal control word".

Bit number in signal control word	Digital input of the parallel interface
0	X15, pin 1
1	X15, pin 20
2	X15, pin 2
3	X15, pin 21
4	X15, pin 3
5	X15, pin 22
6	X15, pin 4
7	X15, pin 23
8	X15, pin 5
9	X15, pin 24
10	X15, pin 6
11	X15, pin 25
12	X15, pin 7
13	X15, pin 26
14	X15, pin 8
15	X15, pin 27

Fig.4-102: Assignment of Signal Control Word to Digital Inputs

See also "Configurable Signal Control Word"



The connector pin assignment is described in the separate documentation "Control Sections for Drive Controllers, Project Planning Manual" in section "I/O Extensions".

## Configurable Digital Outputs

### Cycle Time

The signal status word for IndraDrive devices is cyclically generated or cyclically transmitted to the I/O module:

- Cycle time "Advanced" → T = 250µs
- Cycle time "Basic" → T = 500µs

Master Communication



The bits of parameter "S-0-0144, Signal status word" are mapped to the digital outputs of the parallel interface.

Bit number in signal status word	Digital output of the parallel interface
0	X15, pin 28
1	X15, pin 10
2	X15, pin 29
3	X15, pin 11
4	X15, pin 12
5	X15, pin 31
6	X15, pin 13
7	X15, pin 32
8	X15, pin 33
9	X15, pin 15
10	X15, pin 34
11	X15, pin 16
12	X15, pin 17
13	X15, pin 36
14	X15, pin 18
15	X15, pin 37

Fig.4-103: Assignment of Signal Status Word to Digital Outputs

See also "Configurable Signal Status Word"



The connector pin assignment is described in the separate documentation "Control Sections for Drive Controllers, Project Planning Manual" in section "I/O Extensions" .

### 4.10.3 Notes on Commissioning/Parameterization

#### Positioning Block Mode with Parallel Interface

See also operating mode "Positioning Block Mode"



With the device configuration "parallel interface " (PL) the signal control word and the signal status word are configured accordingly when the command "load basic parameters" is executed.

**Positioning Block Selection, Start Signal**

With a positive edge (0 → 1) at the strobe input (bit 0 of "P-0-4060, Positioning block control word"), a positioning block is selected and started. The inputs for the positioning block selection are mapped to parameter "P-0-4026, Positioning block selection".

**Block Select Acknowledgement, "In-Pos" Message**

The block selection in parameter P-0-4051 is acknowledged as soon as the positioning block has been started. The "In-Pos" message is simultaneously updated.

**Jogging Inputs**

Selecting the jogging inputs causes an internal switching to the "drive-controlled positioning" mode. The two jogging inputs are mapped to parameter "S-0-0346,

Positioning control word" (bits 1 and bit 2) and the jogging direction is thereby determined.



The jogging inputs are used, among other things, for operational stop (positioning stop; cf. S-0-0346).

### Examples of control of the jogging inputs

S-0-0346, Positioning control word:

- Bit 2, 1 = 01 → Jog +
- Bit 2, 1 = 10 → Jog -
- Bit 2, 1 = 11 → Positioning stop

Bit number in signal control word	Configured parameter	Function/significance
0	P-0-4026, bit 0	Positioning block selection
1	P-0-4026, bit 1	Positioning block selection
2	P-0-4026, bit 2	Positioning block selection
3	P-0-4026, bit 3	Positioning block selection
4	P-0-4026, bit 4	Positioning block selection
5	P-0-4026, bit 5	Positioning block selection
6	P-0-4060, bit 0	Acceptance of positioning block
7	S-0-0148, bit 0	Homing command (C0600)
8	S-0-0346, bit 1	jogging +
9	S-0-0346, bit 2	Jogging -
10	P-0-4028, bit15	Device control word (AF)
11	P-0-4028, bit13	Device control word (AH)
12	S-0-0099, bit 0	Command for error clearing (C0500)
13	--	Not assigned
14	--	Not assigned
15	--	Not assigned

Fig.4-104: Default Configuration for Positioning Block Mode via Digital Inputs

Bit number in signal status word	Configured parameter	Function/significance
0	P-0-0115, bit 1	Device control status "Ready"
1	S-0-0059, bit 0	Position switch point
2	S-0-0403, bit 0	Status reference encoder
3	S-0-0331, bit 0	$n_{act} = 0$
4	P-0-4061, bit 1	Status "End position reached"
5	P-0-0115, bit 2	Device control status "Warning"
6	S-0-0437, bit 12	Status "jog mode active"
7	S-0-0437, bit 3	Status "interpolator stopped"

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Bit number in signal status word	Configured parameter	Function/significance
8	P-0-4051, bit 0	Positioning block acknowledgment
9	P-0-4051, bit 1	Positioning block acknowledgment
10	P-0-4051, bit 2	Positioning block acknowledgment
11	P-0-4051, bit 3	Positioning block acknowledgment
12	P-0-4051, bit 4	Positioning block acknowledgment
13	P-0-4051, bit 5	Positioning block acknowledgment
14	P-0-4051, bit 6	Positioning block acknowledgment
15	P-0-4051, bit 7	Positioning block acknowledgment

Fig.4-105: Default Configuration for Positioning Block Mode via Digital Outputs

**Change of Operating Mode via Parallel Interface**

To change the operation mode, bits 8 and 9 of parameter "P-0-4028, Device control word" have to be assigned to the digital inputs. By setting the inputs, the bits for operation mode selection (primary operation mode and secondary operation modes) are then set.

**Main Spindle Drive with Analog Interface and Parallel Interface**

In the case of main spindle drives, operating states that are important for the working cycle have to be transmitted to the master so that it can process or advance the command blocks in accordance with the process and in a fail-safe way.

The "position spindle" command allows aligning the spindle for tool change without the control master having to leave the "velocity control" mode mainly used for spindles.

In the case of master communication with analog interface, the required messages have to be made available to the master via the digital outputs. The "position spindle" command has to be started via a digital input. To do this, the command parameters are assigned to a digital input, the main spindle messages are assigned to the digital outputs.

The following commands are relevant for main spindle drives:

- C0600 Drive-controlled homing procedure command (S-0-0148)
- C0900 Position spindle command (S-0-0152)

Bit number in signal control word	Configured parameter	Function/significance
0	--	
1	S-0-0152, bit 0	Position spindle command (C0900)
2 ... 6	--	
7	S-0-0148, bit 0	Homing command (C0600)
8, 9	--	
10	P-0-4028, bit15	Device control word (AF)
11	P-0-4028, bit13	Device control word (AH)

Bit number in signal control word	Configured parameter	Function/significance
12	S-0-0099, bit 0	Command for error clearing (C0500)
13 ... 15	--	

Fig.4-106: Example of Configuration for Main Spindle Drive via Digital Inputs

The following messages are relevant for main spindle drives:

- Speed reached ("S-0-0330, Status "n\_feedback = n\_command")
- Spindle has stopped ("S-0-0331, Status "n\_feedback = 0")
- Speed value has fallen below threshold ("S-0-0332, Status "n\_feedback < nx")
- In target position during spindle positioning ("S-0-0336, Status "In position")
- Torque limit value reached ("S-0-0334, Status "T >= Tlimit")
- Torque threshold exceeded ("S-0-0333, Status "T >= Tx")
- Speed value exceeded ("S-0-0335, Status "n\_command > n\_limit")
- Power threshold exceeded ("S-0-0337, Status "P >= Px")



See also descriptions of the respective parameters in the separate documentation "Rexroth IndraDrive, Parameter Description"

Bit number in signal status word	Configured parameter	Function/significance
0	P-0-0115, bit 1	Device control status "Ready"
1	S-0-0330, bit 0	n_actual = n_command
2	S-0-0403, bit 0	Status reference encoder
3	S-0-0331, bit 0	n_feedback = 0
4	S-0-0332, bit 0	nactual < nx
5	P-0-0115, bit 2	Device control status "Warning"
6	S-0-0333, bit 0	T ≥ Tx
7	S-0-0334, bit 0	T ≥ Tlimit
8	S-0-0335, bit 0	n command > n limit
9	S-0-0336, bit 0	In_Position
10	S-0-0337, bit 0	P ≥ Px
11 ... 15	--	

Fig.4-107: Example of Configuration for Main Spindle Messages via Digital Outputs

See also section "Spindle Positioning"

## 4.10.4 Diagnostic and Status Messages

### Monitoring the Digital Inputs/Outputs

For the parallel interface different kinds of errors are monitored at the inputs and outputs or ports. The following error situations can be detected:

- Undervoltage of 24 V supply
- Incorrect polarity of the supply of a port

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- Overload of an output
- Short circuit of an output



There is only the collective message "F2044 External power supply X15 error" for the above-mentioned errors of the parallel interface.

## 4.11 Analog Interface

### 4.11.1 Brief Description

**Overview** Apart from the digital master communication interfaces (SERCOS, PROFIBUS...), the drive controllers of the IndraDrive range provide an interface for analog master communication (analog interface). This allows assigning an analog command value to a drive parameter (e.g. "S-0-0036, Velocity command value").

In conjunction with encoder emulation (SSI or incremental encoder), the position control loop can be closed in a higher-level control unit. The drive provides the possibility of, for example, emulating the actual position value for evaluation in the control unit.

The figures below illustrate the structure of drive solutions with analog interface and open-loop or closed-loop operation.

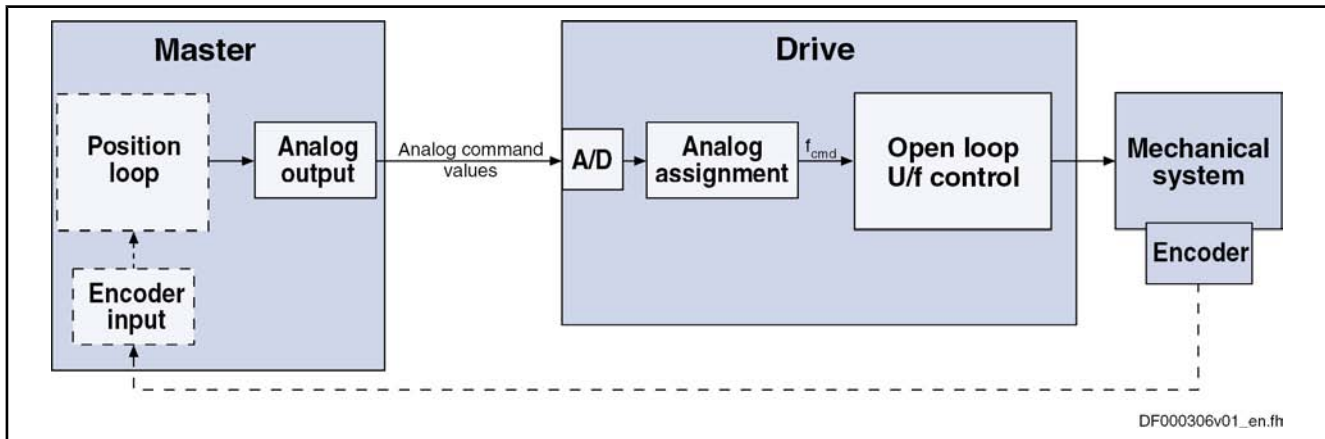


Fig.4-108: Open-Loop Operation With Analog Interface (With Optional Position Feedback to Open-Loop Control)

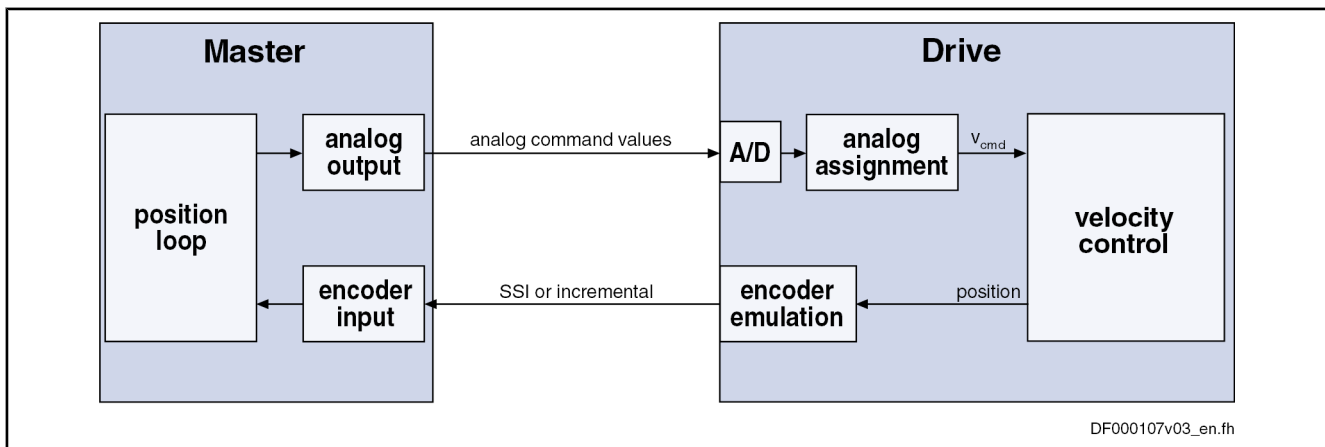


Fig.4-109: Closed-Loop Operation With Analog Interface (With Analog Command Value Input and SSI Emulation)



This section describes the basic functions of the analog interface and contains notes on commissioning and parameterization. The individual functions used, "analog inputs" and "encoder emulation", are described in separate chapters.

See also "Encoder Emulation"

See also "Analog Inputs"

**Features** The analog interface is an interface for master communication with analog command values and digital I/Os (drive enable, Drive HALT...).

Features of the **analog inputs**:

- Analog inputs (14 bit) which can be assigned to parameters, with smoothing to be set (number of analog inputs depending on control section design)
- Sampling of the analog inputs in the position loop clock  $T_{\text{position}}$  (see "Performance Data")

Features of the **analog assignment**:

- Two assignments to parameters are possible; offset and scaling of the analog input can be set for each assignment
- Sampling rates for analog input assignment:
  - Assignment channel A → assignment in position loop clock  $T_{\text{position}}$
  - Assignment channel B → assignment in clock of 2 ms

Features of **encoder emulation**:

- Freely configurable incremental encoder and SSI emulation of the different position values in the drive (actual position value, position command value...) load- or motor-related via position scaling (S-0-0076)

Features of **absolute encoder emulation**:

- Adjustable relationship via command "set absolute measuring" (C0300)
- Resolution to be set, only binary resolution (incr./motor rev. or mm)
- Power failure bit available

Features of **incremental encoder emulation**:

- Emulation of the reference pulse
- Reference pulse offset to be set; dead time compensation
- Resolution to be set (incr./motor rev. or mm)
- Monitoring of the maximum frequency

Features of the **digital inputs/outputs**:

- Digital control and status information determined via configuration of the digital inputs of the control section:
  - **Digital control inputs** for analog master communication:
    - Signals "Drive enable" and "Drive HALT"
    - Zero switch, limit switch (+/-); clearing errors and E-Stop
  - **Digital status outputs** for analog master communication:
    - Ready and warning output
    - Relay output for readiness for operation

**Hardware Requirements** Master communication with analog interface is possible via the following control sections or control section designs:

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- Analog command value input **for open-loop operation** (also for closed-loop operation):
  - Single-axis BASIC for open-loop operation (CSB01.1N-FC)
  - Single-axis BASIC ANALOG (CSB01.1N-AN)
  - Single-axis ADVANCED (CSH01.xC)
  - Double-axis BASIC UNIVERSAL (CDB01.1C)

In addition, the following (configurable) control sections are possible, when they are equipped with the optional module for analog inputs/outputs (MA1):

  - Single-axis BASIC UNIVERSAL (CSB01.1C)
- Analog command value input **for closed-loop operation** with position feedback via encoder emulation:
  - Single-axis BASIC ANALOG (CSB01.1N-AN)

In addition it is possible to use the following configurable control sections if they have been designed with the optional module for encoder emulation (MEM):

  - Single-axis ADVANCED (CSH01.xC)
  - Double-axis BASIC UNIVERSAL (CDB01.1C)



With double-axis devices the function "analog interface" is available once per axis.

**Pertinent Parameters**

Control and status parameters:

- P-0-0115, Device control: status word
- P-0-0116, Device control: control word
- P-0-4028, Device control word

Digital inputs/outputs:

- P-0-0300, Digital I/Os, assignment list
- P-0-0301, Digital I/Os, bit numbers
- P-0-0302, Digital I/Os, direction
- P-0-0303, Digital I/Os, inputs
- P-0-0304, Digital I/Os, outputs

Analog inputs:

- P-0-0208, Analog input 5
- P-0-0209, Analog input 6
- P-0-0210, Analog input 1
- P-0-0211, Analog input 2
- P-0-0212, Analog input, list of assignable parameters
- P-0-0213, Analog input, assignment A, target parameter
- P-0-0214, Analog input, assignment A, scaling per 10V full scale
- P-0-0215, Analog input, assignment A, signal value at 0V
- P-0-0216, Analog input, assignment A, dead zone
- P-0-0217, Analog input 1, time constant input filter
- P-0-0218, Analog input, control parameter
- P-0-0219, Analog input, maximum value for adjustment

- P-0-0220, C2800 Analog input adjustment command
- P-0-0228, Analog input 3
- P-0-0229, Analog input 4
- P-0-0231, Analog input 2, time constant input filter
- P-0-0232, Analog input 3, time constant input filter
- P-0-0233, Analog input 4, time constant input filter
- P-0-0234, Analog input 5, time constant input filter
- P-0-0235, Analog input 6, time constant input filter
- P-0-0236, Analog input, assignment B, target parameter
- P-0-0237, Analog input, assignment B, scaling per 10V full scale
- P-0-0238, Analog input, assignment B, signal value at 0V
- P-0-0239, Analog input, assignment B, dead zone
- P-0-3901, Adjustment values of control section
- P-0-3904, Adjustment values analog I/O interface 3-4

Encoder emulation:

- P-0-0900, Encoder emulation signal selection list
- P-0-0901, Encoder emulation signal selection
- P-0-0902, Encoder emulation control parameter
- P-0-0903, Encoder emulation resolution
- P-0-0904, Encoder emulation zero pulse offset

## 4.11.2 Functional Description

### Control

With the analog interface, the drive is controlled via the digital inputs of the control section. Via the list parameter "P-0-0300, Digital I/Os, assignment list", the pins of the connectors X31, X32, X33 and X11 at the control section are assigned to drive parameters. Depending on the control section design, there is a default assignment of the pins of these terminal strips. The preset default assignment can be modified according to the application-specific requirements.



See Parameter Description "P-0-0300, Digital I/Os, assignment list"



As a matter of principle, using an ADVANCED control section with analog interface requires manual configuration of the digital I/Os.



See also "Overview of Functions and Interfaces" in the documentation "Control Sections for Drive Controllers; Project Planning Manual"

#### Drive Enable

The activation of the drive requires a positive edge of the "drive enable" signal (connector pin assignment see corresponding section in the documentation "Drive Controllers, Control Sections; Project Planning Manual").



The "drive enable" signal is mapped to the parameters "P-0-4028, Device control word" and "P-0-0116, Device control: control word".

See also "Device Control and State Machines"

## Master Communication

The enable signal is accepted, i.e. the drive switches from its de-energized status to its energized status, when the following conditions have been fulfilled:

- There mustn't be any drive error present.
- The drive must be in operating mode (phase 4).
- Power must have been switched on and the DC bus voltage must be above the defined minimum threshold.

The drive displays this status on the control panel with "Ab". The diagnostic drive message in parameter "S-0-0095, Diagnostic message" is "A0012 Control and power sections ready for operation".

**"Drive HALT"Signal** When drive enable is set and the "Drive HALT" signal is active (P-0-4028 or P-0-0116, bit 13 = 0),

- the display of the control panel changes to "AH" and
- the diagnostic drive message then is "A0010 Drive HALT" and thereby signals the activation of "Drive Halt".

If the "Drive HALT" signal is then deactivated (P-0-4028 or P-0-0116, bit 13 = 1),

- the display of the control panel changes to "AF" and
- the diagnostic drive message depends on the active operation mode (see description of the respective diagnostic message in the separate documentation "Troubleshooting Guide (description of diagnostic messages)")



The "Drive HALT" signal is status-controlled and active when the signal = 0 V; this means that for signal = 0 V the drive is in status "Drive HALT"

---

**Clear Error** A positive edge at the "clear error" input starts the command for error clearing. For this purpose, the command C0500 has to be assigned to a digital input:

- Configure parameter "S-0-0099, C0500 Reset class 1 diagnostics" in "P-0-0300, Digital I/Os, assignment list"
- Set bit 0 for the element of S-0-0099 in parameter "P-0-0301, Digital I/Os, bit numbers"
- Set the data direction for the element of S-0-0099 to input (value "0") in parameter "P-0-0302, Digital I/Os, direction"

See also "Digital Inputs/Outputs"



All drive errors are cleared by activating the command for error clearing!

---

## Analog Command Value Input

The number of analog inputs, which differs according to control section, is used to input the analog command value.

For IndraDrive devices, the analog inputs are cyclically sampled and evaluated:

- Assignment channel A works in position loop clock (see "Performance Data")
- Assignment channel B works in 2-ms clock

See "Analog Inputs"

## Emulation of Position Value

In order to close the position control loop via the master, it is necessary to transmit the axis position to the master. This is done by means of encoder emulation (incremental or SSI).

See "Encoder Emulation"

### 4.11.3 Notes on Commissioning/Parameterization

#### Encoder Emulation

In spite of its high degree of functionality and performance, the encoder emulation available for IndraDrive devices is subject to some systematic restrictions.

See "Encoder Emulation"



If the higher-level master and the drive have not been synchronized, beat effects can occur during sampling due to the different clock-pulse rates. Bosch Rexroth therefore recommends not to use the analog interface in high end applications, but in these cases use digital interfaces, such as SERCOS interface.

---

#### Analog Inputs

For inputting the cyclic command value, you should preferably use assignment channel A as it has a higher sampling rate than assignment channel B.

In spite of their high degree of functionality and performance, the analog inputs available for IndraDrive devices are subject to certain restrictions. These restrictions are explained in detail in section "Analog Inputs".

See also "Analog Inputs"



If the drives with analog command value input have not been synchronized, beat effects can occur during sampling in spite of the 8-fold oversampling. Bosch Rexroth therefore recommends not to use the analog interface in high end applications, but in these cases use digital interfaces, such as SERCOS interface.

---

### Main Spindle Drive With Analog Interface and Parallel Interface

In the case of main spindle drives, operating states that are important for the working cycle have to be transmitted to the master so that it can process or advance the command blocks in accordance with the process and in a fail-safe way.

The "position spindle" command allows aligning the spindle for tool change without the master having to leave the "velocity control" mode mainly used for spindles.

In the case of master communication with analog interface, the required messages have to be made available to the master via the digital outputs. The "position spindle" command has to be started via a digital input. For this purpose, the main spindle messages are assigned to the digital outputs, the command parameter to a digital input.

#### Messages

The following messages are relevant for main spindle drives:

- Speed reached ("S-0-0330, Status "n\_feedback = n\_command")
- Spindle has stopped ("S-0-0331, Status "n\_feedback = 0")
- Speed value has fallen below threshold ("S-0-0332, Status "n\_feedback < nx")

Master Communication

- In target position during spindle positioning ("S-0-0336, Status "In position"")
- Torque limit value reached ("S-0-0334, Status "T >= Tlimit"")
- Torque threshold exceeded ("S-0-0333, Status "T >= Tx"")
- Speed value exceeded ("S-0-0335, Status "n\_command > n\_limit"")
- Power threshold exceeded ("S-0-0337, Status "P >= Px"")



See also descriptions of the respective parameters in the separate documentation "Parameter Description"

Bit in signal status word	Configured parameter	Configured bit in parameter	Function/significance
1	S-0-0330	0	n_actual = n_command
2	S-0-0331	0	n_feedback = 0
3	S-0-0332	0	nactual < nx
4	S-0-0333	0	T ≥ Tx
5	S-0-0334	0	T ≥ Tlimit
6	S-0-0335	0	n command > n limit
7	S-0-0336	0	In_Position
8	S-0-0337	0	P ≥ Px
9	--	--	
10	--	--	
11	--	--	
12	--	--	
13	--	--	
14	--	--	
15	--	--	

Fig.4-110: Example of Configuration for Main Spindle Messages via Digital Outputs

**Command**

The following command is relevant for main spindle drives:

- C0900 Position spindle command (S-0-0152)

Bit in signal control word	Configured parameter	Configured bit in parameter	Function/significance
1	S-0-0152	0	Spindle positioning
2	--	--	
...	...	...	
15	--	--	

Fig.4-111: Example of Configuration for Main Spindle Command via Digital Inputs  
See also "Spindle Positioning"

## 4.11.4 Diagnostic and Status Messages

### Information on General Drive Status

In parameter "P-0-0115, Device control: status word", all important status bits of the state machine of the drive are mapped. Reading and interpreting parameter P-0-0115 provides information on the current status of the drive.



See Parameter Description "P-0-0115, Device control: status word"

### Status of Digital Inputs/Outputs and Analog Inputs

All digital and analog input values can already be read via parameters before assignment to the internal drive parameters. The following applies:

- Digital inputs/outputs of the control module are mapped to parameter "P-0-0303, Digital I/Os, inputs"
- Analog inputs values are displayed in the following parameters:
  - P-0-0208, Analog input 5
  - P-0-0209, Analog input 6
  - P-0-0210, Analog input 1
  - P-0-0211, Analog input 2
  - P-0-0228, Analog input 3
  - P-0-0229, Analog input 4

See also "Diagnostic and Status Messages" in the following sections:

- "Digital Inputs/Outputs"
- "Analog Inputs"
- "Encoder emulation"

## 4.12 MultiEthernet

### 4.12.1 Brief Description, Basic Function

#### General Information

Operating IndraDrive controllers with a MultiEthernet-Interface is possible. This allows operation of the following master communications:

- SERCOS III
- EtherCAT®
- PROFINET®
- EtherNet/IP™

The protocol is selected or deactivated via "P-0-4089.0.1, Master communication: Protocol". The change does not take effect until the device has been restarted.

Engineering via master communication (TC/IP communication) can also be made via the MultiEthernet interface. This function is maintained, even if the master communication is deactivated.

#### Features

- Protocol selection via control panel or "P-0-4089.0.1, Master communication: Protocol"
- SERCOS III, EtherCAT®, PROFINET®, EtherNet/IP™ protocols are supported

Master Communication

- IP engineering (TC/IP communication) is supported, depending on the protocol
- Master communication engineering is supported depending on the protocol

**Hardware Requirements**

The description used for the MultiEthernet interface in the type codes is ET.

- Single-axis ADVANCED (CSH01.xC)
- Single-axis BASIC UNIVERSAL (CSB01.1C)
- Double-axis BASIC UNIVERSAL (CDB01.xC)

**Pertinent Parameters**



For controls which cannot access 32-bit EIDN parameters certain relevant parameters were mapped to 16-bit IDN parameters; for allocation see table of pertinent parameters below.

32-bit EIDN parameters	16-bit IDN parameters
P-0-4089.0.1, Master communication: Protocol	P-0-2310, Master communication: Protocol
P-0-4089.0.2, Master communication: Device name	P-0-2311, Master communication: Device name
P-0-4089.0.10, Master communication: MAC address device	P-0-2312, Master communication: MAC address device
P-0-4089.0.11, Master communication: MAC address Port1	P-0-2313, Master communication: MAC address Port1
P-0-4089.0.12, Master communication: MAC address Port2	P-0-2314, Master communication: MAC address Port2
P-0-4089.0.13, Master communication: IP address	P-0-2315, Master communication: IP address
P-0-4089.0.14, Master communication: Network mask	P-0-2316, Master communication: Network mask
P-0-4089.0.15, Master communication: Gateway address	P-0-2317, Master communication: Gateway address

Fig.4-112: Pertinent Parameters

**Pertinent Diagnostic Messages**

- C0299 Configuration changed. Restart

**Notes on Commissioning**

**Protocol Selection**

**Protocol Selection**

The protocol is selected via parameter P-0-4089.0.1. Setting is made either via the menu or through the "Display" or via the "IndraWorks" commissioning tool.



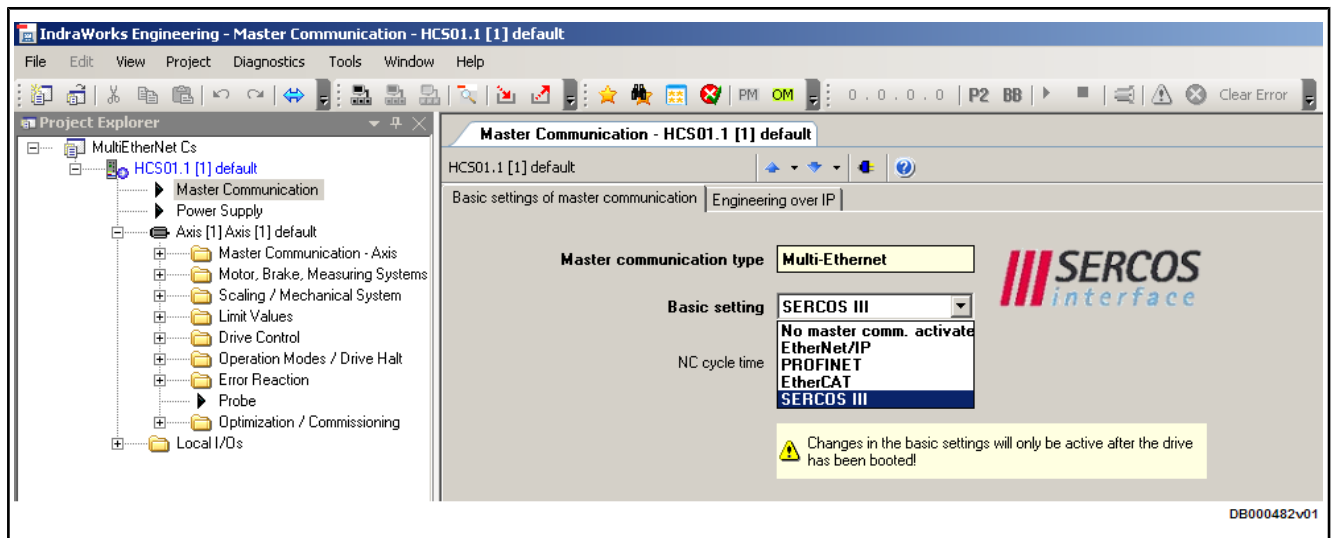


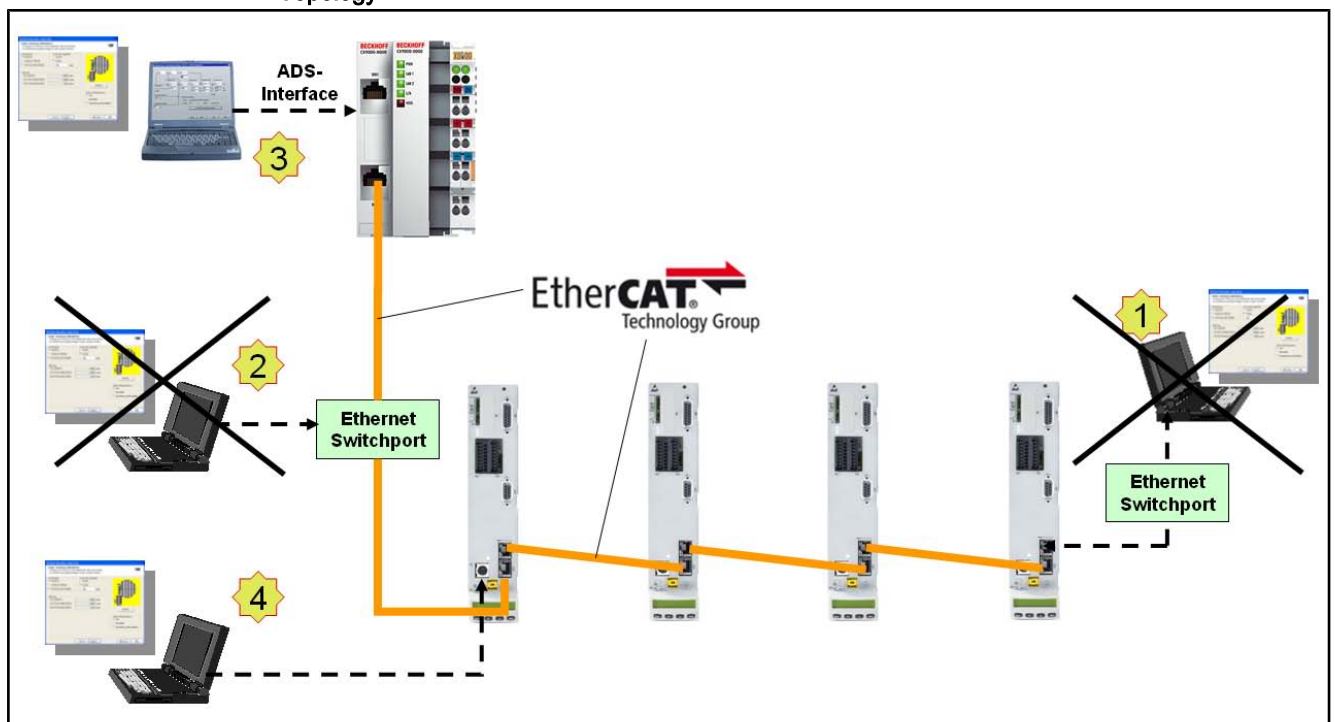
Fig.4-113: MultiEthernet, Protocol Selection

After parameters "P-0-4089.0.1, Master communication: Protocol" has been changed, perform a reboot at the drive. If the attempt is made to switch to the operating mode (OM) without performing a reboot, the drive will signal "C0299 Configuration changed. Restart".

### 4.12.2 EtherCAT®

#### Brief Description

##### Topology



- 1 Engineering via optional Ethernet switch port
- 2 Engineering via optional Ethernet switch port
- 3 Engineering via third-party control unit by means of ADS interface
- 4 Engineering via RS232 or existing engineering port at CSH01.3

Fig.4-114: EtherCAT Topology

## Master Communication

IndraDrive controllers with MultiEthernet interface (ET) can be operated as EtherCAT® master communication. Via these modules, it is possible to exchange real-time data with an EtherCAT® master. The "Servo Drive Profile over EtherCAT®" which is based on the SERCOS II profile is supported.

We distinguish the following communication channels:

- **Cyclic data channel** (process data)
  - Data container for cyclic transmission of useful data (**process data**) in real time
- **Acyclic data channel** (service channel)
  - EtherCAT® mailbox procedure for acyclic transmission of useful data (**service data**)

**General Features**

- Transmission rate 100 Mbit/s
- Data transmission via Ethernet cable (CAT5e copper)
- Topology: "Line"
- Addressing:



There is no connection between the master communication address (S-0-1040) shown on the display and the address set in the master (e.g. SystemManager by BECKHOFF). The drives identify themselves only via the order in the bus (example: address = "1" in the master corresponds to "1st drive" in the line).

- Access to 16-bit SERCOS parameters of the drive via "SoE" protocol (Servo Drive Profile over EtherCAT®)
- EtherCAT® mailbox procedure for parameterization and diagnosis
- Cyclic data exchange of command values and actual values
- Free configuration of telegram contents
- Max. length of configurable MDT/AT data 15 IDNs with max. 48 bytes; if bus cycle time = position cycle time the max. length is reduced by half to 24 bytes
- Cycle time: Min. 500µs (multiples of position cycle time can be set)
- "Distributed clock synchronization" (exact adjustment of distributed clocks)
- Synchronization between time command value takes effect and measurement starting time of the actual values for all drives on a ring
- Overall synchronization of all connected drives to the master
- "CAN over EtherCAT®" (CoE) not supported
- Currently only released in conjunction with "Beckhoff TwinCAT"

**Hardware Requirements**

Using the master communication "EtherCAT®" requires the following control section design:

- Single-axis ADVANCED (CSH01.xC)
- Single-axis BASIC UNIVERSAL (CSB01.1C)
- Double-axis BASIC UNIVERSAL (CDB01.xC)

The option ET must be available as master communication module.

**Pertinent Parameters**

- S-0-0001, NC cycle time (TNcyc)
- S-0-0002, SERCOS cycle time (TScyc)

- S-0-0005, Minimum feedback acquisition time (T4min)
- S-0-0006, AT Transmission starting time (T1)
- S-0-0007, Feedback acquisition starting time (T4)
- S-0-0008, Command value valid time (T3)
- S-0-0014, Interface status
- S-0-0015, Telegram type parameter
- S-0-0016, Configuration list of AT
- S-0-0024, Configuration list of MDT
- S-0-0028, MST error counter
- S-0-0089, MDT Transmit starting time (T2)
- S-0-0097, Mask class 2 diagnostics
- S-0-0098, Mask class 3 diagnostics
- S-0-0134, Master control word
- S-0-0135, Drive status word
- S-0-0185, Length of the configurable data record in the AT
- S-0-0186, Length of the configurable data record in the MDT
- S-0-0187, List of configurable data in the AT
- S-0-0188, List of configurable data in the MDT
- S-0-0301, Allocation of real-time control bit 1
- S-0-0303, Allocation of real-time control bit 2
- S-0-0305, Allocation of real-time status bit 1
- S-0-0307, Allocation of real-time status bit 2
- S-0-0413, Bit number allocation of real-time control bit 1
- S-0-0414, Bit number allocation of real-time control bit 2
- S-0-0415, Bit number allocation of real-time status bit 1
- S-0-0416, Bit number allocation of real-time status bit 2


**Pertinent Diagnostic Messages**

- C0104 Config. IDN for MDT not configurable
- C0105 Maximum length for MDT exceeded
- C0106 Config. IDNs for AT not configurable
- C0107 Maximum length for AT exceeded
- C0108 Time slot parameter > Sercos cycle time
- C0112 TNcyc (S-0-0001) or TScyc (S-0-0002) error
- C0113 Relation TNcyc (S-0-0001) to TScyc (S-0-0002) error
- C0114 T4 > TScyc (S-0-0002) - T4min (S-0-0005)
- E4005 No command value input via master communication
- F4002 RTD telegram failure
- F4009 Bus failure


**Notes on Commissioning**

Bosch Rexroth provides a commissioning description ("IndraDrive mit EtherCAT® an BECKHOFF TwinCAT.pdf", for further information please contact Drive Support) which explains the essential steps for commissioning an IndraDrive with EtherCAT® at a BECKHOFF TwinCAT.

Master Communication

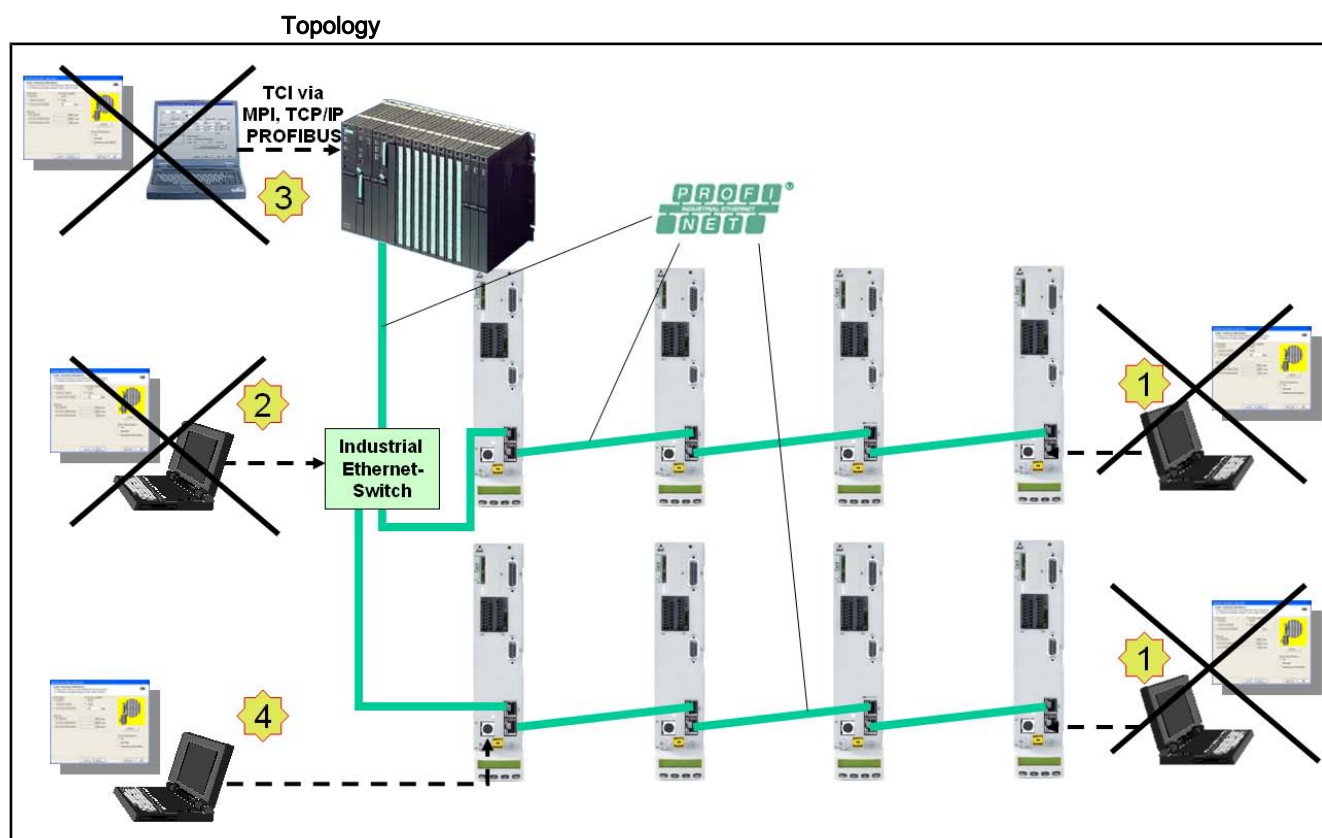
 When setting up an EtherCAT® network with IndraDrive C/M controllers ensure that

- slot X23 is used as input and
- slot X22 as output.

 There is no connection between the master communication address (S-0-1040) shown on the display and the address set in the master (e.g. SystemManager by BECKHOFF). The drives identify themselves only via the order in the bus. (Example: Address = "1" in the master corresponds to "1st drive" in the line).

### 4.12.3 PROFINET®

#### Brief Description



- 1 Engineering via free PROFINET® port of a bus node
- 2 Engineering via optional Industrial-Ethernet switch
- 3 Engineering via third-party control by means of TCI (in preparation)
- 4 Engineering via RS232 or existing engineering port at CSH01.3

Fig.4-115: PROFINET® Topology

IndraDrive controllers with MultiEthernet interface (ET) can also be operated as PROFINET® master communication. Via this module it is possible to exchange real-time data with a PROFINET® controller.


The field bus provides data containers in which useful data can be cyclically transmitted. This section is called **cyclic data channel** (PROFINET®).

The cyclic data channel is divided as follows:

- (Optional) **device-specific parameter channel** for reading and writing of all parameters via PROFINET®.

 The **device-specific parameter channel** does not fulfill "real-time properties"!

- (Optional) **safety-related, axis-specific process data channel** (PROFIsafe).

 The **safety-related, axis-specific process data channel** is not available in MPx06VRS. For configuration, however, the module "F-module not used" has to be integrated!

- **Axis-specific process data channel** (real-time channel) which contains fixed, selected information that can be directly interpreted by the receiver.

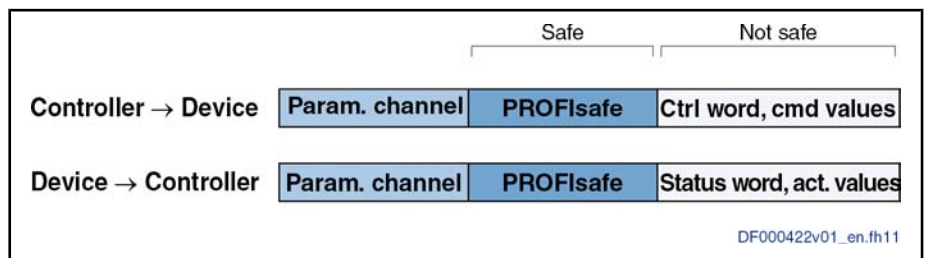



Fig.4-116: Overview of Cyclic Data Channel

 To simplify field bus communication, Bosch Rexroth makes available function blocks for different programmable logic controllers (PLCs). The principles applied can be easily used for other field bus masters.

**Features** The PROFINET® device circuit with MultiEthernet interface has the following features:

- Ethernet according to IEEE 802.3 and prioritization according to IEEE 802.1Q
- Transmission rate 100 Mbit/s
- Data transmission via Ethernet cable (CAT5e copper)
- Topologies: "Star", "line" (by means of integrated cut-through switch)
- Assignment of IP addresses via DCP protocol (Discovery and Basic Configuration)
- Configurable cyclic data up to 15 parameters (incl. field bus control word and field bus status word) in both data directions (max. 48 bytes or 24 words)

Min. cycle time	Max. quantity of process data/setting P-0-4076	Notes
0,5 ms ( $T_{A\_pos}$ )	16 bytes → P-0-4076 = 0.5ms 32 bytes → P-0-4076 = 1ms 48 bytes → P-0-4076 = 1ms	Additionally a maximum of 16 bytes parameter channel for PROFIBUS®

Fig.4-117: Quantity of Cyclic Data Depending on P-0-4076

Valid values for P-0-4076: 0,5 ms, 1 ms, 2 ms, 3 ms, 4 ms, 5 ms, ...

- Additional optional parameter channel in the cyclic channel with up to 16 bytes (8 words)
- LED for diagnosis of PROFINET® status (network status)

## Master Communication

- LEDs for display of link/activity status
- For reasons of compatibility with IndraDrive drive controllers with PROFIBUS® master communication module, diagnoses and alarms are not used.
- PROFINET® IRT is not supported.
- Operation in PROFINET® IRT networks not possible
- Supported field bus profiles:
  - 0xFF82: I/O mode "positioning" with configurable real-time data
  - 0xFF92: I/O mode " preset velocity" with configurable real-time data
  - 0xFFFFD: Freely configurable mode "operation modes neutral"
  - 0xFFFFE: Freely configurable mode

**Hardware Requirements** Using the master communication "PROFINET®" requires the following control section design:

- Single-axis ADVANCED (CSH01.xC)
- Single-axis BASIC UNIVERSAL (CSB01.1C)

The option ET must be available as master communication module.

**Pertinent Parameters** **Communication parameters**

Specific parameters for communication via PROFINET®:

- P-0-4089.0.11, Master communication: MAC address Port1
- P-0-4089.0.12, Master communication: MAC address Port2

Parameters for general communication via field bus interfaces:

- P-0-4073, Field bus: diagnostic message
- P-0-4074, Field bus: data format
- P-0-4075, Field bus: watchdog
- P-0-4076, Field bus: cycle time (T<sub>cyc</sub>)
- P-0-4079, Field bus: baud rate
- P-0-4088, Master communication: Drive configuration
- P-0-4089.0.2, Master communication: Device name
- P-0-4089.0.10, Master communication: MAC address device
- P-0-4089.0.13, Master communication: IP address
- P-0-4089.0.14, Master communication: Network mask
- P-0-4089.0.15, Master communication: Gateway address

**Profile type parameters**

Apart from mere communication parameters, we use parameters in conjunction with the profile types.

See "Profile Types (With Field Bus Interfaces)"

**Parameters for extended communication**

We use additional parameters for extended communication.

See following sections:

- "Configurable Signal Control Word"
- "Configurable signal status word"
- " Multiplex Channel"

**Pertinent Diagnostic Messages**

- C0229 Field bus: IDN for cycl. command val. not configurable

- C0230 Field bus: Max. length for cycl. command val. exceeded
- C0231 Field bus: IDN for cycl. actual val. not configurable
- C0232 Field bus: Length for cycl. actual values exceeded
- C0233 Field bus: Tcyc (P-0-4076) incorrect
- C0234 Field bus: P-0-4077 missing for cycl. command values
- E4005 No command value input via master communication
- F4009 Bus failure
- F4012 Incorrect I/O length

## Configuring the PROFINET®-Slave

### Device Data Sheet for IndraDrive

Like every other PROFINET® device, IndraDrive controllers have to be configured in the field bus controller. This requires the corresponding device data sheet (DDS) "**GSDML-V2.0-Rexroth-Indradrive-YYYYMMDD.xml**" that has to be included in the project ("YYYYMMDD" represents the creation date of the DDS file). This DDS file, when configuring the bus controller, is required for each node.



The device data sheet for IndraDrive controllers supports all hardware types and enabling of functional packages.

IndraDrive controllers assign their data to four slots (for single-axis devices) or up to 31 slots for devices operated via CCD group (1 CCD master + 9 CCD slaves), which have to be configured, if necessary. Each drive in the CCD group has an F-module, one input module and one output module: A slot is used for plugging in modules. In the example: A parameter channel module is plugged in slot 1. The parameter channel module can have the length 0 or 5 words.

In the case of single-axis devices, IndraDrive controllers assign their data to four slots which have to be plugged in specific modules.

- Slot 1: Parameter channel module (device-specific)
- Slot 2: Module-F module (axis 0)
- Slot 3: Inputs module (axis 0)
- Slot 4: Outputs module (axis 0)

The default configuration stored in the device data sheet is "Input 1 Word" and "Output 1 Word" (single-axis device) without safety technology and without parameter channel. For IndraDrive this setting is active after the load defaults procedure.


#### Parameter Channel Module

These modules are marked with "ParamCh" and are of the "input/output module" type. If no parameter channel is required, the module "ParamCh not used" has to be selected. If the parameter channel is activated, select "ParamCh 5 Words" module.

The drive automatically recognizes the configuration of the controller and adjusts accordingly. If the default configuration of 0 words has not been set in the controller, the PROFINET® connection will be interrupted after detection of the parameter channel length and re-established with the detected parameter channel length. Parameterization by the controller is therefore always possible even in the case of incorrect configuration of the command values/actual values. This allows parameter download from the controller by means of the parameter channel after a device was replaced.

Master Communication

---


 This active setting is displayed in parameter "P-0-4083, Field bus: length of parameter channel" in bytes.  
In the case of incorrect configuration of the command values/actual values the error "F4012 Incorrect I/O length" is displayed.

---


**F-Module** Slot 2 is assigned with the blank module "F-module not used"

**Module Inputs** In these modules the length of the input data in words is set. The module identifier is "Input". For successful data exchange the length that was set has to equal the value in parameter "P-0-4082, Field bus: length of cyclic actual value data channel" which indicates the length in bytes.

---

 Even if the input data length is incorrect, communication via the device-specific parameter channel is possible.


---

 If the configuration of the controller does not correspond with the one of the IndraDrive controller, the IndraDrive device will generate the error message "F4012 Incorrect I/O length".

---

**Module Outputs** In these modules the length of the output data in words is set. The module identifier is "Output". The length of the output data that was set has to correspond with the value of parameter "P-0-4071, Field bus: length of cyclic command value data channel":

---

 If the configuration of the controller does not correspond with the one of the IndraDrive controller, the IndraDrive device will generate the error message "F4012 Incorrect I/O length".


---

**Modules 5 to 31** The modules 5 to 31 are provided for devices operated at the CCD group.

**Displaying the Device Name/IP Address of the IndraDrive Device**

The device name of the IndraDrive device assigned when naming the device is displayed in "P-0-4089.0.2, Master communication: Device name". When replacing a device this parameter can be used to manually reset the device name via IndraWorks (see "Notes on How to Replace the Devices"). The IP Suite assigned to the device by the controller during run-up is displayed in the following parameters:

- P-0-4089.0.13, Master communication: IP address
  - P-0-4089.0.14, Master communication: Network mask
  - P-0-4089.0.15, Master communication: Gateway address
- 

 The IP address is only relevant for communication with the controller! For Engineering (e.g. IndraWorks) the engineering address (S-0-1020, Master comm. engineering over IP: IP address) must be used.


---

**Configuring the Process Data Channel**

**Standard Process Data Channel  
(Not Safety Related)**

The user can freely configure the cyclical data in the standard process data channel according to the process requirements.



 For the profile types "freely configurable mode" (P-0-4084 = 0xFFFFE) or "I/O mode positioning" (P-0-4084 = 0xFF82) or "I/O mode" (P-0-4084 = 0xFF92 preset velocity) there is a default configuration that the user can change at any time.


See also "Profile Types (With Field Bus Interfaces)"

**Configuration List  
Cyclic Command Value Data Channel**


The structure and therefore the number of words and their assigned objects (indices) for the process input data (device → controller) are mapped in parameter "P-0-4080, Field bus: config. list of cyclic actual value data ch.". The controller can use this configuration in order to locate the individual real-time data in the field bus.

**Configuration List  
Cyclic Command Value Data Channel**

The structure of the process output data (controller → device) is mapped in parameter "P-0-4081, Field bus: config. list of cyclic command value data ch.". This enables the read-out via the parameter channel of the current structure and thus the assignments in the field bus.

 It is possible to configure up to 15 real-time parameters (incl. control or status word) on the bus in each data direction (max. 48 bytes or 24 words).

**PROFIsafe Process Data Channel  
(Safety Related)**


 The **safety-related, axis-specific process data channel** is not available in MPx06VRS. For configuration, however, the module "F-module not used" has to be integrated!

**Length of the Process Data Channel (Real-Time Data Channel)**

**Standard Process Data Channel  
(Not Safety Related)**

Within the cyclic channel, the parameter channel (optional) and the process data channel, in which the real-time data of the drive controller are transmitted, are arranged.

The PROFIBUS® device circuit allows flexible configuration of the process data channel, the length of the process data channel thereby changing accordingly.

 The length currently effective is contained in the parameters "P-0-4082, Field bus: length of cyclic actual value data channel" and "P-0-4071, Field bus: length of cyclic command value data channel".

The process data channel (real-time data channel) can only have words or double words, but not bytes, as data types. Length, however, is specified in bytes for the sake of compatibility with other bus systems.

PROFIBUS® and PROFINET®--> The length of the process data channel (number of cyclical data) depends on parameter P-0-4076.

Min. cycle time	Max. quantity of process data ↔ setting P-0-4076	Notes
0,5 ms (T <sub>A_pos</sub> )	16 bytes → P-4076 = 0.5 ms 32 bytes → P-4076 = 1 ms 48 Bytes → P-4076 > 1 ms	Additionally a maximum of 16 bytes parameter channel for PROFIBUS and PROFINET

Fig.4-118: Quantity of Cyclic Data Depending on P-0-4076

The length of the process data channel is determined by the contents of the configuration lists "P-0-4080, Field bus: config. list of cyclic actual value data ch." or "P-0-4081, Field bus: config. list of cyclic command value data ch." and can be taken from the following parameters:

Master Communication

- P-0-4071, Field bus: length of cyclic command value data channel
- P-0-4082, Field bus: length of cyclic actual value data channel

The setting is calculated from the contents of the parameters P-0-4080 and P-0-4081 and takes effect as the drive controller runs up to the operating mode.



Note that a change in the length of the process data channel also requires a change in the controller configuration. The length of the process data channel that was set has to be in accordance with the projected length in the controller. Otherwise the error message "F4012 Incorrect I/O length" is generated.

### Cyclic Communication via Process Data Channel

#### Communication Cycle Time

Cyclic communication via the process data channel takes place in the so-called communication cycle (cf. "P-0-4076, Field bus: cycle time (T<sub>cyc</sub>)"). The possible quantity of cyclic data depends on the setting of parameter P-0-4076.

Min. cycle time	Max. quantity of process data ↔ setting P-0-4076	Notes
0,5 ms (T <sub>A_pos</sub> )	16 bytes → P-4076 = 0.5 ms 32 bytes → P-4076 = 1 ms 48 Bytes → P-4076 > 1 ms	Additionally a maximum of 16 bytes parameter channel for PROFIBUS and PROFINET

Fig.4-119: Quantity of Cyclic Data Depending on P-0-4076

Valid values for P-0-4076: 0,5 ms, 1 ms, 2 ms, 3 ms, 4 ms, 5 ms, ...

#### Axis-Specific Process Data Channel

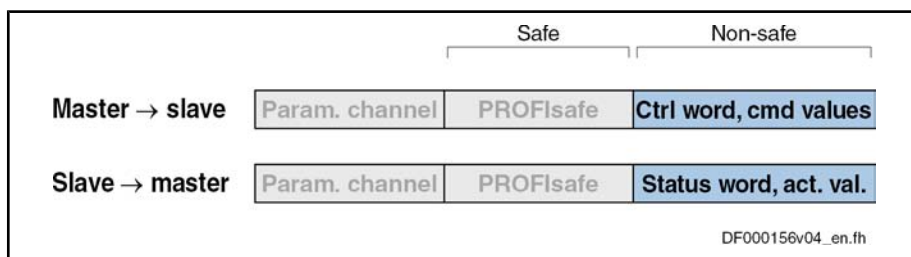


Fig.4-120: Position of the Non-Safe Process Data Channel in the Cyclic Data Channel


#### Processing the Cyclic Data

The internal processing of the command values and actual values is carried out synchronously with the control clock. As the communication via PROFINET® RT is not carried out in a synchronous way, this type of master communication is not suited for synchronous operation modes such as "position control with cyclic command value input", but only for positioning modes and the "velocity control" mode.

Min. cycle time	Max. quantity of process data ↔ setting P-0-4076	Notes
0,5 ms (T <sub>A_pos</sub> )	16 bytes → P-4076 = 0.5 ms 32 bytes → P-4076 = 1 ms 48 Bytes → P-4076 > 1 ms	Additionally a maximum of 16 bytes parameter channel for PROFIBUS and PROFINET

Fig.4-121: Quantity of Cyclic Data Depending on P-0-4076

**Configuring the Cyclic Data**

 There is no limit value check for the cyclically transmitted command values and they are stored in volatile form.

The cyclic data have to be configured in the parameter mode. It is described in section "Configuring the PROFINET®-DP slave" .

**Safe, Axis-Specific Process Data Channel (PROFIsafe)**

**General Information**

 The **safety-related, axis-specific process data channel** is not available in MPx06VRS.

**PROFIsafe Configuration**

 The **safety-related, axis-specific process data channel** is not available in MPx06VRS.

**Parameter Channel in the Cyclic Channel (Device-Specific)**




*Fig.4-122: Position of the Parameter Channel in the Cyclic Data Channel*

Parameterization of the drive can be made by means of the field bus via the parameter channel. The parameter channel is part of the cyclic data.

For IndraLogic and Siemens S7 function blocks are available which implement the parameter channel protocol. This allows the user to ignore the parameter channel details.

The parameter channel is described in Technical Note "TN\_40\_Bosch\_Rexroth PROFIBUS\_PROFINET\_ParameterChannel\_V1.x".

 The parameter channel is always at the beginning of the cyclical data channel. The length of the parameter channel is configured in the controller and taken over by the drive to parameter "P-0-4083, Field bus: length of parameter channel".

**Monitoring Functions and Diagnostic Functions**

**Diagnostic Possibilities**

For simple diagnosis of network status a network status LED is provided.

The following table shows the possible statuses:

Message on display	Significance
Permanently off	The device does not have a valid IP address or is switched off
Flashing green	The device was initialized with a valid IP address but does not have a cyclic connection.
Permanently green	The I/O connection has been established without error.

## Master Communication

Message on display	Significance
Flashing red	The existing I/O connection was unexpectedly interrupted (e.g. watchdog)
Permanently red	During "Duplicate IP Address Check", the IP address which was set was detected to already exist in the network.
Flashing green/red	The device is currently initializing and performs a self test.

Fig. 4-123: Overview of Diagnostic Messages for PROFINET® Communication

**Error Codes of PROFINET® Communication****Parameter Channel Errors**

The table below contains an overview of the possible parameter channel error messages and their significance:

Error code	Significance
0x0082	quantity of all transmitted data is too low, i.e. less than 4 bytes
0x0083	quantity of data still to be transmitted is greater than the internal buffer
0x0088	the length of the valid data indicated in the control word is longer than the parameter channel
0x008C	status conflict, a new request was sent although there are still data to be transmitted
0x008D	The length of data that are still to be transmitted indicated in the control word is incorrect

Fig. 4-124: Overview Parameter Channel Errors

**Parameter Access Errors**

The table below contains an overview of the possible parameter access errors and their significance; the error values are transmitted in word format:

Error No. (hex)	Significance
0x1001	No IDN
0x1009	Invalid access to element 1
0x2001	No name
0x2004	Name cannot be changed (read only)
0x3004	Attribute cannot be changed (read only)
0x4001	No units
0x4004	Unit cannot be changed (read only)
0x5001	No minimum input value
0x5004	Minimum input value cannot be changed (read only)
0x6001	No maximum input value
0x6004	Maximum input value cannot be changed (read only)
0x7002	Operation data transmission too short
0x7003	Operation data transmission too long
0x7004	Operation data cannot be changed (read only)

Error No. (hex)	Significance
0x7005	Operation data is write-protected at this time (e.g. communication phase)
0x7006	Operation data is smaller than minimum input value
0x7007	Operation data is greater than maximum input value
0x7008	Invalid operation data: Configured IDN will not be supported, invalid bit number or bit combination
0x7009	Operation data write protected by a password
0x700A	Operation data is write protected, it is configured cyclically
0x700B	Invalid indirect addressing (e.g. data container, list handling)
0x700C	Operation data is write protected, due to other settings (e.g., parameter, operation mode, drive enable, drive on etc.)
0x7010	Procedure command already active
0x7011	Procedure command not interruptible
0x7012	Procedure command at this time not executable (e.g., in this phase the procedure command cannot be activated)
0x7013	Procedure command not executable (invalid or false parameters)
0x9001	Input cannot be identified as application
0x9002	Parameter type error
0x9003	Invalid data set number
0x9004	invalid data block number
0x9005	Data element number invalid
0x9006	error in R/W flag
0x9007	Invalid character in the data

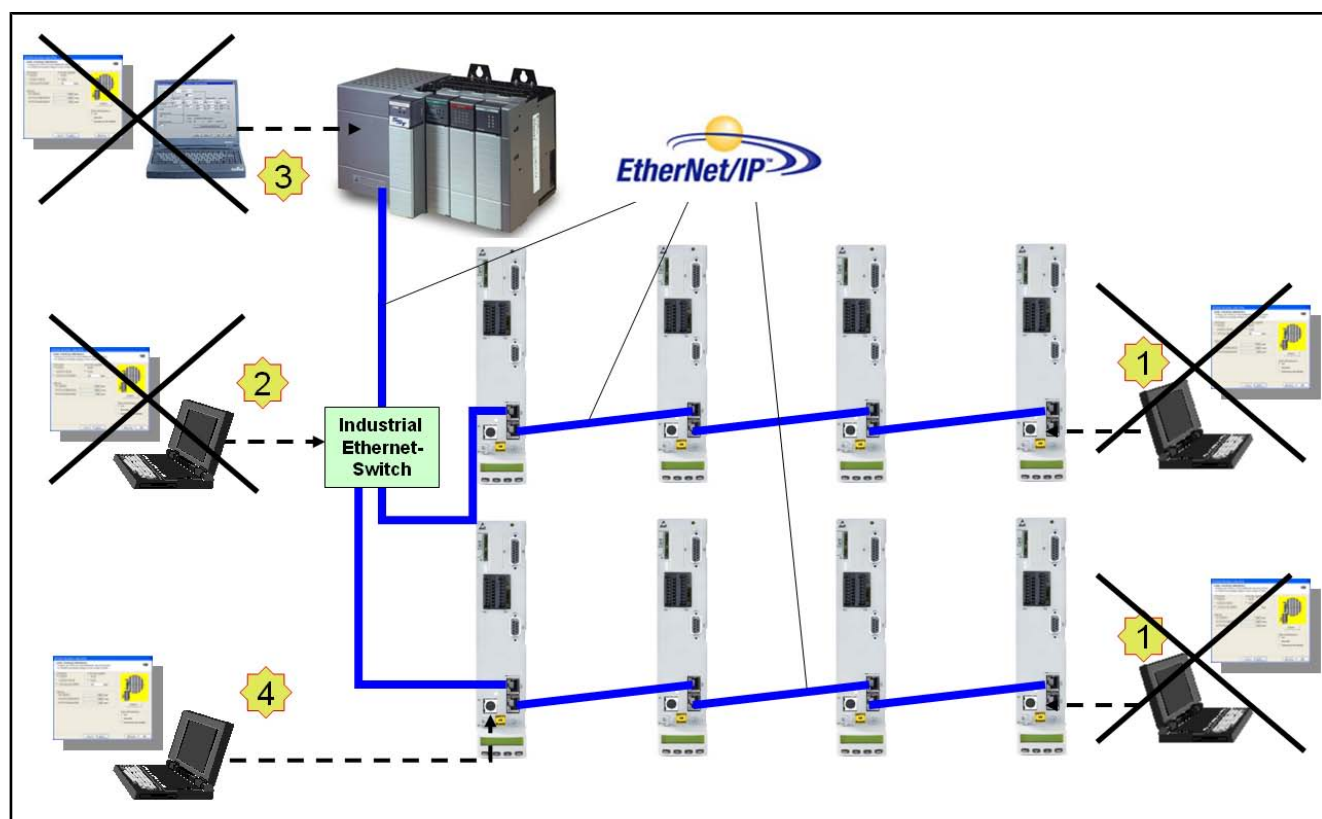
Fig. 4-125: Overview Parameter Access Errors

## 4.12.4 EtherNet/IP™ Interface

### Brief Description

#### Topology

## Master Communication



- 1 Engineering via free EtherNet/IP™ port of a bus node
- 2 Engineering via optional Industrial-Ethernet switch
- 3 Engineering via third-party control not possible
- 4 Engineering via RS232 or existing engineering port at CSH01.3

Fig.4-126: EtherNet/IP Topology

IndraDrive controllers with MultiEthernet interface can also be operated as EtherNet/IP™ master communication. Via this module it is possible to exchange real-time data with an EtherNet/IP™ scanner.

Real-time data can be transmitted via this interface by means of I/O connection (Class 1 connection).

#### Features

- Transmission rate 100Mbit/s (full duplex)
- Data transmission via Ethernet cable (CAT5e copper)
- Topologies: "Star", "line" (by means of integrated cut-through switch)
- Auto negotiation is supported, as a prerequisite the transmission rate mentioned above must be met
- Profile type is "Generic Device", specified in ODVA 2.0 (Open DeviceNet Vendors Association)
- EtherNet/IP™ Level 2 server
- Cyclic exchange via "EtherNet/IP™-I/O-Messaging" (Class 1)
- Configurable cyclic data up to 15 parameters (incl. field bus control word and field bus status word) in both data directions (max. 48 bytes or 24 words)

Min. cycle time	Max. quantity of process data/setting P-0-4076	Notes
0.5 ms ( $T_{A\_pos}$ )	16 bytes → P-0-4076 = 0.5ms 32 bytes → P-0-4076 = 1ms 48 bytes → P-0-4076 > 1 ms	

Fig.4-127: Quantity of Cyclic Data Depending on "P-0-4076, Field Bus: Cycle time ( $T_{cyc}$ )"

Valid values for P-0-4076: 0.5 ms, 1 ms, 2 ms, 3 ms, 4 ms, 5 ms, ...

- Supported field bus profiles:
  - 0xFF82: I/O mode "positioning" with configurable real-time data
  - 0xFF92: I/O mode "preset velocity" with configurable real-time data
  - 0xFFFFD: Freely configurable mode "operation modes neutral"
  - 0xFFFFE: Freely configurable mode

#### Hardware Requirements

Using the master communication "EtherNet/IP™" requires the following control section design:

- Single-axis ADVANCED (CSH01.xC)
- Single-axis BASIC UNIVERSAL (CSB01.1C)
- Double-axis BASIC UNIVERSAL (CDB01.xC)

The option ET must be available as master communication module.

#### Pertinent Parameters

- P-0-4073, Field bus: diagnostic message
- P-0-4074, Field bus: data format
- P-0-4075, Field bus: watchdog
- P-0-4076, Field bus: cycle time ( $T_{cyc}$ )
- P-0-4079, Field bus: baud rate
- P-0-4088, Master communication: Drive configuration
- P-0-4089.0.2, Master communication: Device name
- P-0-4089.0.10, Master communication: MAC address device
- P-0-4089.0.13, Master communication: IP address
- P-0-4089.0.14, Master communication: Network mask
- P-0-4089.0.15, Master communication: Gateway address

#### Profile type parameters

Apart from mere communication parameters, we use parameters in conjunction with the profile types.

See "Profile Types (With Field Bus Interfaces)"

#### Parameters for extended communication

We use additional parameters for extended communication.

See the following sections:

- "Configurable Signal Control Word"
- "Configurable Signal Status Word"
- "Multiplex Channel"

#### Pertinent Diagnostic Messages

- C0229 Field bus: IDN for cycl. command val. not configurable
- C0230 Field bus: Max. length for cycl. command val. exceeded

## Master Communication

- C0231 Field bus: IDN for cycl. actual val. not configurable
- C0232 Field bus: Length for cycl. actual values exceeded
- C0233 Field bus: Tcyc (P-0-4076) incorrect
- C0234 Field bus: P-0-4077 missing for cycl. command values
- C0299 Configuration changed. Restart
- E4005 No command value input via master communication
- F4009 Bus failure

## Configuration of the EtherNet/IP™ Slave

### EDS File

For each EtherNet/IP™ device, it is necessary to have an EDS file (\*.EDS) which contains the data required for operating the device on the field bus. When configuring bus masters supported by the EDS file, this file is required for each node.

The EDS file for IndraDrive is an ASCII file with the name "IndraDrive\_EIP\_MPx06.eds".

### Setting the IP Address of the Slave

Setting is either made via the display or by means of the "IndraWorks" commissioning tool.

The IP address for the EtherNet/IP™ adapter is stored in parameter "P-0-4089.0.13, Master communication: IP address", the subnet mask in parameter "P-0-4089.0.14, Master communication: Network mask" and the gateway address in parameter "P-0-4089.0.15, Master communication: Gateway address".

For a more detailed description, see user documentation of the engineering channel.

### Configuring the Cyclic Data

The parameters for configuring the cyclic data (P-0-4080 and P-0-4081) can contain a maximum of 15 elements each. The maximum length is limited to 24 words. The maximum length depends on "P-0-4076, Field bus: cycle time (Tcyc)":

Min. cycle time	Max. quantity of process data/setting P-0-4076	Notes
0.5 ms ( $T_{A\_pos}$ )	16 bytes → P-0-4076 = 0.5ms 32 bytes → P-0-4076 = 1ms 48 bytes → P-0-4076 > 1 ms	

Fig.4-128: Quantity of Cyclic Data Depending on P-0-4076

Valid values for P-0-4076: 0.5 ms, 1 ms, 2 ms, 3 ms, 4 ms, 5 ms, ...

For configuration of cyclic data of a possible subordinate CCD system see also "Cross Communication (CCD)"

These parameters are set via the commissioning tool "IndraWorks".

## Specification of the EtherNet/IP™ Interface

The drive works with EtherNet/IP™ interface switched on as Level-2 device. This means that the drive makes available one server each for implicit messages (Class 1) and explicit messages (Class 3). The explicit messages are limited to the standard objects.



The implemented EtherNet/IP™ object directory contains the objects specified for a "Generic Device":

- Identity object (0x01)
- Message router object (0x02)
- Ethernet link object (0xF6)
- TCP/IP object (0xF5)
- Port object (0xF4)
- Connection manager object (0x06)
- Assembly object (0x04)

### Cyclic Communication via the Process Data Channel (Class 1)

#### EtherNet/IP™ Connection Types

With an IndraDrive device as EtherNet/IP™ slave, parameters can be cyclically transmitted via an I/O container. This can be done via an "Exclusive Owner Connection" (Transport-Class-1) or a "Listen Only Connection" (Transport-Class-1).

With the "Exclusive Owner Connection", the EtherNet/IP™ input image is transmitted to the drive by means of "point-to-point connection". The output image can be transmitted by means of "point-to-point" or "multicast" connection.

With an already existing "Multicast-Exclusive Owner Connection", a second master can, with a "Listen Only Connection", read the EtherNet/IP™ output image of the IndraDrive device. In this case, a "Heartbeat Connection Point" is used as Consuming Connection Point, and the same Connection Point as with the "Exclusive Owner Connection" is used as Producing Connection Point.

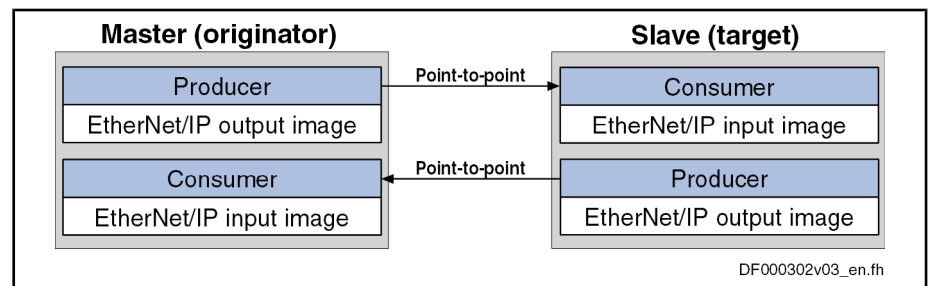


Fig.4-129: EtherNet/IP™ Connection Type "Point-to-Point"

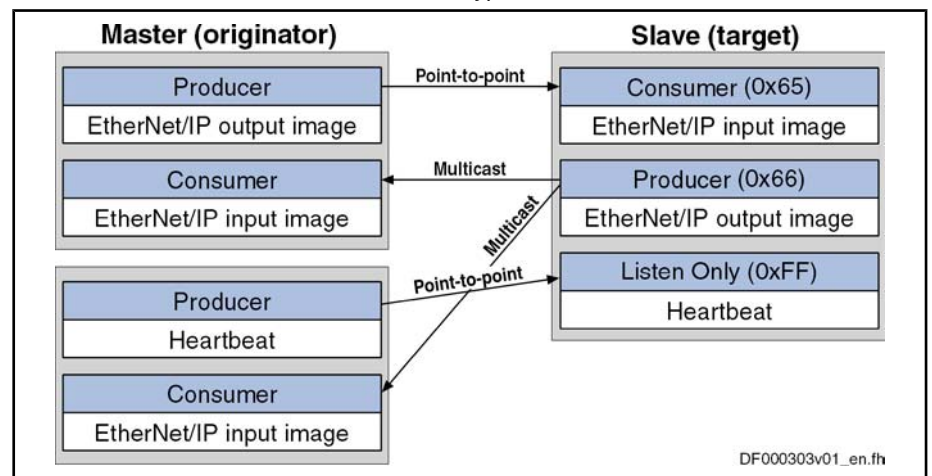


Fig.4-130: EtherNet/IP™ Connection Type "Multicast"

Master Communication

For the cyclic I/O data channel (Implicit Message), the drive makes available a Consumer and Producer, i.e. it consumes the command values of the master and produces the actual values for the master.

Communication in this case runs via a UDP protocol; the direction from master to slave is transmitted with unicast telegrams, the opposite direction is transmitted with multicast telegrams.

**Characteristic of the Cyclic Data Transmission**

- Features**
- The smallest cycle time IndraDrive supports (API → Actual Packet Interval) is 2 ms.
  - The "Idle/Run Header" of the EtherNet/IP™ interface is supported (32 bits). The header is not visible in the cyclic I/O image of the IndraDrive device. The reaction of the IndraDrive device to the Idle/Run Header is defined via the settings of the setting-up mode (easy startup mode).
  - The consumer instance of the IndraDrive device monitors the cyclic transmission of the master output image via a so-called "TimeOut" which the master determines when the connection is established.

The monitoring time is calculated according to the formula below:

$$t = TM \times API$$

$$TM = 2^{(TMV + 2)}$$

t Monitoring time (in ms)  
 TM TimeOut Multiplier  
 API Actual Packet Interval  
 TMV TimeOut Multiplier value  
 Fig.4-131: Calculating the Monitoring Time in two Steps

**Examples**

TMV	TM	API (in ms)	t (in ms)
0	4	2	8
0	4	5	20
1	8	2	16
1	8	5	40
2	16	2	32
3	32	2	64
4	64	5	320
2	16	10	160

Fig.4-132: Exemplary Values for the Monitoring Time

In most of the configuration user interfaces it is possible to directly enter the "TimeOut Multiplier", the user then does not have to take the first formula into account.

**Configuring the Cyclic Process Data**

The cyclic channel is configured by parameterization of "P-0-4080, Field bus: config. list of cyclic actual value data ch." and "P-0-4081, Field bus: config. list of cyclic command value data ch."

On the level of EtherNet/IP™ communication, a static Output Assembly Instance (Class 4, instance 101) and a static Input Assembly Instance (Class 4,

instance 102) are created in the cyclic channel. The data direction in this case is written from the master's point of view. If the parameter setting of P-0-4080 and P-0-4081 or the data length of a CCD slave is changed, new assembly instances are created during the transition from parameter mode (PM) to operating mode (OM). This results in a short interruption of communication.

**Specific Features Cross Communication (CCD) in System Mode**

For communication via EtherNet/IP™ with a CCD system, the configurable I/O data of the individual axes are copied one after the other to the data container of the assembly or removed. This means that the length of the assembly results from the sum of the individual lengths of the local axis and the CCD slave axes (see also "Cross Communication (CCD)").

**Notes on Commissioning**

In preparation

**Diagnostic and Status Messages**

**Diagnostic Messages via Display**

The diagnostic displays via LED (module status, network status), required according to EtherNet/IP™ specification, have been realized by the corresponding display messages.

**Module Status** As the EtherNet/IP™ functionality is not an individual module, one of the status messages of the drive corresponding to the LED display is generated in the display.

**Network Status** The network status of the EtherNet/IP™ unit is indicated via the corresponding "network status LED"

The following table shows the possible states:

Message on display	Significance
Permanently off	The device does not have a valid IP address or is switched off
Flashing green	The device was initialized with a valid IP address but does not have a cyclic connection
Permanently green	The I/O connection has been established without error.
Flashing red	The existing I/O connection was unexpectedly interrupted (e.g. watchdog)
Permanently red	During "Duplicate IP Address Check", the IP address which was set was detected to already exist in the network.
Flashing green/red	The device is currently initializing and performs a self test.

Fig.4-133: Overview of Diagnostic Messages for EtherNet/IP™ Communication

**Diagnostic Messages of IndraDrive**

Diagnostic messages of IndraDrive and their significances in conjunction with EtherNet/IP™ master communication:

- E4005 No command value input via master communication

## Master Communication

→ The master is in the stop mode and the EtherNet/IP™ stack thereby is in the status "IDLE" or the master has specifically aborted the I/O connection and the EtherNet/IP™ stack thereby is in the status "CLOSED".

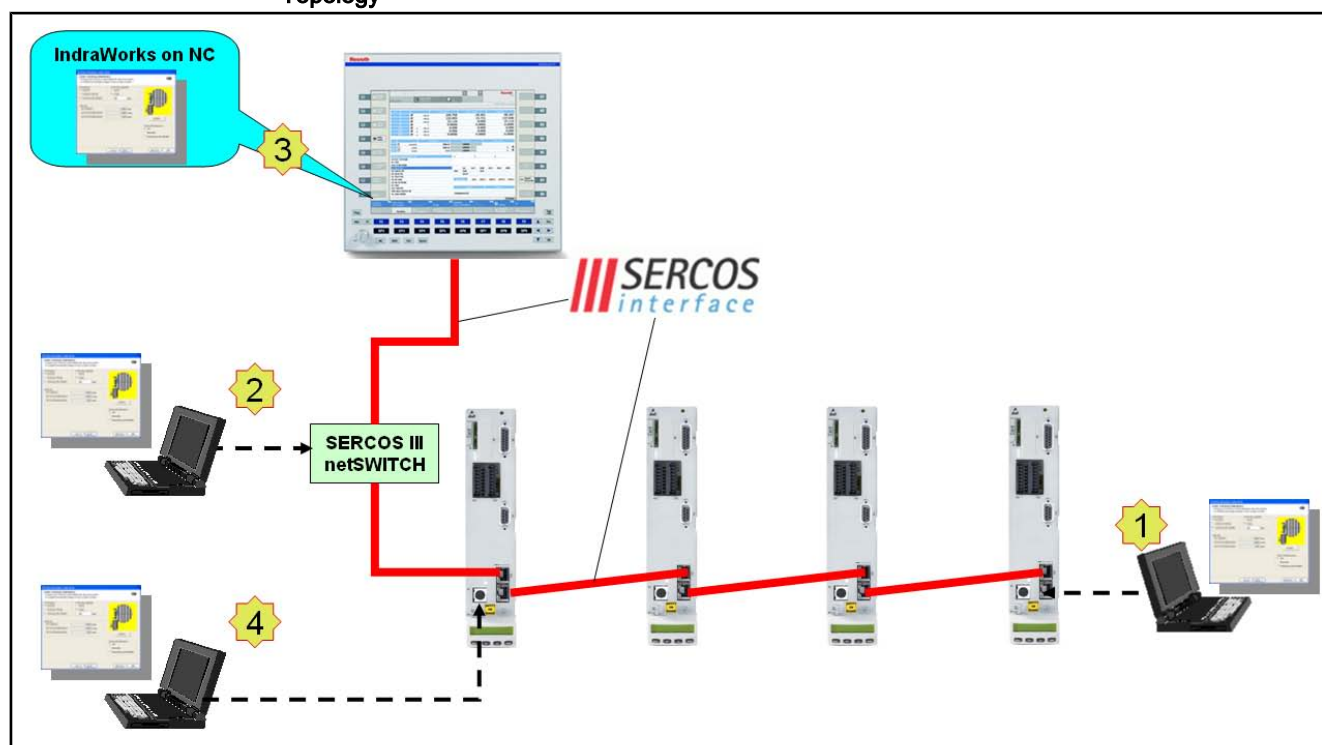
- F4009 Bus failure

→ The master hasn't received any telegram within the watchdog time. The watchdog time is calculated by the formula for the "timeout" time explained under 1.4.2.

## 4.12.5 SERCOS III

## Brief Description

## Topology



- 1 Engineering via free SERCOS III port of a bus node
- 2 Engineering via optional SERCOS III-netSWITCH
- 3 Engineering via IndraWorks on SERCOS III control
- 4 Engineering via RS232 or existing engineering port at CSH01.3

Fig.4-134: SERCOS III - Topology

Operation of IndraDrive controllers with an MultiEthernet interface (ET) or the option module "SERCOS III" (S3) as SERCOS III master communication is possible. Via this modules it is possible to exchange real-time data with a SERCOS III master.

The following communication channels are distinguished:

- **Cyclic data channel** (consumer, producer)
  - Data container for cyclic transmission of useful data (**process data**) in real time
- **Acyclic data channel** (service channel)
  - Data container for acyclic transmission of useful data (**service data**).
- **Non-real time channel (NRT channel)**
  - Defined time slot within the cycle time for transmission of standard Ethernet telegrams

- General Features**
- Transmission rate 100 Mbit/s
  - Cyclical data exchange of command and actual values in equal time intervals
  - Topologies: "Line" (= simple ring) or "ring" (= contra-rotating double ring)
  - Data transmission via Ethernet cable (CAT5e copper)
  - Service channel for parameterization and diagnosis
  - Free configuration of telegram contents
  - Synchronization between time command value takes effect and measurement starting time of the actual values for all drives on a ring
  - Overall synchronization of all connected drives to the master

**Firmware-Specific Features**

			BASIC MPB-06VRS	Advanced MPH-06VRS
<b>Position loop cycle</b>	$T_{\text{position}}$	$\mu\text{s}$	500	250
<b>Master communication cycle time</b>	min	$\mu\text{s}$	500	250
	Max.	ms	65	65
<b>MotionData</b> for each MDT/AT	$T_{\text{Sercos}} = T_{\text{position}}$	Byte	24	24
		IDN	12	12
	$T_{\text{Sercos}} > T_{\text{position}}$	Byte	48	48
		IDN	16	16
<b>CC connections</b> [incl. 2 bytes connection control word (C_Con)]		Byte	10	10
		IDN	2	2

Fig.4-135: SERCOS III Characteristic Numbers

- Cycle time Min. 250 $\mu\text{s}$ , max. 65ms (multiples of position clock 250 $\mu\text{s}$  or 500 $\mu\text{s}$  can be set)
- max number of configurable consumer data: 52 bytes/16 identification numbers
- max number of configurable producer consumer data: 52 bytes/16 identification numbers



The number of configurable bytes in the consumer/producer connections depends on the relation of the position cycle time (P-0-0556, bit 2) to the SERCOS cycle time:

- SERCOS cycle time = position cycle time → max. length 28 bytes/12 identification numbers
- SERCOS cycle time = position cycle time → max. length 52 bytes/16 identification numbers

The NRT channel is only possible, if a time slot of more than 125  $\mu\text{s}$  is available.

**Hardware Requirements**

The optional module with SERCOS III interface is available for the following configurable control sections:

- Single-axis ADVANCED (CSH01.xC)
- Single-axis BASIC UNIVERSAL (CSB01.1C)

## Master Communication

- Double-axis BASIC UNIVERSAL (CDB01.xC)

The option ET or S3 must be available as master communication module.

**Pertinent Parameters**

Specific parameters for SERCOS III communication:

- S-0-1000, SERCOS III: SCP Type & Version
- S-0-1002, SERCOS III: Communication Cycle time (tScyc)
- S-0-1005, SERCOS III: Minimum feedback processing time (t5)
- S-0-1006, SERCOS III: AT0 transmission starting time (t1)
- S-0-1007, SERCOS III: Feedback acquisition capture point (t4)
- S-0-1008, SERCOS III: Command value valid time (t3)
- S-0-1009, SERCOS III: Device Control (C-Dev) offset in MDT
- S-0-1010, SERCOS III: Lengths of MDTs
- S-0-1011, SERCOS III: Device Status (S-Dev) offset in AT
- S-0-1012, SERCOS III: Length of ATs
- S-0-1013, SERCOS III: SVC offset in MDT
- S-0-1014, SERCOS III: SVC offset in AT
- S-0-1015, SERCOS III: Ring delay
- S-0-1016, SERCOS III: Slave delay (P/S)
- S-0-1017, SERCOS III: NRT transmission time
- S-0-1019, Master comm. engineering over IP: MAC address
- S-0-1020, Master comm. engineering over IP: IP address
- S-0-1021, Master comm. engineering over IP: Network mask
- S-0-1022, Master comm. engineering over IP: Gateway address
- S-0-1023, SERCOS III: SYNC jitter
- S-0-1024, C5300 SERCOS III: SYNC delay measuring procedure command
- S-0-1026, SERCOS III: Version of communication hardware
- S-0-1027.0.1, SERCOS III: Requested MTU
- S-0-1027.0.2, SERCOS III: Effective MTU
- S-0-1031, SERCOS III: Signal assignment TSx
- S-0-1035, SERCOS III: Error counter Port1 & Port2
- S-0-1040, Drive address of master communication
- S-0-1041, SERCOS III: AT Command value valid time (t9)
- S-0-1044, SERCOS III: Device Control (C-Dev)
- S-0-1045, SERCOS III: Device Status (S-Dev)
- S-0-1046, SERCOS III: List of SERCOS addresses in device
- S-0-1050.x.1, SIII-Connection: Connection setup
- S-0-1050.x.2, SIII-Connection: Connection number
- S-0-1050.x.3, SIII-Connection: Telegram assignment
- S-0-1050.x.4, SIII-Connection: Max. length of connection
- S-0-1050.x.5, SIII-Connection: Current length of connection
- S-0-1050.x.6, SIII-Connection: Configuration list
- S-0-1050.x.8, SIII-Connection: Connection control (C-Con)

- S-0-1050.x.10, SIII-Connection: Producer cycle time
- S-0-1050.x.11, SIII-Connection: Allowed data losses
- S-0-1050.x.12, SIII-Connection: Error counter data losses
- S-0-1050.x.20, SIII-Connection: IDN allocation of real-time bit
- S-0-1050.x.21, SIII-Connection: Bit allocation of real-time bit
- S-0-1051, SIII-Connection: Image of connection setups

Additional pertinent parameters according to "SERCOS interface":

- S-0-0014, Interface status
- S-0-0015, Telegram type parameter
- S-0-0097, Mask class 2 diagnostics
- S-0-0134, Master control word
- S-0-0135, Drive status word
- S-0-0187, List of configurable data in the AT
- S-0-0188, List of configurable data in the MDT
- P-0-1044, Master comm. engineering over IP: Status IP communication

#### Pertinent Diagnostic Messages

- C0108 Time slot parameter > Sercos cycle time
- C0109 Telegram offset unsuitable
- C0112 TNcyc (S-0-0001) or TScyc (S-0-0002) error
- C0113 Relation TNcyc (S-0-0001) to TScyc (S-0-0002) error
- C0170 Config. IDNs for connection not configurable
- C0171 Maximum length for connections exceeded
- C0172 Delay measurement (S-0-1024) not carried out
- C0173 Connections (number) not configurable
- C0174 Connection configuration not allowed
- C0175 Producer cycle time of a connection not correct
- C5301 SERCOS III: Delay measurement failed
- E4001 Double MST failure shutdown
- E4005 No command value input via master communication
- E4007 SERCOS III: Consumer connection failed
- E4010 Slave not scanned or address 0
- F4001 Sync telegram failure
- F4002 RTD telegram failure
- F4003 Invalid communication phase shutdown
- F4004 Error during phase progression
- F4005 Error during phase regression
- F4006 Phase switching without ready signal
- F4017 S-III: Incorrect sequence during phase switch






## 5 Motor, Mechanical Axis System, Measuring Systems

### 5.1 General Information on Operation of Motors With IndraDrive

#### 5.1.1 Basics on the Motors to be Controlled

##### Brief Description

	<p>With the controllers of the IndraDrive range it is possible to control both synchronous motors and asynchronous motors.</p>
<b>Types of Construction</b>	<p>The following types of construction are possible:</p> <ul style="list-style-type: none"> <li>• Rotary motors</li> <li>• Linear motors</li> </ul> <p>Both types can be used in housing design (motor with an output shaft that includes the bearing) or in kit design (stator and rotor as individual components).</p>
<b>Thermal Monitoring</b>	<p>When IndraDrive is used, the controlled motors are protected against thermal damage when they are provided with a temperature sensor connected to the controller. The controllers are equipped for evaluating the following temperature sensors:</p> <ul style="list-style-type: none"> <li>• NTC thermistor K227 (manufacturer: Siemens)</li> <li>• PTC thermistor KTY84 (manufacturer: Siemens)</li> <li>• Thermal contact and thermal switch SNM150DK (manufacturer: Thermik)</li> </ul> <p>In addition, it is possible to evaluate temperature sensors not listed above, but their specific resistance characteristics have to be entered manually!</p>
<b>Diagnostic Data of Motor Operation</b>	<p>The firmware provides the option to collect dynamic operating data of the motor and store them in the motor or the controller (operating hours counter, thermal and mechanical operating data, operational performance).</p>
<b>Adjusting Motor/Controller</b>	<p>The IndraDrive controllers are adjusted to the motor to be controlled by providing or inputting the motor-specific data.</p> <ul style="list-style-type: none"> <li>• In the case of <b>Rexroth motors</b>, this can be done without any problem, because the manufacturer provides a specific data set for adjusting each motor type. The data are documented by the manufacturer as parameter values, stored and made available in motor-specific parameters.</li> <li>• In the case of <b>third-party motors</b>, it is necessary to check, by means of the motor data and the data of the possibly available motor encoder, whether they are basically suited for operation with IndraDrive. The parameter values for adjusting the controller have to be specifically determined for each motor.</li> </ul> <hr/> <p> Rexroth motors, by motor-specific parameter values made available and temperature evaluation adjusted in an optimum way, guarantee easy commissioning, full drive performance and a high degree of operational safety!</p> <hr/>
<b>Motor Holding Brakes</b>	<p>IndraDrive allows controlling and monitoring holding brakes that are mechanically connected to the motor:</p> <ul style="list-style-type: none"> <li>• Electrically releasing brakes (self-holding)</li> <li>• Electrically holding brakes (self-releasing)</li> </ul>
<b>Hardware Data</b>	<p>For the electrical connection of the motors to the controller, see the Project Planning Manuals for the IndraDrive controllers. A complete connection dia-</p>

## Motor, Mechanical Axis System, Measuring Systems

gram for the use of Rexroth motors is contained in the respective Project Planning Manual.

**Pertinent Parameters**

Motor parameters:

- S-0-0109, Motor peak current
- S-0-0111, Motor current at standstill
- S-0-0113, Maximum motor speed
- S-0-0141, Motor type
- P-0-0018, Number of pole pairs/pole pair distance
- P-0-0051, Torque/force constant
- P-0-0510, Rotor inertia
- P-0-0640, Cooling type
- P-0-4014, Type of construction of motor
- P-0-4048, Stator resistance

Asynchronous motor parameters:

- P-0-0532, Premagnetization factor
- P-0-4004, Magnetizing current

Field-weakening range parameters:

- P-0-0533, Voltage loop proportional gain
- P-0-0534, Voltage loop integral action time
- P-0-0535, Motor voltage at no load
- P-0-0536, Maximum motor voltage

**Other Motor-Relevant Parameters**

In connection with the motor, there are other important parameters of the following parameter groups:

- Measuring system parameters
- Motor holding brake parameters
- Temperature sensor parameters
- Default control loop parameters

## 5.1.2 Motor Temperature Monitoring

### Brief Description

**Pertinent Parameters**

See "Basics on the Motors to be Controlled"

- S-0-0201, Motor warning temperature
- S-0-0204, Motor shutdown temperature
- S-0-0383, Motor temperature
- P-0-0512, Temperature sensor
- P-0-0513, Temperature sensor characteristic

**Pertinent Diagnostic Messages**

- E2021 Motor temperature outside of measuring range
- E2051 Motor overtemp. prewarning
- F2019 Motor overtemperature shutdown
- F2021 Motor temperature monitor defective

### Functional Description

Motors can be thermally monitored by the controller and thereby protected against damage by overload.

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For this purpose, there are the following prerequisites:

- Motor has a built-in temperature sensor
- Motor-specific parameter values in firmware-side motor temperature model are active
- Ambient temperature is in allowed range

The motor is protected against thermal overload by

- monitoring motor temperature by means of sensor  
- and -
- limiting motor current by means of temperature model.

Monitoring the motor temperature by means of sensor is the most reliable way of protecting the motor against inadmissible temperature rise. Limiting the motor current by means of the temperature model assumes thermal requirements not guaranteed in reality in the "case of failure"!



Limitation of the motor current by means of the temperature model is described in the section "Current and Torque/Force Limitation" .

The monitoring of the motor temperature is activated by entering the sensor type in "P-0-0512, Temperature sensor". Standard sensor types are characterized by a characteristic number; a characteristic stored in the firmware is assigned to this number.

The current motor temperature is output in "S-0-0383, Motor temperature" and monitored for the following threshold values:

- Motor warning temperature (S-0-0201)
- Motor shutdown temperature (S-0-0204)

The threshold values have to be entered in the respective parameters, depending on the thermally restricting material properties and constructional features. Thermally restricting properties can be:

- Insulation class of the motor
- Type and construction of the bearing
- Allowed thermal effect on the machine design, etc.

If the temperature sensor has not been connected, this is detected by the motor temperature monitor, too.

Depending on the sensor type, motor temperature monitoring has the following states:

Thermal status	Motor temperature...	Message and reaction
Thermal range not allowed, temperature sensor possibly not connected.	... for 30 s ≤ -20°C	<b>Error:</b> F2021 Motor temperature monitor defective  <b>Reaction:</b> Motor is immediately shut down (error reaction which was set) and switched off!
		Only with Sensor <b>KTY84</b> :  <b>Warning:</b> E2021 Motor temperature outside of measuring range  <b>Reaction:</b> No specific reaction!

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Thermal status	Motor temperature...	Message and reaction
Allowed thermal range	... < value of S-0-0201	No specific message or reaction!
Thermal range allowed, but warning temperature exceeded, because temperature has fallen below the minimum distance to the upper limit.	... ≥ value of S-0-0201	<b>Warning:</b> E2051 Motor overtemp. prewarning <b>Reaction:</b> No specific reaction!
Upper limit of allowed thermal range reached!	... ≥ value of S-0-0204	<b>Error:</b> F2019 Motor overtemperature shutdown <b>Reaction:</b> Motor is immediately shut down (error reaction which was set) and switched off!
Only with Sensor <b>KTY84</b> : Short circuit or conductor break detected		Only with Sensor <b>KTY84</b> : <b>Error:</b> F2021 Motor temperature monitor defective <b>Reaction:</b> Motor is immediately shut down (error reaction which was set) and switched off!

Fig. 5-1: States of the Thermal Motor Monitoring

**Rexroth Motors**

Rexroth motors are equipped with standard type sensors. The respective parameter values for the temperature sensor, as well as for the motor shutdown temperature, are automatically set correctly when loading the motor parameters!



The motors MHD, MKD, MBS and MKEE have temperature sensors with switching characteristic. They are not suited for measuring the temperature and only used to switch off the motor in the case of overtemperature.

The message and shutdown threshold have been permanently set and **cannot** be set via S-0-0201 and S-0-0204!

**Third-Party Motors**

Third-party motors may include temperature sensors that do not correspond to the standard type sensors. This information is given to the controller via "P-0-0512, Temperature sensor". The respective resistance temperature characteristic then has to be input manually as a table of values in "P-0-0513, Temperature sensor characteristic".

Third-party motors without built-in temperature sensor can also be operated with IndraDrive controllers, but they are only protected against thermal overload by the firmware-side motor temperature model! The temperature monitor has to be switched off in the mentioned case, because otherwise the controller demands a temperature sensor to be connected.

See also "Third-Party Motors at IndraDrive Controllers"

**Notes on Commissioning**

**Relevant Parameters**

Rexroth motors with the characteristic temperature sensor number "1" (MHD, MKD, MLP, MBT, MBS motors) or "4" (MKE motors):

→ No parameter settings regarding the temperature sensor are required!

Rexroth motors with the characteristic temperature sensor number "2", "3" or "5" (1MB, MAD, MAF or SF motors):

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→ An adjusted value has to be written to the following parameter during commissioning:

- S-0-0201, Motor warning temperature

Third-party motors with the characteristic temperature sensor number "2", "3" or "5":

→ The following parameter has to be replaced by an adjusted value during commissioning:

- S-0-0201, Motor warning temperature
- S-0-0204, Motor shutdown temperature
- P-0-0512, Temperature sensor

Third-party motors with the characteristic temperature sensor number "100":

- S-0-0201, Motor warning temperature
- S-0-0204, Motor shutdown temperature
- P-0-0512, Temperature sensor
- P-0-0513, Temperature sensor characteristic



The value in S-0-0201 has to be lower than the value of S-0-0204!

### Activating/Deactivating the Function

The motor temperature monitoring is activated by entering the sensor type in "P-0-0512, Temperature sensor". The value "0" deactivates motor temperature monitoring.

When this function has been activated, the following diagnostic messages are possible:

- E2021 Motor temperature outside of measuring range
- E2051 Motor overtemp. prewarning
- F2019 Motor overtemperature shutdown
- F2021 Motor temperature monitor defective

Querying the current motor temperature (not in the case of the characteristic temperature sensor number "1" or "4"):

- S-0-0383, Motor temperature

## 5.2 Rexroth Motors

### 5.2.1 Basics on Rexroth Motors

**Classification** Bosch Rexroth's "Electric Drives and Controls" technology field offers a wide range of motors for equipping machines and installations with drives.

Due to their types of construction, Rexroth electric motors can be divided into:

- Housing motors with output shaft and flange or mounting supports
- Kit motors to be installed in machines and installations; consisting of individual components that are mounted to a moving and a static part of the mechanical system

**Adjusting Motor/Controller** The controllers can be adjusted to Rexroth motors without any problem because the manufacturer provides the respective data set for each motor type. These data are available as parameter values.

- In the case of housing motors with data memory in the motor encoder, the parameter values are delivered as an integral part of the motor. At the initial commissioning they are automatically loaded to the controller.

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- In the case of kit motors (individual components) and housing motors without data memory in the motor encoder, the respective motor parameters are not delivered with the motor. They can be easily loaded to the controller, however, from a data base in the "IndraWorks Ds/D/MLD" commissioning tool.

The motor parameter values determined by the manufacturer guarantee that the motor can be loaded in accordance with its operating characteristic, if the required current and the corresponding power are provided by controller and supply unit.

**Thermal Motor Monitoring**

Rexroth motors are thermally monitored by the controller and protected against overheating. To do this the current motor temperature is determined by thermo sensors installed in the motor winding. Depending on temperature thresholds that can be set, the controller generates a warning or switches the motor off.



Rexroth motors, by motor parameters made available and temperature evaluation adjusted in an optimum way, guarantee easy commissioning, full drive performance and a high degree of operational safety!

**Measuring System**

As a standard, Rexroth housing motors are equipped with a position measuring system. The individual motor series have different measuring systems which allows offering cost-efficient motors depending on the application.

The following measuring systems are used:

- HSF ("high-resolution servo feedback"), single- or multi-turn type
- Resolver, single- or multi-turn type

Together with Rexroth kit motors it is possible to use different encoder systems:

- Encoder with sine signals and EnDat interface, 1Vpp, Heidenhain standard
- Encoder with sine signals, 1Vpp, Heidenhain standard
- Encoder with square-wave signals, TTL, Heidenhain standard
- Hall sensor box and encoder with sine signals, 1Vpp, Heidenhain standard (only for Rexroth linear kit motors)
- Hall sensor box and encoder with square-wave signals, TTL, Heidenhain standard (only for Rexroth linear kit motors)

## 5.2.2 Rexroth Housing Motors

### Rexroth Housing Motors With Encoder Data Memory

**Motor Lines**

The following Rexroth housing motors are equipped with an encoder data memory:

- MSK, MHD, MKE, MKD, MSP, KSM
- MAD, MAF



The Bosch motor with the type designation "SF..." that can be controlled with IndraDrive controllers is equipped with an encoder data memory, too. As regards commissioning and parameters, SF motors have the same behavior as Rexroth housing motors with encoder data memory!

**Brief Description**

See section "Basics on Rexroth Motors"

## Motor, Mechanical Axis System, Measuring Systems

**Pertinent Parameters** The encoder data memory, amongst others, contains the parameters listed below.

Motor parameters:

- P-0-2109, Motor peak current, encoder memory
- P-0-2111, Motor current at standstill, encoder memory
- P-0-2113, Maximum velocity of motor, encoder memory
- P-0-2141, Motor type, encoder memory
- P-0-3002, Number of pole pairs/pole pair distance, encoder memory
- P-0-3003, Rotor inertia, encoder memory
- P-0-3005, Torque/force constant, encoder memory
- P-0-3007, Stator resistance, encoder memory
- P-0-3008, Commutation offset, encoder memory
- P-0-3050, Motor inductance, encoder memory

Parameters for measuring system:

- P-0-1000, Kind of encoder 1, encoder memory
- P-0-1001, Encoder 1 resolution, encoder memory

Only for absolute encoders (multi-turn):

- P-0-1002, Absolute encoder offset 1, encoder memory

Only for resolvers as absolute encoders (multi-turn resolvers):

- P-0-1003, Pulse wire encoder offset 1, encoder memory
- P-0-1004, Pulse wire encoder status 1, encoder memory

Parameter for motor holding brake (if available):

- P-0-3010, Torque of motor holding brake, encoder memory

Default control loop parameters:

- P-0-2100, Velocity loop proportional gain, encoder memory
- P-0-2101, Velocity loop integral-action time, encoder memory
- P-0-2104, Position loop Kv-factor, encoder memory
- P-0-2106, Current loop proportional gain 1, encoder memory
- P-0-2107, Current loop integral-action time 1, encoder memory
- P-0-3004, Speed loop smoothing time constant, encoder memory

At a command, default control loop parameters can be loaded to the controller. They are useful starting values for further control loop optimization.

- Pertinent Diagnostic Messages**
- C0700 Load defaults procedure com. (load controller param.) (C07\_0)
  - C0702 Default parameters not available
  - C0703 Default parameters invalid
  - C0704 Parameters not copyable
  - C0706 Error when reading the controller parameters
  - F2008 RL The motor type has changed.
  - F2104 Commutation offset invalid

### Notes on Commissioning

**Initial Commissioning** In the case of Rexroth housing motors with encoder data memory, the values for the motor parameters stored in the encoder, the measuring system param-

## Motor, Mechanical Axis System, Measuring Systems

eters and, where required, the motor holding brake parameters are automatically loaded to the controller when the drive is switched on.

During initial commissioning of a drive, the error message "F2008 RL The motor type has changed." will appear. This message only means that this motor has not yet been connected to the controller.

By clearing this error message (reset via control panel or command "S-0-0099, C0500 Reset class 1 diagnostics"), "S-0-0262, C07\_x Load defaults procedure command" is automatically started. Default control loop parameter values for this motor are thereby loaded.



Depending on the setting in "P-0-4090, Configuration for loading default values", the following parameter values are loaded with the "load defaults procedure" command (S-0-0262):

- Default control loop parameter values (default setting)
- Basic parameter values (default parameter set) of the firmware

In the case of motors with integrated holding brake, the type of motor holding brake and the activation of the brake control is automatically set in "P-0-0525, Holding brake control word".

In the case of motors with several cooling type variants (MHD, MKD), the load data can be referred to the cooling type realized by entering the corresponding value in "P-0-0640, Cooling type".

**Recommissioning**

When the machine is repaired, the motor can be replaced by a motor of the same type without any problem. The adjustment to the controller does not need to be repeated. In the case of an absolute motor encoder, it is only necessary to make an adjustment to the machine axis by establishing the position data reference.

If the motor type connected to the controller has changed, the controller signals this with "F2008 RL The motor type has changed." and requests the default values of the control loop parameters and the motor type parameter to be loaded. In the case of a desired motor change, initial commissioning of the new axis motor is necessary. Otherwise, there is an assembly error that has to be corrected!

**Diagnostic Messages**

In connection with the loading and verifying of parameter values from the encoder data memory, the following messages might possibly be generated:

- When the default control loop parameter values and the motor type parameter are loaded  
→ C0700 Load defaults procedure com. (load controller param.) (C07\_0)
- If the parameter values in the encoder data memory cannot be read  
→ C0706 Error when reading the controller parameters
- If the motor type connected to the controller has changed  
→ F2008 RL The motor type has changed.
- If an invalid value for the commutation offset is contained in the encoder memory  
→ F2104 Commutation offset invalid

**Rexroth Housing Motors Without Encoder Data Memory****Motor Lines**

The following Rexroth housing motor does not have an encoder data memory:

- MAL



**Brief Description**

See section "Basics on Rexroth Motors"

**Pertinent Parameters**

The parameters mentioned in "Basics on the Motors to be Controlled" are used for these motors.

**Functional Description**

**Application-Dependent Motor Parameters for Asynchronous Motors**

The Rexroth motors without encoder data memory, MAD and MAF series, are asynchronous motors. Therefore, a value adjusted to the application has to be written to "P-0-0532, Premagnetization factor".

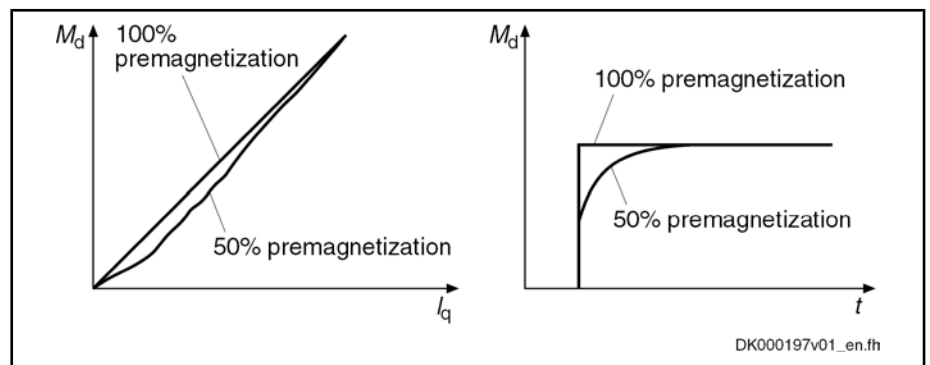
The premagnetization factor influences the "magnetizing current" motor parameter:

$$\text{Effective magnetizing current} = \frac{(P-0-0532)}{100 \%} \times (P-0-4004)$$

P-0-0532 Premagnetization factor  
 P-0-4004 Magnetizing current

*Fig. 5-2: Setting the Effective Magnetizing Current for Asynchronous Motors*

The magnetizing current value determined for Rexroth motors by the manufacturer guarantees perfect torque development (maximum torque/force constant, according to the value of P-0-0051) and minimum delay when making available the torque in the case of abrupt load.



Md Torque at the motor shaft  
 Iq Torque-generating component of the motor current

*Fig. 5-3: Influence of the Premagnetization Factor on the Torque*

**Notes on Commissioning**

**Parameter Values Made Available**

In the case of Rexroth motors without encoder data memory, the motor-specific parameter values made available, such as

- motor parameters
- parameters of the measuring system
- parameters of the motor holding brake
- temperature sensor parameters

can either be input manually by means of a list (e.g. via the control terminal) or loaded via the "IndraWorks Ds/D/MLD" commissioning tool from a database.

**Setting the Premagnetization Factor**

The following table contains the recommended setting for "P-0-0532, Premagnetization factor", depending on the application.

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Usage	Value of P-0-0532 in %	Effect
Servo drive	100	Torque generation free of delay in the case of acceleration or sudden load variation
Main drive	50	Less power dissipation in no-load operation, noise level reduced

Fig.5-4: Recommended Setting for P-0-0532

With values between 50% and 100%, it is possible to obtain a compromise between the mentioned effects!

It is therefore necessary to make sure you obtain the desired results for processing or acceleration/deceleration procedures after the premagnetization factor has been reduced!



The selection lists for motor/controller combinations with Rexroth asynchronous motors (1MB, MAD, MAF), published by Rexroth, refer to a premagnetization of 100%.

With lower values, you have to expect deviation from these data!

## 5.2.3 Rexroth Kit Motors

### General Information

Kit motors consist of individual components that are mounted to a moving and as static part of the machine's mechanical system and functionally put together to form a motor.

A kit motor consists of the following components:

- Electrically active part with thermo sensor
- Electrically passive part
- Measuring System
- Storage

The electrical parts of the kit motor are supplied by Rexroth, the measuring system and the bearing are provided on the machine side.

Rexroth kit motors are manufactured according to the "asynchronous motor" or "synchronous motor" functional principles. With regard to control, the functional principles have different requirements:

- In the case of synchronous motors, the current in the windings of the stator must have a fixed allocation to the permanent magnetic field of the rotor so that the maximum torque or the maximum force is generated.
- In the case of asynchronous motors there is no fixed allocation between stator and rotor required in order to generate the maximum torque or the maximum force.

### Rexroth Kit Motors, Synchronous

#### Brief Description

The following Rexroth kit motors are manufactured according to the "synchronous motor" functional principle:

- Linear motor MLF
- Rotary motors MBS and MBT

As the motor is assembled in the machine, stator, rotor and measuring system can only be put together on site. The electric-magnetic-mechanical allocation

of the synchronous motor is therefore only to be made on site. This is done by determining and setting the commutation offset.



The measuring system should be realized with high resolution and as a motor encoder to be evaluated in absolute form (see also "Absolute Measuring Systems"). If it is necessary to use an incremental measuring system the use of encoders with square-wave signals should be avoided!

#### Determining the Commutation Offset

The commutation offset can be determined with different methods. The method is chosen in accordance with the axis geometry, the practicability and the chances of success of the respective method depending on the mechanical axis system:

- **Calculation method** for relative motor encoder when using the Hall sensor box
  - Distance measurement, currentless (only possible for Rexroth linear kit motors)
- **Measuring method** for motor encoders that can be evaluated in absolute form
  - Distance measurement, currentless (only possible for Rexroth linear kit motors)
- **Saturation method** (axis needs to be blocked or at standstill)
  - With current (possible with all types of construction in combination with motor encoders that can be evaluated in absolute form or with relative motor encoders)
- **Sine-wave method** (requires unrestricted movement of axis)
  - With current (possible with all types of construction in combination with motor encoders that can be evaluated in absolute form or with relative motor encoders)



In the case of absolute measuring systems, the commutation offset only has to be determined once (at initial commissioning), in the case of incremental measuring systems this has to be done each time the drive is switched on again!

Description of the method for commutation setting, see "Drive Control: Commutation setting"

### Rexroth Kit Motors, Asynchronous

#### Brief Description

The following Rexroth kit motors are manufactured according to the "asynchronous motor" functional principle:

- Rotary motors 1 MB

As the motor is assembled in the machine, stator, rotor and measuring system can only be put together on site. After loading the specific parameter values for motor and measuring system the assembled motor can be put into operation independent of rotor position and allocation of the measuring system.



The measuring system should be realized with high resolution and as an absolute encoder! Avoid using encoders with square-wave signals!

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The parameters mentioned under "Basics on the Motors to be Controlled" are used for these motors.

### Notes on Commissioning

#### Parameter Values Made Available

For commissioning the motor-specific parameter values made available by Rexroth, such as

- motor parameters and
- temperature sensor parameters

can either be input manually by means of a list (e.g. via the control terminal) or loaded via the "IndraWorks Ds/D/MLD" commissioning tool from a database.

#### Premagnetization Factor

A value adjusted to the application has to be written only to "P-0-0532, Premagnetization factor".

See section "Rexroth Housing Motors without Encoder Data Memory"

## 5.3 Third-Party Motors at IndraDrive Controllers

### 5.3.1 General Information on Third-Party Motors

Today, machine axes are mainly moved with electric drives. Motors of standard design are used in most cases, as this is the most cost-efficient solution.

#### Special Requirements

Due to special requirements at machine axes, constructional or safety-related aspects, it may be necessary for the machine manufacturer to use a motor construction diverging from the standard.

#### Motor Design not Included in Product Range

For these cases there is the demand on the drive supplier to realize, apart from the deliverable standard drive consisting of (standard) motor, controller, cable and, if required, machine control unit, drives with motors that are not included in his own product range due to the special design.

With Rexroth controllers of the IndraDrive range, it is also possible to control third-party motors.

#### Checking Whether Third-Party Motors Can be Controlled

For successfully and fail-safely controlling a third-party motor, it is necessary to check beforehand

- whether the third-party motor to be controlled meets the requirements of the controller,
- whether the third-party motor has the required minimum inductance,
- whether the mounted position measuring system can be evaluated by the controller or which position measuring system can be selected for kit motors,
- whether the motor can be protected against inadmissible temperature rise in the case of overload,
- which controller, including supply, is suitable due to the motor power to be delivered.

#### How to do Project Planning?

The requirements relevant in the system combination are documented in the Project Planning Manual of the drive system.



See documentation "Rexroth IndraDrive – Drive System, Project Planning Manual" (DOK-INDRV\*-SYSTEM\*\*\*\*\*-PR\*\*-EN-P; part no.: R911309636)!

#### How to Commission?

The motor parameter values have to be determined first (see section "Determining the Parameter Values for Motor and Motor Control"). The parameter values of motor control are calculated by command internally in the firmware.

It is advisable to document the determined motor parameter values in the forms contained in the section "Forms for Parameter Values".

## 5.3.2 General Information on Controlling Third-Party Motors

### Pertinent Parameters and Diagnostic Messages

See "Automatic Setting of Motor Control"

### Hardware Data

For the electrical connection of the motors to the controller, see the Project Planning Manuals for the IndraDrive Controllers. A complete connection diagram for the use of Rexroth motors is contained in the respective Project Planning Manual.

## 5.3.3 Determining the Parameter Values of Third-Party Motors

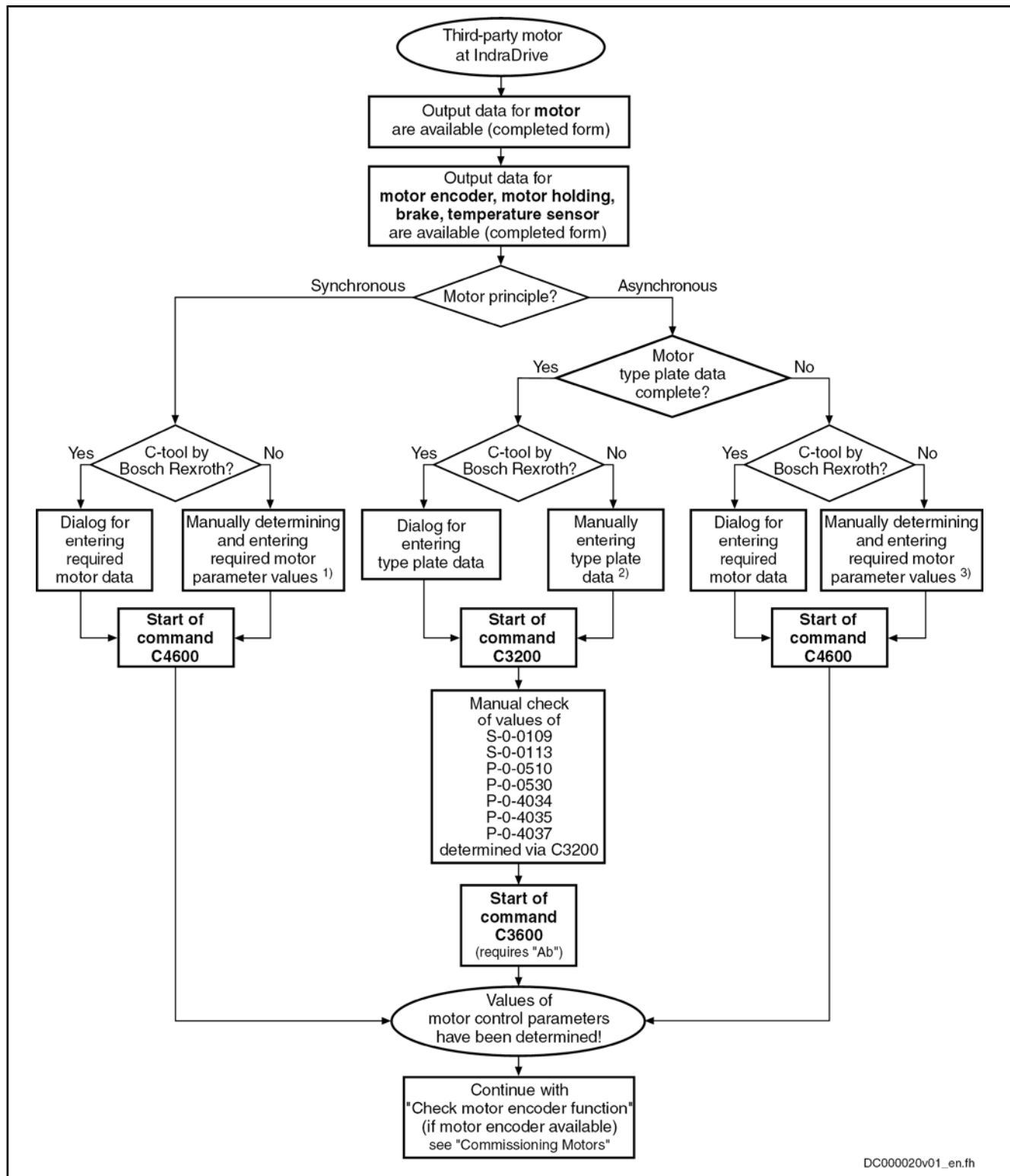
### General Information on How to Determine the Parameter Values

As Bosch Rexroth cannot make available parameter values for motor control of third-party motors, these values have to be determined before or during the commissioning of the third-party motor. The determination of these parameter values is supported by the following commands:

- **C3200 Command Calculate motor data**  
→ For asynchronous motors, drive-internal calculation of the values for the motor control parameters from the data on the type plate
- **C3600 Command Motor data identification**  
→ For asynchronous motors, drive-internal optimization of the motor control parameter values calculated by means of the command C3200
- **C4600 Command Calculate motor control parameters**  
→ Calculating the motor control parameter values from the motor-specific data for synchronous motors and, if necessary, also for asynchronous motors (after manual input of motor-specific data in addition to the data from the type plate)

The specific motor data have to be made available by the motor manufacturer. To collect all required manufacturer-side data of the motor, use the appropriate forms to copy below.

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DC000020v01\_en.fh

- 1) According to form "Motor Parameters for Synchronous Motors"
  - 2) in parameter "P-0-4032, Motor type plate data"
  - 3) According to form "Motor Parameters for asynchronous Motors"
- C-tool  
commissioning tool (e.g. IndraWorks Ds/D/MLD)

Fig. 5-5: Determining the Values for the Motor Control Parameters

For detailed explanations on the scope of functions of the mentioned commands see "Automatic Setting of Motor Control"!

## Determining the Motor Parameter Values for Manual Input (for Command C4600)

On the basis of the motor-specific data made available by the manufacturer, you have to determine the motor parameter values for synchronous third-party motors. For asynchronous motors, the values can be determined in an external way, apart from the drive-internal way via the commands C3200 and C3600.

### Procedure Without "IndraWorks Ds/D/MLD"

The collection of the motor parameter values to be determined is supported by the forms "Motor Parameters for Synchronous Motors" or "Motor Parameters for Asynchronous Motors" .

### Procedure With "IndraWorks Ds/D/MLD"

If you use the commissioning tool "IndraWorks Ds/D/MLD", the values of the motor parameters, after the required data have been input (according to the completed form "Manufacturer-Side Data of Synchronous Motors" or "Manufacturer-Side Data of Asynchronous Motors"), are determined by means of the corresponding dialog, stored in a file and then loaded to the controller.

### Type of Construction of Motor

The functional principle and type of the third-party motor has to be entered in parameter "P-0-4014, Type of construction of motor".



In parameter P-0-4014, the bits for further settings have to be set to "0", because the respective functions generally cannot be used for third-party motors!

### Number of Pole Pairs/Pole Pair Distance

Take the value for parameter "P-0-0018, Number of pole pairs/pole pair distance" from the completed form "Manufacturer-Side Data of Synchronous Motors" or "Manufacturer-Side Data of Asynchronous Motors" .

### Rotor Inertia

For the setting of parameter "P-0-0510, Rotor inertia", take the the values from the completed form "Manufacturer-Side Data of Synchronous Motors" or "Manufacturer-Side Data of Asynchronous Motors" .

### Motor Peak Current

The rms value of the maximum allowed total motor current (magnetic-field-generating and torque-generating current) has to be indicated in parameter "S-0-0109, Motor peak current".

For asynchronous motors, there usually isn't any value indicated for the maximum allowed peak current.



For synchronous motors, see manufacturer's specification for the value of the maximum allowed peak current.

If there hasn't any value been specified for the maximum allowed peak current, we recommend limitation according to the following relationships for thermal reasons:

Rotary motors	$(S-0-0109) = f \times I_N$
Linear motors	$(S-0-0109) = f \times I_d$

S-0-0109 Motor peak current (rms value of maximum total motor current in A)

f Safety factor 1.1 ... 2.5

$I_N$  Rated current (rms value in A)

$I_d$  Continuous current at standstill (rms value in A)

Fig.5-6: Recommendation for Value of Parameter S-0-0109

### Motor Current at Standstill

The motor current at standstill is the rms value of the torque-generating component of the continuous motor current.

The value entered in parameter "S-0-0111, Motor current at standstill" is the 100% reference value for the torque/force limit parameters S-0-0092 and P-0-0109 with percentage-based scaling (see below).

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$$\begin{aligned} \text{Rotary synchronous motors (S-0-0111)} &= I_N \\ \text{Linear synchronous motors (S-0-0111)} &= I_d \end{aligned}$$

S-0-0111 Motor current at standstill (rms value)  
 $I_N$  Rated current (rms value, acc. to motor data)  
 $I_d$  Continuous current at standstill (rms value, acc. to motor data)  
*Fig.5-7: Calculating the Value of Parameter S-0-0111 for Synchronous Motors*

$$\text{Rotary asynchronous motors (S-0-0111)} = I_N \times \cos \varphi$$

S-0-0111 Motor current at standstill (rms value)  
 $I_N$  Rated current (rms value, acc. to motor data)  
 $\cos \varphi$  Power factor  
*Fig.5-8: Calculating the Value of Parameter S-0-0111 for Asynchronous Motors*

**Maximum Motor Speed**

The velocity command value that is output by the controller is limited to the value of parameter "S-0-0113, Maximum motor speed". The value mustn't be higher than the maximum allowed velocity (speed)!

**Torque/Force Constant**

Calculating the value for parameter "P-0-0051, Torque/force constant" with motor at operating temperature and rated current or continuous current at standstill:

$$\begin{aligned} \text{Rotary synchronous motors (P-0-0051)} &= \frac{M_N}{I_N} \\ \text{Linear synchronous motors (P-0-0051)} &= \frac{F_N}{I_d} \end{aligned}$$

P-0-0051 Torque/force constant (in Nm/Arms for rotary motors; in N/Arms for linear motors)  
 $M_N$  Rated torque (acc. to motor data)  
 $I_N$  Rated current (rms value, acc. to motor data)  
 $F_N$  Rated force (acc. to motor data)  
 $I_d$  Continuous current at standstill (rms value, acc. to motor data)  
*Fig.5-9: Calculating the Value of Parameter P-0-0051 for Synchronous Motors*

$$\text{Rotary asynchronous motors (P-0-0051)} = \frac{M_N}{I_N \times \cos \varphi}$$

P-0-0051 Torque/force constant (in Nm/Arms for rotary motors; in N/Arms for linear motors)  
 $M_N$  Rated torque (acc. to motor data)  
 $I_N$  Rated current (rms value, acc. to motor data)  
 $\cos \varphi$  Power factor  
*Fig.5-10: Calculating the Value of Parameter P-0-0051 for Asynchronous Motors*

**Stator Resistance**

Calculating the value for parameter "P-0-4048, Stator resistance":



$$(P-0-4048) = (R_{U-V} + 2 \times R_{Dr} + 2 \times R_{Lt})$$

P-0-4048	Stator resistance (total resistance of the connected motor in $\Omega$ )
$R_{U-V}$	Resistance of the motor between the terminals at 20°C (in $\Omega$ )
$R_{Dr}$	Phase resistance of a possibly required choke at 20°C (in $\Omega$ )
$R_{Lt}$	Resistance of a power cable strand at 20°C (in $\Omega$ ), possibly relevant for open-loop operation of asynchronous motors with long motor line

Fig.5-11: Calculating the Value of Parameter P-0-4048



By menu prompt via dialogs, the commissioning tool "IndraWorks Ds/D/MLD" supports the input of the motor parameter values of third-party motors by means of the forms "Manufacturer-Side Data of Synchronous Motors" or "Manufacturer-Side Data of Asynchronous Motors" completed by the motor manufacturer!

## Manual Input of Motor Parameter Values for Synchronous Motors

### Direct-Axis Inductance of Motor and Quadrature-Axis Inductance of Motor

Based on the motor-specific data made available by the manufacturer, the motor parameter values specific to synchronous motors are determined.

For motors with reluctance property, different values are observed when the inductance is measured, depending on the position of the primary part of the motor with regard to the secondary part of the motor. The values are fluctuating between a minimum and a maximum value:

- The minimum value is relevant to the direct-axis inductance of the motor.
- The maximum value is relevant to the quadrature-axis inductance of the motor.



Even if the reluctance property of synchronous third-party motors cannot be used (respective bit in parameter "P-0-4014, Type of construction of motor" must not have been set!), it is advantageous to use the mentioned values for current control!

### Direct-axis Inductance of Motor

To determine the parameter value for "P-0-4016, Direct-axis inductance of motor", use the minimum value of motor inductance for calculation, as indicated in the completed form "Manufacturer-Side Data of Synchronous Motors" :

$$(P-0-4016) = L_{(U-V)\min} \times 0,5$$

P-0-4016	Direct-axis inductance of motor
$L_{(U-V)\min}$	Value acc. to motor data

Fig.5-12: Calculating the Value of Parameter P-0-4016

### Quadrature-Axis Inductance of Motor

To determine the parameter value for "P-0-4017, Quadrature-axis inductance of motor", use the maximum value of motor inductance for calculation, as indicated in the completed form "Manufacturer-Side Data of Synchronous Motors" :

$$(P-0-4017) = L_{(U-V)\max} \times 0,5$$

P-0-4017	Quadrature-axis inductance of motor
$L_{(U-V)\max}$	Value acc. to motor data

Fig.5-13: Calculating the Value of Parameter P-0-4017

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<b>Charact. of Quadrature-Axis Induct. of Motor, Inductances</b>	List parameter "P-0-4002, Charact. of quadrature-axis induct. of motor, inductances": → Enter the value "1,0" in each of the five lines
<b>Charact. of Quadrature-Axis Inductance of Motor, Currents</b>	List parameter "P-0-4003, Charact. of quadrature-axis inductance of motor, currents": → Enter the value "1,0" in each of the five lines
<b>Flux-Generating Current, Limit Value</b>	Calculating the value for parameter "P-0-4005, Flux-generating current, limit value":

$$(P-0-4005) = -(S-0-0109)$$

or

$$(P-0-4005) = -[2 \times (S-0-0111)]$$

P-0-4005	Flux-generating current, limit value
S-0-0109	Motor peak current
S-0-0111	Motor current at standstill

*Fig.5-14: Calculating the Value of Parameter P-0-4005 (The Value With the Smaller Absolute Value has to be Entered with Negative Sign in Parameter P-0-4005.)*



By menu prompt via dialogs, the commissioning tool "IndraWorks Ds/D/MLD" supports the input of the motor parameter values of third-party synchronous motors by means of the form "Manufacturer-Side Data of Synchronous Motors" completed by the motor manufacturer!

## Manual Input of Motor Parameter Values for Asynchronous Motors

Based on the motor-specific data made available by the manufacturer, the motor parameter values specific to asynchronous motors can also be manually determined.

<b>Magnetizing Current</b>	The value for parameter "P-0-4004, Magnetizing current" is the rms value of the motor magnetizing current:
----------------------------	--

$$(P-0-4004) = I_{Mag}$$

P-0-4004	Magnetizing current (rms value in A)
$I_{Mag}$	Indicated magnetizing current (rms value in A)

*Fig.5-15: Value for Parameter P-0-4004 acc. to Manufacturer's Specification*

If there hasn't any value been indicated in the manufacturer-side data of the asynchronous motor, the following approximation can be used for calculation:

$$(P-0-4004) = \sqrt{1 - (\cos \varphi)^2} \times I_N$$

P-0-4004	Magnetizing current (rms value in A)
$I_N$	Rated current of the motor (rms value in A)
$\cos \varphi$	Power factor at rated load

*Fig.5-16: Calculating the Value of Parameter P-0-4004 by Means of Approximation*

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**Rated Motor Speed**

Take the value for parameter "P-0-4036, Rated motor speed" from the completed form "Manufacturer-Side Data of Asynchronous Motors" .

**Stator and Rotor Leakage Inductance; Motor Magnetizing Inductance**

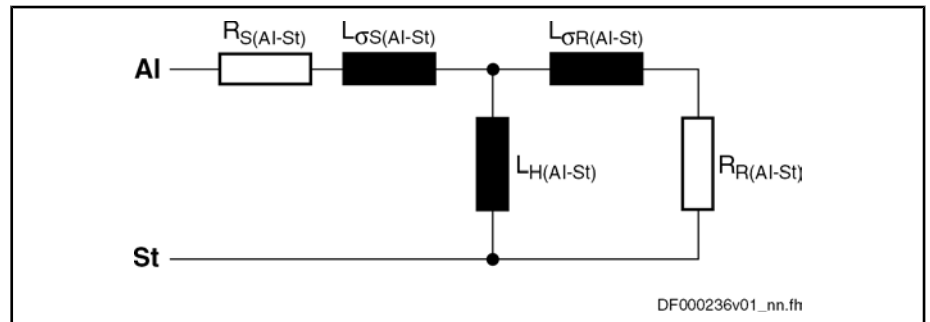
The values for the parameters P-0-4039, P-0-4040, P-0-4041 refer to the single-phase equivalent circuit diagram of asynchronous motors with star point reference (see below).

From the data of the stator and rotor leakage inductance and the motor magnetizing inductance, it is possible to determine more exact motor parameter values than from the type plate data. It is therefore advantageous to have these data supplied by the motor manufacturer and contained in the completed form "Manufacturer-Side Data of Asynchronous Motors" .

$$\begin{aligned} (P-0-4039) &= L_{\sigma S(AI-St)} \\ (P-0-4040) &= L_{\sigma R(AI-St)} \\ (P-0-4041) &= L_H(AI-St) \end{aligned}$$

- P-0-4039 Stator leakage inductance (in mH)
- P-0-4040 Rotor leakage inductance (in mH)
- P-0-4041 Motor magnetizing inductance (in mH)
- $L_{\sigma S(AI-St)}$  Leakage inductance of stator
- $L_{\sigma R(AI-St)}$  Leakage inductance of rotor
- $L_H(AI-St)$  Motor magnetizing inductance

Fig.5-17: Values of Parameter P-0-4039, P-0-4040 and P-0-4041 acc. to Manufacturer's Specification



- AI Outer conductor
- St Star point
- $R_S(AI-St)$  Ohmic resistance of stator at 20°C
- $R_R(AI-St)$  Ohmic resistance of rotor at 20°C
- $L_{\sigma S(AI-St)}$  Leakage inductance of stator
- $L_{\sigma R(AI-St)}$  Leakage inductance of rotor
- $L_H(AI-St)$  Motor magnetizing inductance

Fig.5-18: Equivalent Circuit Diagram of Asynchronous Machine, Single-Phase, With Star Point Reference

**Characteristic of Motor Magnetizing Inductance**

List parameter "P-0-4042, Characteristic of motor magnetizing inductance":

→ Unless otherwise specified, enter the value "1,0" in each of the five lines

**Rotor Time Constant**

Take the values for parameter "P-0-4043, Rotor time constant" from the completed form "Manufacturer-Side Data of Asynchronous Motors" .

If the value is not available, it can be calculated by means of approximation:

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$$(P-0-4043) = \frac{L_{\sigma R(AI-St)} + L_{H(AI-St)}}{R_{R(AI-St)}} = \frac{(P-0-4040) + (P-0-4041)}{R_{R(AI-St)}}$$

P-0-4043	Rotor time constant (in ms)
$L_{H(AI-St)}$	Motor magnetizing inductance
$R_{R(AI-St)}$	Ohmic resistance of rotor at 20°C
$L_{\sigma R(AI-St)}$	Leakage inductance of rotor
P-0-4040	Rotor leakage inductance (in mH)
P-0-4041	Motor magnetizing inductance (in mH)

*Fig.5-19: Calculating the Value of Parameter P-0-4043 by Means of Approximation*



By menu prompt via dialogs, the commissioning tool "IndraWorks Ds/D/MLD" supports the input of the motor parameter values of third-party asynchronous motors by means of the form "Manufacturer-Side Data of Asynchronous Motors" completed by the motor manufacturer!



For project planning and commissioning of a third-party motor the required, manufacturer-specific motor data must always be available!

### 5.3.4 Forms for Required Manufacturer-Side Motor Data

#### Form for Manufacturer-Side Data of Synchronous Motors

Manufacturer, Motor type: _____ Customer, Installation, Axis designation: _____			
Motor characteristic	Symbol/short form	Unit	Value
Rated power	$P_N$	kW	
Rated torque or rated force <sup>1)</sup>	$M_N / F_N$	Nm / N	
Rated current	$I_N$	$A_{rms}$	
Rated speed or rated velocity <sup>1)</sup>	$n_N / v_N$	min <sup>-1</sup> / m/min	
Rated voltage	$U_N$	$V_{eff}$	
Continuous current at standstill <sup>1)</sup>	$I_d$	$A_{rms}$	
Inertia or mass	$J / m$	–	
Rated force <sup>1)</sup>	$F_N$	N	
Allowed maximum current (magn. saturation effects?)	$I_{max}$	$A_{eff}$ (yes/no)	
Maximum torque or maximum force <sup>1)</sup>	$M_{max} / F_{max}$	Nm / N	
Maximum speed or maximum velocity <sup>1)</sup>	$n_{max} / v_{max}$	min <sup>-1</sup> / m/min	
Number of pole pairs (rotary) or pole pair distance (linear)	PPZ / PWT (N-N-pol)	-- / mm	
Insulation class	Isol.Kl.	--	
Motor inductance, minimum value	$L_{U-V, min}$	mH	
Motor inductance, maximum value	$L_{U-V, max}$	mH	
Motor inductance, average value	$L_{U-V}$	mH	
Winding resistance (20°C)	$R_{U-V}$	$\Omega$	
Allowed periodic peak voltage	$\hat{U}_{max, zul.}$	$V_{pp/2}$	
Allowed rate of rise of voltage	$du/dt_{zul.}$	kV/ $\mu$ s	
Cooling type (without/with blower, liquid cooling)	--	--	
Thermal Time constant motor (see "Limitations")	$T_{Motor}$	min	
Thermal Time constant winding (see "Limitations")	$T_{Wicklung}$	s	
Thermal Short-time overload of winding (see "Limitations")	$k_{\text{Überlast}}$	--	
Type of construction of motor (rotary/linear)	--	--	
Type of winding (distributed winding/toothed winding)	--	--	
Winding body material (iron/ironless)	--	--	

1) Only for linear motor  
Fig. 5-20: Motor Data of Synchronous Motors

\_\_\_\_\_  
Name

\_\_\_\_\_  
Data

\_\_\_\_\_  
Signature

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Take form "Manufacturer-Side Data of Motor Temperature Sensor,  
Motor Encoder and Motor Holding Brake" into account, too!

---

### Form for Manufacturer-Side Data of Asynchronous Motors

Manufacturer, Motor type: _____ Customer, Installation, Axis designation: _____			
Motor characteristic	Symbol/short form	Unit	Value
Rated power <sup>1)</sup>	$P_N$	kW	
Rated torque	$M_N$	Nm	
Rated current <sup>1)</sup>	$I_N$	$A_{rms}$	
Power factor <sup>1)</sup>	$\cos \varphi$	--	
Magnetizing current	$I_{Mag}$	$A_{rms}$	
Rated speed <sup>1)</sup>	$n_N$	$min^{-1}$	
Rated frequency <sup>1)</sup>	$f_N$	Hz	
Rated voltage <sup>1)</sup>	$U_N$	$V_{eff}$	
Inertia	$J$	--	
Maximum speed	$n_{max}$	$min^{-1}$	
Number of pole pairs	PPZ	--	
Insulation class	Isol.Kl.	--	
Motor inductance (minimum/maximum/average value)	$L_{U-V, min} / L_{U-V, max} / L_{U-V}$	mH	
Stator leakage inductance <sup>2)</sup>	$L_{\sigma S(AI-St)}$	mH	
Rotor leakage inductance <sup>2)</sup>	$L_{\sigma R(AI-St)}$	mH	
Motor magnetizing inductance <sup>2)</sup>	$L_H(AI-St)$	mH	
Stator resistance (20°C) <sup>2)</sup>	$R_{S(AI-St)}$	$\Omega$	
Rotor resistance (20°C) <sup>2)</sup>	$R_{R(AI-St)}$	$\Omega$	
Rotor time constant <sup>2)</sup>	$T_R$	ms	
Winding resistance (20°C)	$R_{U-V}$	$\Omega$	
Allowed periodic peak voltage	$\hat{U}_{max\_zul.}$	$V_{pp/2}$	
Allowed rate of rise of voltage	$du/dt_{zul.}$	kV/ $\mu$ s	
Cooling type (without/with blower, liquid cooling)	--	--	
Thermal time constant motor (see "Limitations")	$T_{Motor}$	min	
Thermal time constant winding (see "Limitations")	$T_{Wicklung}$	s	
Thermal Short-time overload of winding (see "Limitations")	$k_{\text{Überlast}}$	--	
Type of construction of motor (rotary/linear)	--	--	
Does rotor/secondary part have closed slots?	--	Yes/no	

1) Data on type plate of rotary motor  
 2) Helpful but not obligatory data  
 Fig.5-21: Motor Data of Asynchronous Motors

\_\_\_\_\_  
Name

\_\_\_\_\_  
Data

\_\_\_\_\_  
Signature

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Take form "Manufacturer-Side Data of Motor Temperature Sensor, Motor Encoder and Motor Holding Brake" into account, too!

## Form for Manufacturer-Side Data of Motor Temperature Sensor, Motor Encoder and Motor Holding Brake

### Temperature sensor data

PTC? NTC? Switch contact?	
Type designation?	
How many and where installed?	
Characteristics available?	

Fig. 5-22: Data of Temperature Sensor

### Motor encoder data (if available)

Kind/standard?	
Signal amplitude?	
Signal shape?	
Cycles/revolution?	
Division period/ $\mu\text{m}$ ?	
Manufacturer?	
Type of construction?	

Fig. 5-23: Data of Motor Encoder

### Data of motor holding brake (if available)

Manufacturer		
Type designation		
Holding torque/force	Nm / N	
Rated voltage	V	
Rated current	A	
Inertia/moved mass	$\text{kgm}^2/\text{kg}$	
Clamping delay	ms	
Release delay	ms	
Mass	kg	

Fig. 5-24: Data of Motor Holding Brake

\_\_\_\_\_  
Name

\_\_\_\_\_  
Data

\_\_\_\_\_  
Signature



### 5.3.5 Forms for Parameter Values

#### Form "Motor Parameters for Synchronous Motors"



Determine the values according to the description in the section "Determining the Motor Parameter Values for Manual Input (for Command C4600)".

Manufacturer, Motor type: _____ Customer, Installation, Axis designation: _____			
Parameter IDN	Parameter name	Input value	Unit
P-0-4014	Type of construction of motor		
P-0-0018	Number of pole pairs/pole pair distance		PPZ / mm
P-0-0510	Rotor inertia		(Scaling-dependent)
S-0-0109	Motor peak current		A
S-0-0111	Motor current at standstill		A
S-0-0113	Maximum motor speed		(Scaling-dependent)
P-0-0051	Torque/force constant		(Scaling-dependent)
P-0-4048	Stator resistance		$\Omega$
P-0-4016	Direct-axis inductance of motor		mH
P-0-4017	Quadrature-axis inductance of motor		mH
P-0-4002	Charact. of quadrature-axis induct. of motor, inductances	[0] [1] [2] [3]	
P-0-4003	Charact. of quadrature-axis inductance of motor, currents	[0] [1] [2] [3]	
P-0-4005	Flux-generating current, limit value		A

Fig. 5-25: Motor Parameters for Synchronous Motors

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### Form "Motor Parameters for Asynchronous Motors"

Manufacturer, Motor type: _____ Customer, Installation, Axis designation: _____			
Parameter IDN	Parameter name	Input value	Unit
P-0-4014	Type of construction of motor		--
P-0-0018	Number of pole pairs/pole pair distance		PPZ / mm
P-0-0510	Rotor inertia		(Scaling-dependent)
S-0-0109	Motor peak current		A
S-0-0111	Motor current at standstill		A
S-0-0113	Maximum motor speed		(Scaling-dependent)
P-0-0051	Torque/force constant		(Scaling-dependent)
P-0-4048	Stator resistance		$\Omega$
P-0-4004	Magnetizing current		A
P-0-4036	Rated motor speed		1/min
P-0-4039	Stator leakage inductance		mH
P-0-4040	Rotor leakage inductance		mH
P-0-4041	Motor magnetizing inductance		mH
P-0-4042	Characteristic of motor magnetizing inductance	[0] [1] [2] [3] [4]	
P-0-4043	Rotor time constant		ms

Fig. 5-26: Motor Parameters for Asynchronous Motors



After having entered the data from the type plate (in P-0-4032) and executed the command C3200, the parameter values contained in this list are automatically determined. If you want to enter the data manually, determine the values according to description in the section "Determining the Motor Parameter Values for Manual Input (for Command C4600)".

## Form "Parameters for Temperature Monitoring, Motor Encoder and Motor Holding Brake"

Manufacturer, Motor type: _____ Customer, Installation, Axis designation: _____			
Parameter IDN	Parameter name	Input value	Unit
<b>Temperature monitoring</b>			
P-0-0512	Temperature sensor		–
P-0-4034	Thermal time constant of motor		min
P-0-4035	Thermal time constant of winding		s
P-0-4037	Thermal short-time overload of winding		–
S-0-0201	Motor warning temperature		°C
S-0-0204	Motor shutdown temperature		°C
<b>Motor encoder</b>			
P-0-0074	Encoder type 1 (motor encoder)		
S-0-0116	Feedback 1 Resolution		
S-0-0277	Position feedback type 1		
<b>Motor holding brake</b>			
S-0-0206	Drive on delay time		ms
S-0-0207	Drive off delay time		ms
S-0-0273	Maximum drive off delay time		ms
P-0-0525	Holding brake control word		

Fig. 5-27: Parameters for Temperature Monitoring, Motor Encoder and Holding Brake

### 5.3.6 Notes on Commissioning

For commissioning third-party motors the required, manufacturer-side motor data, the motor encoder data and temperature sensor data always have to be available (entirely completed forms)!



By menu prompt via the corresponding dialogs, the commissioning tool "IndraWorks Ds/D/MLD" simplifies the commissioning of third-party motors.

See also "Commissioning the Motor"

#### Basic Commissioning Steps for Third-Party Motors

The commissioning of a third-party motor (synchronous and asynchronous motors) starts with the following basic steps:

1. First check whether third-party motor has been connected according to manufacturer's specification.
2. Enter type designation of third-party motor in parameter "S-0-0141, Motor type". For closed-loop operation (obligatory for synchronous motors, optional for asynchronous motors), settings for motor encoder have to be made in corresponding parameters:
  - S-0-0116, Resolution of feedback 1
  - S-0-0277, Position feedback 1 type

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- P-0-0074, Encoder type 1 (motor encoder)
3. Settings for motor temperature sensor and motor temperature model have to be made in corresponding parameters:
    - S-0-0201, Motor warning temperature
    - S-0-0204, Motor shutdown temperature
    - P-0-0512, Temperature sensor
    - P-0-4034, Thermal time constant of winding
    - P-0-4035, Thermal time constant of motor
    - P-0-4037, Thermal short-time overload of winding
  4. If a motor holding brake is controlled by controller, it is necessary to make further parameter settings:
    - S-0-0206, Drive on delay time
    - S-0-0207, Drive off delay time
    - S-0-0273, Maximum drive off delay time
    - P-0-0525, Holding brake control word



Further commissioning steps for asynchronous third-party motors and synchronous third-party motors are supported by:

- Dialogs of the commissioning tool and
  - Specific prompts of the comfort control panel (optional equipment of the control section) or the small operator terminal (optional additional component).
- 

**Synchronous Third-Party Motors**

**After the basic commissioning steps (1 to 4; see above),** there are further steps required for synchronous third-party motors:

1. Manufacturer-side motor data have to be entered in motor parameters or converted by means of completed form "Manufacturer-Side Data of Synchronous Motors" (see "Determining the Parameter Values of Third-Party Motors"). All required motor parameters are listed in form "Motor Parameters for Synchronous Motors" (data can already be entered in communication phase "P2").

**Note:** If you use the commissioning tool "IndraWorks Ds/D/MLD" the values of the motor parameters, after the motor-specific data have been input (via dialog), are determined, stored in a file and then loaded to the controller.

2. Then "P-0-0566, C4600 Command Calculate motor control parameters" has to be started for calculating values of motor control parameters.
3. After having successfully completed command execution, values of motor control parameters have been calculated and stored. Initial commissioning for initial start of motor can be continued with "check motor encoder function".

See "Commissioning Motors: Initial Start With the Commissioning Tool"



Before the initial start it is obligatory to set the commutation offset for synchronous third-party motors. Only with correctly set commutation offset is the motor operational and safe to operate!

See also "Commutation Setting"

---

**Asynchronous Third-Party Motors**

**After the basic commissioning steps (1 to 4; see above),** there are further steps required for asynchronous third-party motors:

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1. Rated data according to completed form or type plate have to be entered in "P-0-4032, Motor type plate data" (data can already be entered in communication phase "P2").
2. With "P-0-4033, C3200 Command Calculate motor data", start calculation of values of motor and motor control parameters.
3. Then optimize parameter values calculated via command "P-0-0565, C3600 Command Motor data identification". To do this, put drive in status "ready for power output" ("Ab"); then start command.

**Note:** The command C3600 may only be started when the motor is in standstill. This is monitored by a possibly available motor encoder. If there is no motor encoder available and the motor is not in standstill at the start of the command, the results can be invalidated!

4. Depending on whether a motor encoder is used, initial commissioning for initial start of motor can be continued with "check motor encoder function" (in closed-loop operation) or with "setting the kind of motor control" (in open-loop operation).

See "Commissioning Motors: Initial Start With the Commissioning Tool"

5. By executing command C3200, some parameters are set to default values, as they require data that cannot be identified by the command. Before continuing commissioning of drive, these parameters have to be checked and, if necessary, set to correct value by means of data of completed form:
  - S-0-0109, Motor peak current
  - S-0-0113, Maximum motor speed
  - P-0-0510, Rotor inertia
  - P-0-0530, Slip increase
  - P-0-4034, Thermal time constant of winding
  - P-0-4035, Thermal time constant of motor
  - P-0-4037, Thermal short-time overload of winding

## 5.4 Motor Holding Brake

### 5.4.1 Operating Behavior of the Motor Holding Brake

#### Brief Description

Motor holding brakes are used to hold axes with drive enable having been switched off. This is particularly important for non-equilibrated vertical axes. With IndraDrive controllers it is possible to control and monitor motor holding brakes in a wear-resistant way.



Holding brakes at Rexroth motors normally aren't designed for decelerating when in operation. Increased wear caused by deceleration in operation can destroy the holding brake at an early stage!

The following motor holding brake types are possible:

- Electrically releasing brakes (self-holding) for servo drives
- Electrically holding brakes (self-releasing) for main drives

The motor holding brake can be directly mounted on the motor shaft, e.g. in the case of Rexroth housing motors, or directly connected to the mechanical axis system, e.g. in the case of linear kit motors.

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IndraDrive controllers include application-specific controls of the holding brake in order to minimize wear of the brake in the case of error. The following two functional principles of holding brake control are supported:

- Control of holding brake **for servo drives**
- Control of holding brake **for main drives**

Control of the holding brake is linked with drive enable, considering holding and releasing delays. In special cases it may be appropriate to avoid this programmed link and release or apply the holding brake independently. This, too, is possible with IndraDrive!

**Hardware Requirements**

The motor holding brake is controlled via a controller-internal relay contact. Power supply is realized by the controller via the 24V control voltage. The holding brake must be suited for the voltage that is output, the holding brake current must not exceed the allowed maximum value of the respective device (see documentation "Supply Units and Power Sections; Project Planning Manual for Controllers"). If necessary, the holding brake has to be controlled separately.



The optionally available holding brakes of Rexroth motors can be directly controlled via the controller!

**Pertinent Parameters**

- S-0-0206, Drive on delay time
- S-0-0207, Drive off delay time
- S-0-0273, Maximum drive off delay time
- P-0-0525, Holding brake control word
- P-0-0539, Holding brake status word
- P-0-0540, Torque of holding brake
- P-0-0542, C2000 Command Release holding brake
- P-0-0543, C3800 Command Apply holding brake

**Pertinent Diagnostic Messages**

- C2000 Command Release motor holding brake
- C2001 Command not enabled
- C3800 Command Apply motor holding brake
- F6024 Maximum braking time exceeded

**Functional Description**

With IndraDrive it is possible to control both self-releasing (electrically holding) and self-holding (electrically releasing) motor holding brakes. The controller is informed of the brake type via the respective bit in "P-0-0525, Holding brake control word", Holding brake control word.

**Releasing the Holding Brake**

When drive enable (AF = Antriebsfreigabe) is set by the control unit the releasing of the holding brake is activated. The brake is released with a delay, due to the inductance of the brake winding. This delay is communicated to the controller via "S-0-0206, Drive on delay time".

In order to avoid wear of the brake the command value acceptance is blocked within this delay. Only then does the controller signal to the control unit, by means of a bit in the respective status word (e.g. "S-0-0135, Drive status word" for SERCOS), that it is ready to move.

See also "Basic Functions of Master Communication: Device Control and State Machines"

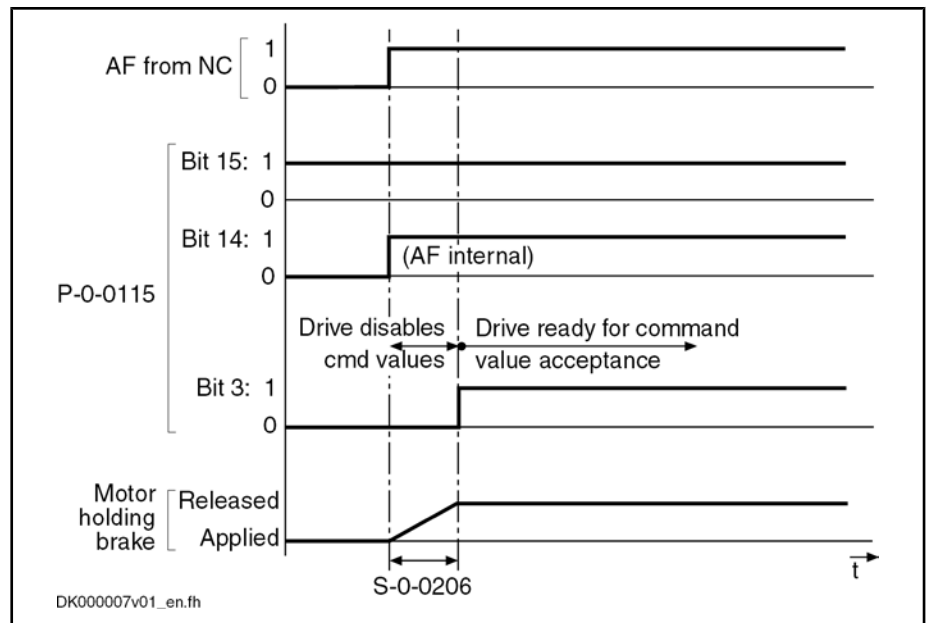


Fig. 5-28: Time Response When Releasing the Holding Brake

**Applying the Holding Brake**

When "AF" (drive enable) is reset by the master the applying of the brake is activated. The brake is applied with a delay, due to the inductance of the brake winding. This delay is communicated to the controller via "S-0-0207, Drive off delay time".

In order to avoid, for example, that a non-equilibrated vertical axis in standstill does not move down due to weight force, "AF" (drive enable) is internally reset by this delay later. During this delay the velocity command value is internally set to zero.

**Behavior of the Holding Brake Control in the Case of Error**

In the case of interruptions and errors that can suddenly occur for different causes during normal operation, in most of the cases there is a demand to quickly shut down the mechanical system for reasons of personnel and installation safety. This is done, if possible, by actively braking the drive.

In the case of error it is decisive whether the drive is able by itself to decelerate. This is the case when the drive comes to a standstill within an axis-specific maximum braking time. This time is communicated to the controller via "S-0-0273, Maximum drive off delay time".



The "maximum drive off delay time" is the time that the drive needs in order to shut down the axis out of maximum velocity at maximum inertia (or inertial mass) with maximum allowed brake torque (or brake force).

If the drive is unable to shut down the mechanical system within the maximum braking time the drive at least reacts with the most convenient control of the holding brake. What is decisive for the control in this case is whether the customer determined the application type to be "servo drive" or "main drive".

You have to distinguish the following situations in the case of error:

**Error Situation 1**

- Drive remains fully operational; "velocity command value reset with or without ramp and filter" or "return motion" was set as the error reaction (F2xxx, F4xxx, F6xxx error or NC-side drive enable reset in the case of axis motion).

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- Error Situation 2**
- Drive defect (F8xxx error) or "torque or force disable of the motor ("coasting")" was set as the error reaction (F2xxx, F4xxx, F6xxx error or NC-side rive enable reset in the case of axis motion).



The error reaction is set in parameter "P-0-0119, Best possible deceleration".

Errors can possibly cause damage to machines or drive components. Depending on the application the following strategies are used for minimizing damage:

**Holding Brake Control for Servo Drives**

In the case of servo drives that mostly drive linear axes with limited travel distances, the protection of the machine is preferred to the drive in the case of error situation 2. The controller, according to the setting made by the customer (in "P-0-0525, Holding brake control word"), therefore tries to realize the shortest possible braking distances, even if this damages the holding brake.

**Holding Brake Control for Main Drives**

Main drives are rotary axes with "unlimited" travel distance, such as spindle motors of milling and turning machines. Due to high speed and high inertia most of these axes produce kinetic energies in operation that often exceed the allowed energy absorption capacity of holding brakes integrated in the motor. In the case of error situation 2, shutdown realized by the holding brake only could destroy the brake very easily. Due to the unlimited travel distance there normally isn't any danger of damaging the machine. The controller therefore, when determined by the customer (P-0-0525), prevents the holding brake from applying and gives priority to friction braking.

**Parameter "P-0-0525, Holding brake control word"**

The required functionality of the holding brake, depending on the application type of the drive (servo or main drive), is determined by the respective bit in parameter P-0-0525.

**Holding Brake Control with Error Situation 1**

If the drive cannot shut down the mechanical system within the time after occurrence of the error entered in parameter S-0-0273, the motor holding brake is applied after motor standstill, independent of the application (servo or main drive).

Depending on the error reaction, motor standstill means:

- Falling below a velocity threshold (in the case of "velocity command value reset" error reaction, with or without ramp)
- Target position attained and actual velocity value lower than the value of "S-0-0124, Standstill window" (in the case of "return motion" error reaction)

See also "Error Reactions"



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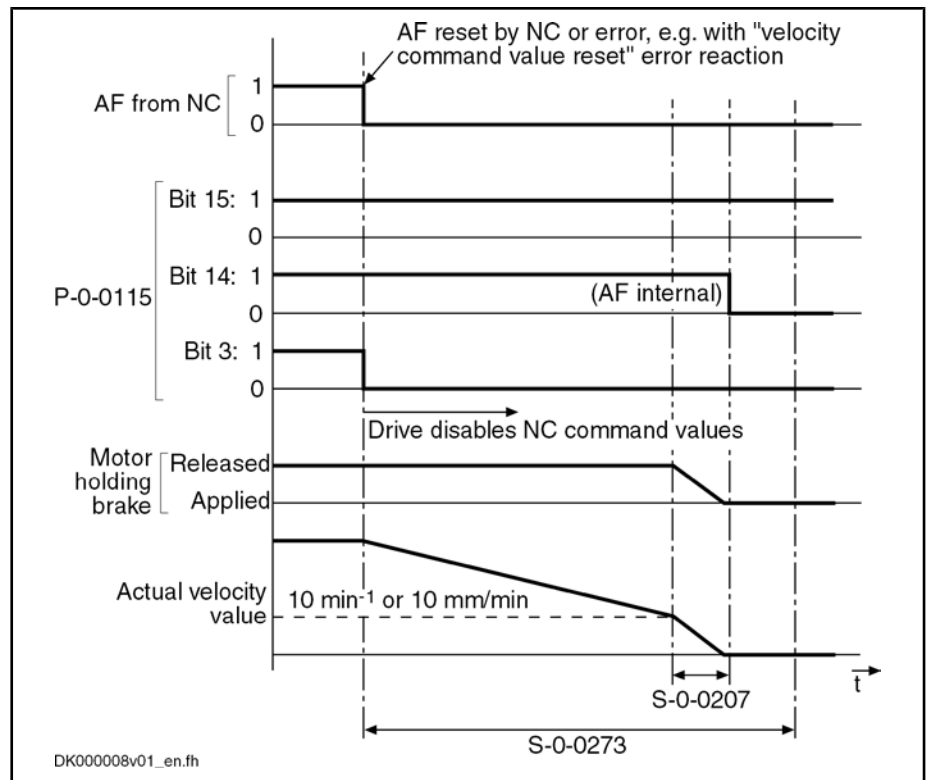


Fig.5-29: Holding Brake Control With Error Situation 1 and Braking Time < S-0-0273 (Error Reaction "Velocity Command Value Reset")

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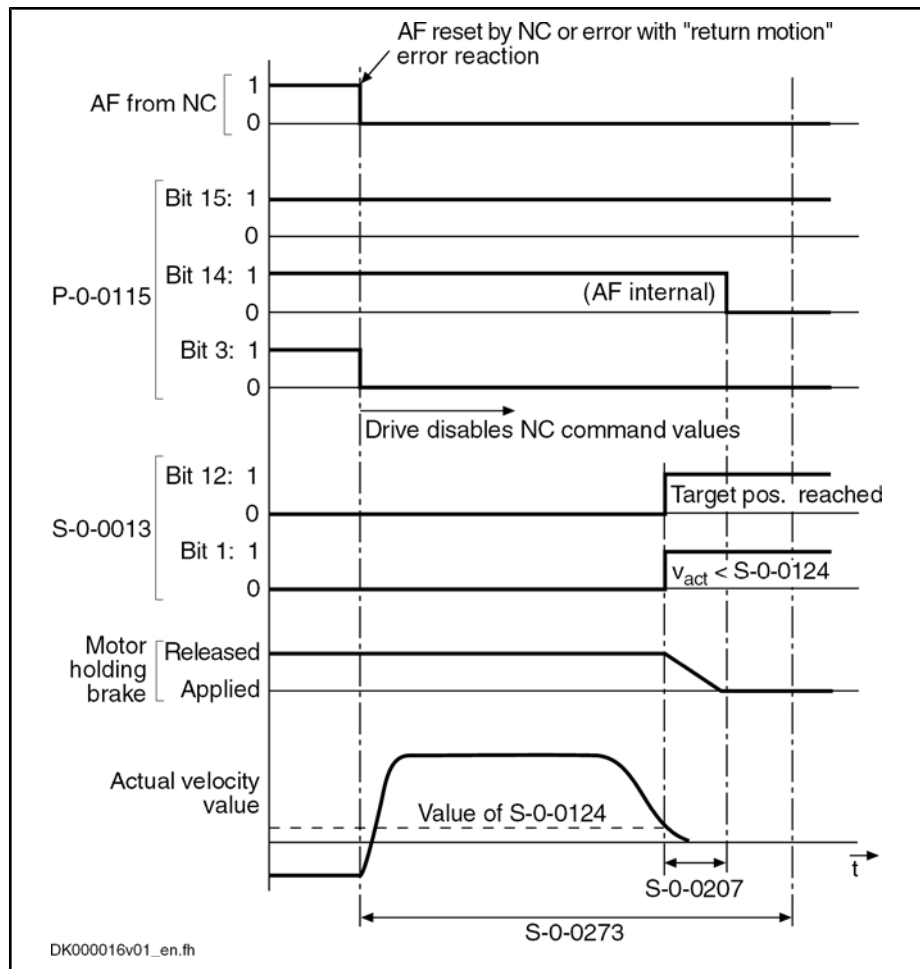


Fig.5-30: Holding Brake Control With Error Situation 1 and Braking Time < S-0-0273 (Error Reaction "Return Motion")

If the drive cannot shut down the mechanical system within the time after occurrence of the error entered in parameter S-0-0273, the motor holding brake is controlled depending on the application (servo or main drive):

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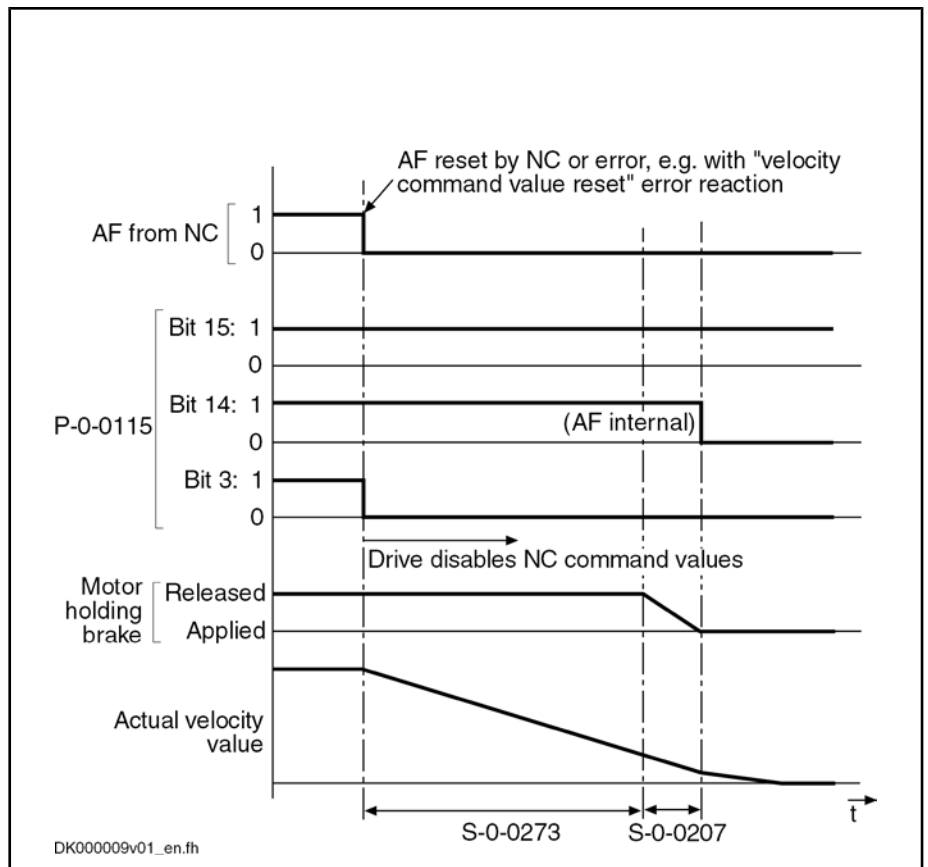


Fig.5-31: Holding Brake Control With Error Situation 1 and Braking Time > S-0-0273 for Servo Drives

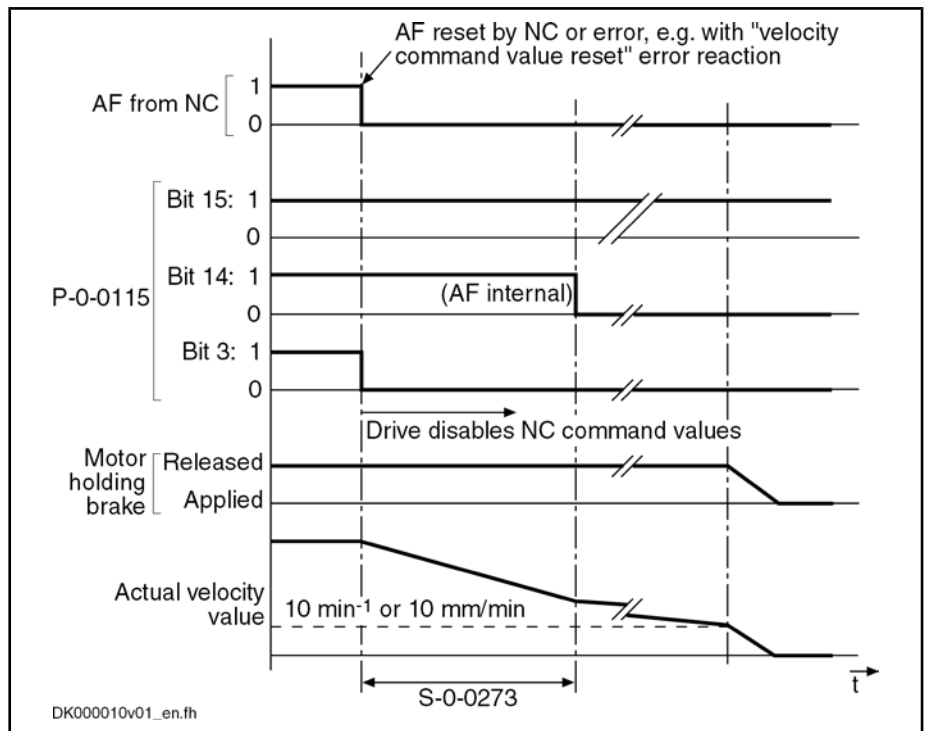


Fig.5-32: Holding Brake Control With Error Situation 1 and Braking Time > S-0-0273 for Main Drives

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If the "return motion" error reaction has not yet been completed after the time set in S-0-0273, it is aborted:

- In the case of servo drives, the holding brake is applied. The internal drive enable is switched off with the delay of "drive off delay time".
- In the case of main drives, the internal drive enable is switched off immediately. The drive coasts to stop. After the velocity has fallen below the minimum value, the holding brake is applied.

**Holding Brake Control with Error Situation 2**

In the case of error situation 2, the drive becomes torque- or force-free after the error event. The braking effect, in addition to the axis friction, can only be achieved by means of the holding brake. To limit the damage the holding brake is controlled depending on the application (servo or main drive).

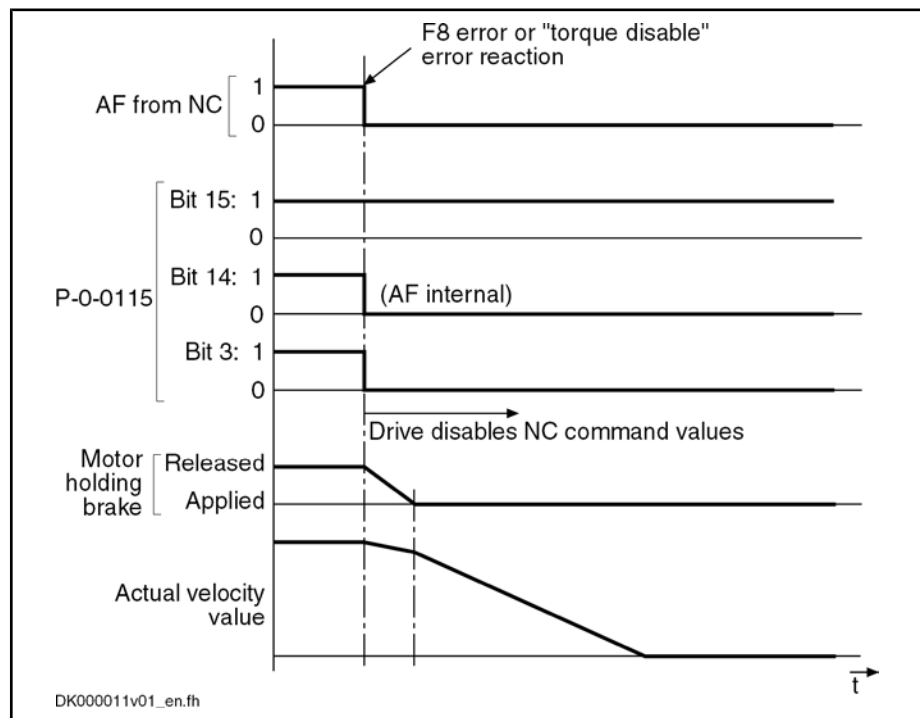


Fig.5-33: Holding Brake Control With Error Situation 2 for Servo Drives

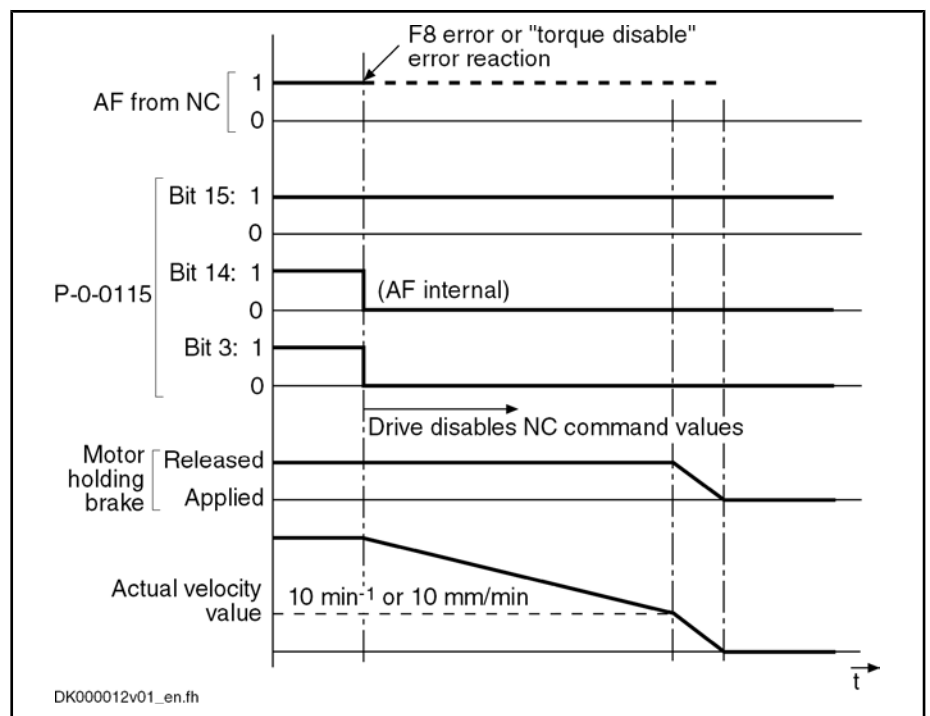


Fig. 5-34: Holding Brake Control With Error Situation 2 for Main Drives

**Command "Releasing the Holding Brake"**

In special cases it can be convenient to release the holding brake even if the drive is not in "AF" (drive enable). This is done by starting "P-0-0542, C2000 Command Release holding brake". This command, however, first has to be enabled by the respective bit in "P-0-0525, Holding brake control word"!



**CAUTION**

**Property damage caused by movement of non-equilibrated axes when releasing the holding brake!**

⇒ Before starting the command, move the axis to a noncritical position!

Upon completion of the command, the brake is applied again. When drive enable is set and then reset with the command being active, the holding brake is applied again when resetting "AF" (drive enable)!



The command for releasing the holding brake can also be started via the control panel, when the corresponding bit has been set in parameter "P-0-0525, Holding brake control word".

**Command "Applying the Holding Brake"**

In special cases it can be convenient to apply the holding brake if the drive is in an active state ("AF", drive enable). This is done by activating "P-0-0543, C3800 Command Apply holding brake".



**CAUTION**

**Damage to the holding brake!**

**If the axis is moved with the holding brake applied, the brake can become prematurely worn!**

⇒ In case of doubt start P-0-0541, C2100 Holding system check command !

**Influence of Drive Enable on Command "Apply Motor Holding Brake"**

If drive enable ("AF") is reset and set again when the command is active, the brake releases when drive enable is set although the command is still active! When the command is completed, the brake releases again if the drive is still active ("AF").

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When the command is completed, the brake remains applied if drive enable was reset during the execution of the command!

## Notes on Commissioning

### Relevant Parameters

Enter application-dependent parameter values:

- S-0-0273, Maximum drive off delay time

In this parameter enter the determined time that the drive needs in order to stop the axis out of maximum velocity at maximum inertia or inertial mass with maximum allowed brake torque or brake force. If necessary, increase the determined time to make sure the axis really stops!



CAUTION

### Danger of damaging the motor brake when value in S-0-0273 is too low!

⇒ The value for "S-0-0273, Maximum drive off delay time" must always be set higher than the time needed to decelerate the axis by velocity command value reset (if necessary with ramp), taking the maximum possible velocity into account.

Enter data of holding brake:

- S-0-0206, Drive on delay time
- S-0-0207, Drive off delay time
- P-0-0540, Torque of holding brake



The holding brake data are ...

- ... entered automatically when switching the drive on, in the case of Rexroth motors **with** encoder data memory!
- ... entered automatically only when loading the motor-specific parameter values from the database of the "IndraWorks Ds/D/MLD" commissioning tool, in the case of Rexroth motors **without** encoder data memory!

Configure holding brake control in:

- P-0-0525, Holding brake control word

### Activating the Holding Brake Function

The holding brake control is linked with drive enable and does not have to be separately activated.

### Command "Releasing the Holding Brake"

The control unit can release the holding brake by means of the following command:

- P-0-0542, C2000 Command Release holding brake



CAUTION

### Property damage caused by movement of non-equilibrated axes when releasing the holding brake!

⇒ Before starting the command, move the axis to a noncritical position!

### Command "Applying the Holding Brake"

The control unit can apply the holding brake by means of the following command when the drive is active:

- P-0-0543, C3800 Command Apply holding brake



CAUTION

### Damage to the holding brake!

If the axis is moved with the holding brake applied, the brake can become prematurely worn!

⇒ In case of doubt start "P-0-0541, C2100 Holding system check command"!

- Operating Status**    Displaying the operating status:
- P-0-0539, Holding brake status word
- Signaling the readiness to accept command values:
- S-0-0135, Drive status word
- Errors**                • F6024 Maximum braking time exceeded
- Command Errors**    • C2001 Command not enabled

## 5.4.2      Function Check of Motor Holding Brake, Drive-Controlled

### Brief Description

If the brake torque of holding brakes is too low due to wear and corrosion, this can interrupt the service and endanger safety in machines and installations. IndraDrive controllers have the advantage of monitoring the effectiveness of the holding brake and recording the monitoring intervals:

- Automatically each time drive enable is set and reset
- Depending on the situation at a command of the control master

This allows cyclic brake check according to EN 13849-1, cat. 2 or dynamization/ check of one of two redundant holding systems according to EN 13849-1, cat. 3.

In the case of corrosion, the effectiveness of the holding brake can be re-established by a drive-controlled "resurfacing procedure".

- Pertinent Parameters**
- P-0-0525, Holding brake control word
  - P-0-0539, Holding brake status word
  - P-0-0540, Torque of holding brake
  - P-0-0541, C2100 Holding system check command
  - P-0-0544, C3900 Command Holding brake resurfacing
  - P-0-0545, Test torque for releasing holding system
  - P-0-0546, Starting torque for releasing holding system
  - P-0-0547, Nominal load of holding system
  - P-0-0549, Oper. hours control sec. at last succ. holding system check
  - P-0-0550, Time interval holding system check

- Pertinent Diagnostic Messages**
- C2100 Command Holding system check
  - C2101 Holding system check only possible with drive enable
  - C2103 Holding brake: Torque too low
  - C2104 Command execution impossible
  - C2105 Load of holding system greater than test torque
  - C2106 Test torque of holding system not reached
  - C3900 Command Holding brake resurfacing
  - C3901 Resurfacing of holding brake only possible with drive enable
  - C3902 Error during resurfacing of holding brake
  - C3903 Command execution impossible
  - E2069 Holding brake torque too low
  - E3115 Prewarning, end of brake check time interval
  - F2069 Error when releasing the motor holding brake

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- F3115 Brake check time interval exceeded

## Functional Description

### Monitoring the Holding Brake

The controller can check the effectiveness of the holding brake and its released state by starting a routine:

- Automatically each time drive enable is set and reset

- or -

- Depending on the situation via "P-0-0541, C2100 Holding system check command"

If the holding brake is all right the drive is operational after the routine is over. If the brake torque is too low the controller outputs the respective message.

The relevant bits for the desired kind of brake monitoring have to be set in "P-0-0525, Holding brake control word".

### Automatic Monitoring

The automatic brake monitoring function is started when "AF" (drive enable) is set. After the time required for releasing the holding brake the motor generates a torque or a force; this sets the motor slightly in motion if the status of the holding brake is without error. The maximum value of this torque or force is determined during initial commissioning and entered in parameter "P-0-0545, Test torque for releasing holding system" (described in the Notes on Commissioning for function check of holding brake).

If the test was successful, the drive starts operations.

If the motor does not move during this test, the error message "F2069 Error when releasing the motor holding brake" is output; the drive switches off.

When "AF" (drive enable) is reset by the master the holding torque of the brake is checked. After the holding brake was applied, a torque or force is generated that mustn't yet set the motor in motion if the status of the holding brake is correct. The value of this torque or force can be entered in parameter "P-0-0547, Nominal load of holding system". This value, too, is determined during initial commissioning (described in the Notes on Commissioning for function check of holding brake).

If the motor does not move during this check, the brake has the specified or required holding torque.

If the motor moves during this check, the diagnostic message "E2069 Holding brake torque too low" is output and drive enable is internally reset.

The warning E2069 is triggered in the case of the following motor motion:

- Rotary motors:  $>2$  dgr
- Linear motors: Pole pair distance (in mm)/180  $\rightarrow$  P-0-0018/180



**CAUTION**

### Possible property damage caused by vertical axis moving down!

$\Rightarrow$  Take constructional precautions!

### "Brake Check" Command

When "P-0-0541, C2100 Holding system check command" is started, the drive must be in "AF".

The routine corresponds to that of automatic monitoring (see above).

### Time Interval of Holding Brake Check

At the activation of the time interval for brake check (in parameter "P-0-0525, Holding brake control word"), the interval since the last successful brake check is measured and compared to the value of parameter "P-0-0550, Time interval holding system check". The monitoring function with regard to this value might possibly generate the following messages:



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- If the measured interval draws up to 15 min nearer to the interval set in parameter P-0-0550, the warning "E3115 Prewarning, end of brake check time interval" is output.
- If the measured interval exceeds the value in parameter P-0-0550, the error message "F3115 Brake check time interval exceeded" is generated.

The warning E3115 disappears automatically when the brake check is successfully carried out within 15 min after the message had been generated. The brake check is carried out, for example, by starting "C2100 Command Holding system check" or, if automatic brake check was set, by resetting drive enable.

If the drive switches off with the error message F3115, the user after having reset this message has 15 min to carry out the brake check, e.g. by starting "C2100 Command Holding system check". After successful execution the "status of holding brake check" and the "status of holding torque check" is set to "1" in "P-0-0539, Holding brake status word". The time of the brake check is stored in "P-0-0549, Oper. hours control sec. at last succ. holding system check" and the time interval measurement is restarted!

If the brake check is not carried out or cannot be successfully carried out, the drive switches off with the error message "F3115 Brake check time interval exceeded", at the latest 15 min after drive enable had been set.



For safety-related use of axis holding systems, observe the respective regulations of the concerned institution for statutory accident insurance and prevention ("Berufsgenossenschaft") with regard to dimensioning and testing!

#### Reestablishing the Holding Brake Torque

For reestablishing the brake torque, "C3900 Command Holding brake resurfacing" (P-0-0544) can be started. To do this, drive enable ("AF") must have been set! After the command was started, the drive is accelerated to 100 rpm or 100 mm/min. Active acceleration and deceleration ramps, as well as filters (P-0-1201, P-0-1202, P-0-1203, P-0-1211, P-0-1213 and P-0-1222) are taken into account! When the motor has reached the command velocity, the brake is applied for 400 ms. After the command has been completed, the motor has been stopped by velocity control with command value "0".

With the execution of command C3900 there is no check run as to whether the resurfacing of the brake was successful! It is therefore recommended to execute command C2100 (brake check) after command C3900!



**CAUTION**

**Property damage caused by drive-controlled axis motion when executing the commands for brake check and for resurfacing of the brake!**

→ Before starting the command, move the axis to a noncritical position!

#### Diagnosing the Brake Check

The result of the brake check and the operating status of the holding brake are displayed in the respective bits of "P-0-0539, Holding brake status word".

#### Notes on Commissioning

##### "Brake Check" Command

The control unit can activate the brake check by means of a command:

- P-0-0541, C2100 Holding system check command



**CAUTION**

**Property damage caused by drive-controlled axis movements during brake check!**

→ Before starting the command, move the axis to a noncritical position!

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**Automatic Brake Check** The "brake check" function can also take place automatically, every time drive enable is set and reset. The function is activated via the respective bit in parameter

- P-0-0525, Holding brake control word.

**Presetting the Brake Check** **Check for brake released:**

The status "holding brake released" is checked by the motor generating a torque or force that sets the motor slightly in motion. The maximum value can be preset in

- P-0-0545, Test torque for releasing holding system.

The appropriate value for P-0-0545 can be determined on the basis of the value displayed in

- P-0-0546, Starting torque for releasing holding system.

If the value "0" is entered in parameter P-0-0545 (or it remains "0"), the releasing of the holding brake is checked with regard to the value in parameter "P-0-0540, Torque of holding brake"!



The value of P-0-0546 should be provided with a safety factor if used for P-0-0545!

See also the respective Parameter Description

**Check for sufficient holding torque of the brake:**

The holding torque of the brake is checked by the motor generating a torque or force with the brake having been applied. The maximum value can be preset in parameter

- P-0-0547, Nominal load of holding system.

The criterion for which the check is to be carried out is decisive for determining an appropriate value for P-0-0547:

- Nominal torque or force of the holding brake
- Holding torque or force for fixing the axis
- Increased holding torque or force.

**Criterion "Nominal Torque" or "Nominal Force"**

The nominal torque or force of the holding brake from "P-0-0540, Torque of holding brake" can be activated for the check. To do this, enter the value "0" in parameter P-0-0547 (or leave it at "0")!



See Parameter Description "P-0-0547, Nominal load of holding system"

**Criterion "Fixing the Axis"**

The torque or force required for fixing the axis can be determined on the basis of "S-0-0084, Torque/force feedback value". To do this, bring the axis to the position with the highest load due to weight and write the value of  $(S-0-0084 \times \text{safety factor } (>1))$  to parameter "P-0-0547, Nominal load of holding system"!



For the criterion "fixing the axis" the required holding torque or holding force, with the holding brake having been sufficiently dimensioned, is smaller than the nominal torque or nominal force of the brake. This expands the tolerance range for detection of holding brake wear and therefore increases the service life of the holding brake.

**Criterion "Increased Holding torque" or "Increased holding force"**

The safety-relevant dimensioning of the holding brake normally requires a higher holding torque than the holding torque necessary to fix the axis. In this case enter the demanded test torque or test force in parameter P-0-0547!



The maximum value for "P-0-0547, Nominal load of holding system" is limited by the value of "P-0-0540, Torque of holding brake"! If the "increased holding torque" is lower than the value of parameter P-0-0540, the tolerance range for detection of holding brake wear is increased which increases the service life of the holding brake!

<b>Criterion "Time Interval Brake Check"</b>	The criterion "brake check time interval" is activated via the respective bit in "P-0-0525, Holding brake control word". The maximum allowed interval to the next brake check has to be entered in parameter "P-0-0550, Time interval holding system check".
<b>Brake Resurfacing "Command"</b>	By starting a command it is possible to reestablish, by removing the oxide film (resurfacing of the brake), the holding torque or the holding force of a holding brake that has not yet become worn. <ul style="list-style-type: none"> <li>• P-0-0544, C3900 Command Holding brake resurfacing</li> </ul>
<b>Operating Status</b>	Displaying the monitoring function: <ul style="list-style-type: none"> <li>• P-0-0539, Holding brake status word</li> </ul> Signaling the readiness to accept command values: <ul style="list-style-type: none"> <li>• S-0-0135, Drive status word</li> </ul>
<b>Warnings</b>	<ul style="list-style-type: none"> <li>• E2069 Holding brake torque too low</li> </ul>
<b>Errors</b>	<ul style="list-style-type: none"> <li>• F2069 Error when releasing the motor holding brake</li> </ul>
<b>Command Errors</b>	<ul style="list-style-type: none"> <li>• C2101 Holding system check only possible with drive enable</li> <li>• C2103 Holding brake: Torque too low</li> <li>• C2104 Command execution impossible</li> <li>• C2105 Load of holding system greater than test torque</li> <li>• C2106 Test torque of holding system not reached</li> <li>• C3901 Resurfacing of holding brake only possible with drive enable</li> <li>• C3902 Error during resurfacing of holding brake</li> <li>• C3903 Command execution impossible</li> </ul>

## 5.5 Measuring Systems

### 5.5.1 Basics on Measuring Systems, Resolution

#### Brief Description

<b>Control Loops and Measuring Systems</b>	<p>Operating drives in the closed control loop requires measuring systems in order to metrologically acquire the current status of the physical value to be controlled, the so-called actual value.</p> <p>The following drive control loops are distinguished:</p> <ul style="list-style-type: none"> <li>• Torque/force control loop <ul style="list-style-type: none"> <li>→ Actual value by evaluating the current measuring system and converting the value</li> </ul> </li> <li>• Velocity control loop <ul style="list-style-type: none"> <li>→ Actual value by evaluating the position measuring system and time-derivation</li> </ul> </li> <li>• Position control loop</li> </ul>
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→ Actual value by evaluating the position measuring system

The actual value of the torque/force control loop is generated by means of the internal current measurement. The measuring system is inaccessible for the user and has a fixed configuration.

**Possibilities of Position Measuring**

For acquiring the actual values of the velocity and position control loop there are position measuring systems available that provide the user possibilities of configuration. Position measurement can be carried out:

- At the motor only (measurement via motor encoder)
- or -
- Both at the motor and at the mechanical axis system (measurement via motor encoder and "external" or "optional" encoder).



Position measurement via motor encoder is always required, measurement at the mechanical axis system is optional, the encoder at the mechanical axis system is therefore called "optional encoder" It is also called "external encoder" because this encoder is not installed internally at the motor, but externally at the axis.

**Types of Position Measuring Systems**

Position measuring systems are available for the different kinds of motion in adapted types of construction:

- Rotary encoders
- Linear encoders

With the appropriate signal specification, encoders in both types of construction can be evaluated by IndraDrive controllers.

**Evaluating Position Measurement**

Depending on their design and the mechanical arrangement at the axis, the position encoders can be evaluated as

- Relative encoders (incremental encoders)

- or -

- Absolute encoders (absolute value encoders).

**Relative Position Measurement**

In the case of relative position measurement, only position differences can be evaluated by means of the measuring system. The actual position values signaled by the measuring system refer to the (mostly undefined) position at the time the drive is switched on. To operate the drive within a limited travel range a position reference must be established (homing) after each time the drive is switched on again.

**Absolute Position Measurement**

In the case of absolute position measurement, the encoder signals actual position values with a fixed encoder-dependent reference point to the controller. After each time the drive is switched on the correct actual position value is immediately available with each axis position. Due to the mostly undefined mounting situation of the encoder to motor or mechanical axis system, it is necessary to determine the position offset (setting the absolute value) once at the initial commissioning.

**Precision, Resolution**

The precision of the position measurement depends on:

- The resolution of the measuring system (division periods = DP)
- The absolute encoder precision
- The digitalization quality of the analog encoder signals
- The dimension of the travel range of the axis

**Monitoring Functions**

Correct position information is of fundamental importance for reliable drive behavior and motion according to contour. The encoder signals are therefore monitored for validity and compliance with the allowed tolerances.

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In addition, it is possible to monitor drives with an encoder that can be evaluated in absolute form for compliance with the position when switching on compared to the last time the drive was switched off.

It is also possible to monitor the difference between the actual position values of motor encoder and external encoder.

See also "Monitoring the Measuring Systems"

**Hardware Requirements**

For connecting the measuring systems to the controller there are three optional interfaces available. "P-0-0077, Assignment motor encoder->optional slot" and "P-0-0078, Assignment optional encoder->optional slot" determine the interface to which the respective encoder is connected. It must be equipped with the encoder input appropriate for the encoder.



See also separate documentation "Drive Controllers, Control Sections; Project Planning Manual"



The following rules apply to P-0-0077 and P-0-0078:

- In the case of motors with encoder data memory (MHD, MKD, MKE), the value for P-0-0077 is automatically set correctly.
- In the case of motors without encoder data memory (rotary and linear kit motors), the value for P-0-0077 must be set manually.
- In the case of optional encoders, the value for parameter P-0-0078 has to be set manually, too.

**Pertinent Parameters**

- S-0-0051, Position feedback value 1
- S-0-0053, Position feedback value 2
- S-0-0115, Position feedback 2 type
- S-0-0116, Resolution of feedback 1
- S-0-0117, Resolution of feedback 2
- S-0-0256, Multiplication 1 (motor encoder)
- S-0-0257, Multiplication 2 (optional encoder)
- S-0-0277, Position feedback 1 type
- S-0-0278, Maximum travel range
- P-0-0074, Encoder type 1 (motor encoder)
- P-0-0075, Encoder type 2 (optional encoder)
- P-0-0129, Internal position data format

**Functional Description****Absolute Encoder Precision**

The absolute precision is a feature of the encoder and is determined by its construction and the quality of its components. The data for the absolute precision are indicated by the manufacturer of the encoder.

**Resolution (Division Periods)**

The resolution of the measuring system (division periods) is entered in the following parameters:

- S-0-0116, Resolution of feedback 1
- S-0-0117, Resolution of feedback 2



Generally, the following applies:

→ **Encoder 1** refers to "motor encoder"

→ **Encoder 2** refers to "external or optional encoder"

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The value of S-0-0116 or S-0-0117 can mean:

- In the case of rotary motor encoders or external rotary encoders, the number of division periods or cycles per encoder revolution (DP/rev)
- In the case of linear motor encoders (used for linear motors) or external linear encoders, the length of the division period in mm (mm/line count)
- In the case of resolvers as motor encoders or external resolver encoders, the number of pole pairs of the resolver

The significance of the value of S-0-0116 is determined in "P-0-4014, Type of construction of motor" (rotary or linear motor).



In the case of Rexroth housing motors (MHD, MKD, MKE, MAD, MAF) and linear motors with EnDat encoder, the correct value is automatically written to S-0-0116!

**Maximum Encoder Resolution After Digitalization**

The analog encoder signals are converted to digital position data via A/D converter. This increases the resolution of the position data available for the axis compared to the resolution of the measuring system (see above)!

Motor encoder (rotary)	(S-0-0116)	×	2 <sup>15</sup>
External encoder (rotary)	(S-0-0117)	×	2 <sup>15</sup>

S-0-0116 Feedback 1 Resolution  
 S-0-0117 Feedback 2 Resolution

Fig. 5-35: Maximum Possible Resolution of Rotary Encoders

Motor encoder (linear)	$\frac{(S-0-0116)}{2^{15}}$
External encoder (linear)	$\frac{(S-0-0117)}{2^{15}}$

S-0-0116 Feedback 1 Resolution  
 S-0-0117 Feedback 2 Resolution

Fig. 5-36: Maximum Possible Resolution of Linear Encoders



Depending on the type of motion of the encoder, the "maximum encoder resolution after digitalization" is output in different units:

- Rotary encoders → position information/encoder revolution
- Linear encoders → mm (length of the shortest measurable distance)

Internally, the value range of the encoder position data is "±2<sup>31</sup>", i.e. the encoder position range can be resolved to "2<sup>32</sup>" data. By digitalization, a multitude of position data results from one division period. By means of adjusted multiplication, the range of encoder position data of "±2<sup>31</sup>" values, referring to the travel range of the axis (S-0-0278), is complied with.

The resulting drive-internal encoder resolution is as follows:

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**Internal Encoder Resolution, Rotary Encoders**

Motor encoder (rotary)	(S-0-0116) × (S-0-0256)
External encoder (rotary)	(S-0-0117) × (S-0-0257)
Auxiliary calculation and internal limitation:	
$(S-0-0256) = \frac{2^{30} \times c_{\_axis\_G1}}{(S-0-0116) \times (S-0-0278)} \leq 2^n$	$n \leq 15$ (in round numbers)
$(S-0-0257) = \frac{2^{30} \times c_{\_axis\_G2}}{(S-0-0117) \times (S-0-0278)} \leq 2^n$	$n \leq 15$ (in round numbers)

- S-0-0116 Feedback 1 Resolution
  - S-0-0256 Multiplication 1
  - S-0-0117 Feedback 2 Resolution
  - S-0-0257 Multiplication 2
  - S-0-0278 Maximum travel range (± travel range)
  - C<sub>\_axis\_G1</sub> axis motion range / motor encoder revolution
  - C<sub>\_axis\_G2</sub> axis motion range / revolution of external encoder
- Fig. 5-37: Drive-Internal Resolution of Rotary Encoders*

**Internal Encoder Resolution, Linear Encoders**

Motor encoder (linear)	(S-0-0116) (S-0-0256)
External encoder (linear)	(S-0-0117) (S-0-0257)
Auxiliary calculation and internal limitation:	
$(S-0-0256) = \frac{2^{30} \times (S-0-0116)}{(S-0-0278)} \leq 2^n$	$n \leq 15$ (in round numbers)
$(S-0-0257) = \frac{2^{30} \times (S-0-0117)}{(S-0-0278)} \leq 2^n$ (load reference)	$n \leq 15$ (in round numbers)
$(S-0-0257) = \frac{2^{30} \times (S-0-0117)}{(S-0-0278) \times c_{\_bef\_M}} \leq 2^n$	(motor reference) $n \leq 15$ (in round numbers)

- S-0-0116 Feedback 1 Resolution
  - S-0-0256 Multiplication 1
  - S-0-0117 Feedback 2 Resolution
  - S-0-0257 Multiplication 2
  - S-0-0278 Maximum travel range (± travel range)
  - C<sub>\_bef\_M</sub> infeed length / motor revolution
- Fig. 5-38: Drive-Internal Resolution of Linear Encoders*

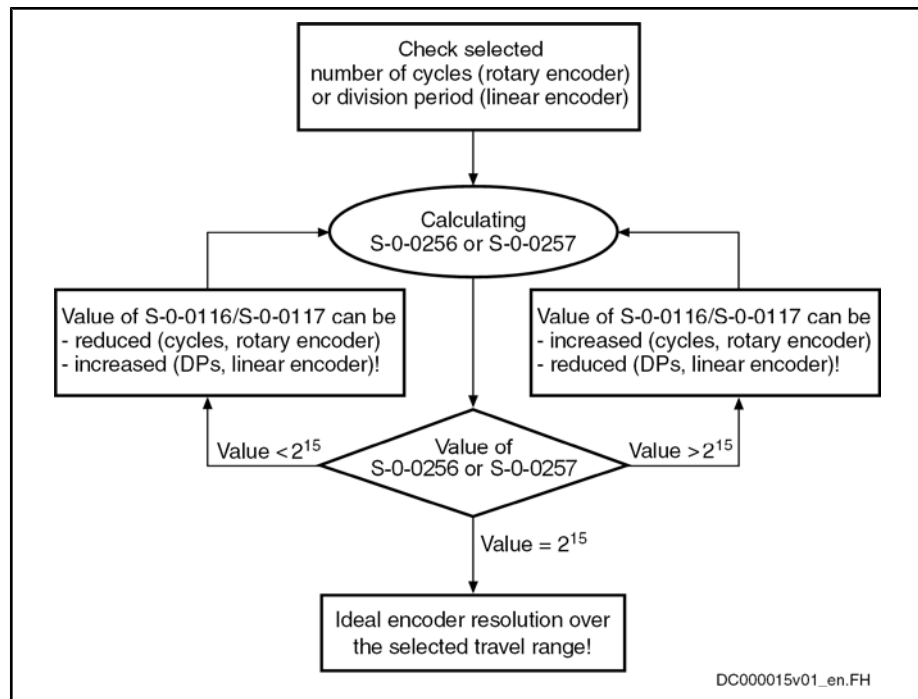


Internally, the multiplication (S-0-0256 and S-0-0257) is automatically determined taking the value of parameter S-0-0278 into consideration.

**Encoder Dimensioning**

The multiplication values (S-0-0256 and S-0-0257) calculated according to the formulas "Drive-internal resolution of rotary encoders" or "Drive-internal resolution of linear encoders", characterize the encoder dimensioning.

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S-0-0116 Feedback 1 Resolution  
 S-0-0117 Feedback 2 Resolution

Fig.5-39: Checking the Selected Resolution and Determining the Ideal Resolution for Encoder 1 (or Encoder 2)



The calculated value of S-0-0256 or S-0-0257 normally will never exactly correspond to "2<sup>15</sup>" (= 32768). With results "=2<sup>15</sup>", the conditions with regard to the possibilities of encoder evaluation are ideal!

Internal Resolution of the Position Data

The position control itself works with the resolution displayed in "P-0-0129, Internal position data format". The value refers to one motor revolution (rotary motor) or one pole pair distance (linear motor) and is limited to "2<sup>28</sup>". In addition, it is influenced by the setting in "S-0-0278, Maximum travel range".

$$(P-0-0129) = \frac{2^{30}}{n_{(S-0-0278)}} \leq 2^{28}$$

P-0-0129 Internal position data format  
 $n_{(S-0-0278)}$  Number of motor revolutions for (S-0-0278)  
 S-0-0278 Maximum travel range (± travel range!)

Fig.5-40: Drive-Internal Resolution of the Position Data for Rotary Motors

$$(P-0-0129) = \frac{2^{30} \times (P-0-0018)}{(S-0-0278)} \leq 2^{28}$$

P-0-0129 Internal position data format  
 P-0-0018 Pole pair distance of linear motors  
 S-0-0278 Maximum travel range (± travel range!)

Fig.5-41: Drive-Internal Resolution of the Position Data for Linear Motors



**Real Resolution of Rotary Encoders**

The lower value from drive-internal encoder resolution and "maximum encoder resolution after digitalization" is the real resolution of the position data of a rotary encoder.

**Real Resolution of Linear Encoders**

The greater value from drive-internal encoder resolution and "maximum encoder resolution after digitalization" is the real resolution of the position data of a linear encoder.



The "maximum encoder resolution after digitalization" is the maximum possible, real encoder resolution. It is limited on the hardware side! If the number of encoder division periods over the travel distance of the axis is accordingly high, the real encoder resolution can also be lower!

**Notes on Commissioning****Configuring the Controller**

The optional interfaces have to be assigned to the encoder connection in the following parameters:

- P-0-0077, Assignment motor encoder->optional slot
- P-0-0078, Assignment optional encoder->optional slot



In the case of motors with encoder data memory (MHD, MKD, MKE), the correct value is automatically written to parameter P-0-0077!

**Configuring the Encoder**

Set the motor encoder type:

- P-0-0074, Encoder type 1 (motor encoder)

Set the encoder type of the optional encoder:

- P-0-0075, Encoder type 2 (optional encoder)

Set the resolution (number of lines, division period) of the motor encoder:

- S-0-0116, Resolution of feedback 1

Set the resolution (number of lines, division period) of the optional encoder:

- S-0-0117, Resolution of feedback 2

Set the kind of encoder and the rotational direction of the motor encoder:

- S-0-0277, Position feedback 1 type

Set the kind of encoder and the rotational direction of the optional encoder:

- S-0-0115, Position feedback 2 type



In the case of Rexroth housing motors (MHD, MKD, MKE, MAD, MAF), the correct value is automatically written to the parameters P-0-0074, S-0-0116 and S-0-0277; in the case of linear motors with EnDat encoder, the correct value is automatically written to P-0-0074 and S-0-0116.

**Setting the Travel Range**

Enter the travel range of the axis:

- S-0-0278, Maximum travel range

**Information on Position Evaluation**

Current actual position value of the motor encoder:

- S-0-0051, Position feedback value 1

Current actual position value of the optional encoder:

- S-0-0053, Position feedback value 2

Position status of the connected encoders:

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- S-0-0403, Position feedback value status

Multiplication of the motor encoder:

- S-0-0256, Multiplication 1 (motor encoder)

Multiplication of the optional encoder:

- S-0-0257, Multiplication 2 (optional encoder)

Resolution of the position data in the drive:

- P-0-0129, Internal position data format



When S-0-0256 and, if available, S-0-0257 have the value "32768", the encoder evaluation is ideal. When the value is lower, S-0-0278 has to be checked for correct travel range input!

## 5.5.2 Monitoring the Measuring Systems

### Brief Description

#### Monitoring the Encoder Signals

Correct position information is the prerequisite for reliable drive behavior and motion according to contour. In order to guarantee best possible position evaluation the encoder signals are therefore monitored for validity and compliance with the allowed tolerances.

Monitoring the encoder signals allows detecting faulty states, such as:

- Encoder is dirty
- Noise injection in the case of inappropriate wire routing or wire design
- Exceeding the max. allowed encoder velocity (limit frequency of the encoder signals)
- Wire break or short circuit on wire

#### Monitoring the Axis Position when Switching On

In addition it is possible to monitor drives with an encoder that can be evaluated in absolute form for compliance with the position when switching on compared to the last time the drive was switched off. This allows detecting, for example, whether a vertical axis moved down after the machine was switched off or whether an axis was moved away from the position it had when the machine stopped.

#### Monitoring Mechanical Transfer Elements

Motor control methods with encoder are only safe to operate if the motor encoder is connected to the movable part without slip. Slip and too little stiffness in the motor encoder connection are detected and indicated with a tolerance to be specified.

It is also possible to monitor the difference between the actual position values of motor encoder and external encoder. This allows, for example, detecting slip due to wear in mechanical transfer elements between motor and axis at an early stage.

#### Monitoring the Position Data Reference

If the loss of the position data reference of absolute encoders (motor encoder or optional encoder) is detected due to changes in parameter values, e.g. of the mechanical drive system, the drive will signal this faulty status.

#### Pertinent Parameters

- S-0-0115, Position feedback 2 type
- S-0-0277, Position feedback 1 type
- S-0-0391, Monitoring window feedback 2
- P-0-0095, Absolute encoder monitoring window for motor encoder
- P-0-0096, Absolute encoder monitoring window for opt. encoder
- P-0-0177, Absolute encoder buffer 1 (motor encoder)

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- P-0-0178, Absolute encoder buffer 2 (optional encoder)
  - P-0-0185, Control word of encoder 2 (optional encoder)
  - P-0-0328, Type of position encoder for measuring encoder
  - P-0-0391, Actual position value difference encoder1 - encoder2
  - P-0-0520, Encoder validation error threshold factor
  - P-0-0620, Encoder validation monitoring signal
  - P-0-0621, Encoder validation upper monitoring threshold
  - P-0-0622, Encoder validation lower monitoring threshold
- Pertinent Diagnostic Messages**
- E2074 Encoder 1: Encoder signals disturbed
  - E2075 Encoder 2: Encoder signals disturbed
  - F2036 Excessive position feedback difference
  - F2042 Encoder 2: Encoder signals incorrect
  - F2048 External power supply X15 error
  - F2074 Actual pos. value 1 outside absolute encoder window
  - F2075 Actual pos. value 2 outside absolute encoder window
  - F2174 Loss of motor encoder reference
  - F2175 Loss of optional encoder reference
  - F8022 Enc. 1: Enc. signals incorr. (can be cleared in ph. 2)
  - F8023 Error mechanical link of encoder or motor connection

**Functional Description**

IndraDrive controllers can evaluate signals of the following encoder types:

- Sine encoder 1 V<sub>pp</sub> (Heidenhain standard)
- Resolver encoder (Rexroth standard)
- Square-wave encoder 5V TTL (Heidenhain standard)

**Signal Monitoring for Sine Encoders**

Analog sine encoder signals are monitored with regard to two criteria:

- Monitoring the signal amplitude
- Monitoring the quadrant allocation

The signals are monitored on the hardware side and on the firmware side. The signal amplitude must be within the allowed voltage range:

$$0,2 \times U_{A,B\_nom} \leq \sqrt{U_A^2 + U_B^2} \leq 1,4 \times U_{A,B\_nom}$$

$U_{A,B\_nom}$  nominal amplitude value of the encoder tracks, in this case 1.0 Vpp

$U_A$  amplitude of encoder track A

$U_B$  amplitude of encoder track B

*Fig. 5-42: Allowed Voltage Range for the Signal Amplitudes of Sine Encoders*

The quadrant allocation is checked by counting the zero crossings of the sine or cosine signal. In the case of trouble-free operation, the count is changed by the value "±1" at every zero crossing of a track.

When the encoder signals temporarily leave (e.g. due to interference injection or local accumulation of dirt on the code disk) the allowed voltage range that is monitored in the hardware side, the controller outputs the respective warning:

- E2074 Encoder 1: Encoder signals disturbed
- E2075 Encoder 2: Encoder signals disturbed

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The warning remains active until the drive is switched off or switched to communication phase P2!

Incorrect counts caused by injected noise and permanently reduced signal amplitudes caused by dirty code disks can be the reason why an error message for the motor encoder or the external encoder is generated:

- F8022 Enc. 1: Enc. signals incorr. (can be cleared in ph. 2)
- F2042 Encoder 2: Encoder signals incorrect

The drive then reacts with the error reaction that has been set.

## Signal Monitoring for Resolver Encoders

Monitoring the analog resolver encoder signals with carrier frequency is only possible by the calculated analysis of digitized values:

$$0,5 \times U_{A,B\_nom} \leq \sqrt{U_A^2 + U_B^2} \leq 1,2 \times U_{A,B\_nom}$$

$$U_{A,B\_nom} = U_{out\_Resolver} \times \ddot{u}_{Resolver}$$

$U_{A,B\_nom}$  nominal amplitude value of the resolver tracks

$U_A$  amplitude of resolver track A

$U_B$  amplitude of resolver track B

$U_{out\_Resolver}$  controller output voltage for resolver supply

$\ddot{u}_{Resolver}$  gear ratio of the resolver

Fig.5-43: Allowed Voltage Range for the Signal Amplitudes of Resolvers



The resolver data and resolver voltage supply data are contained in the Project Planning Manuals for motors and controllers!

## Signal Monitoring for Square-Wave Encoders

Monitoring the signals of square-wave encoders with regard to amplitude and quadrant allocation is not possible with IndraDrive controllers!

The reference marker can also be monitored for failure or distance. For this purpose, the "cyclic reference marker detection" function has to be activated (position encoder type motor encoder: "S-0-0277, Position feedback 1 type", bit 9; position encoder type external encoder: "S-0-0115, Position feedback 2 type", bit 9; position encoder type measurement encoder: "P-0-0328, Type of position encoder for measuring encoder", bit 9). This activates the monitoring function and an encoder error is output, if applicable.

Marker distance monitoring: The difference of the last two markers must be equal to the defined marker distance.

Marker failure monitoring: The distance between the encoder position and the last marker position must not exceed 1.5 \* marker distance.

## Monitoring the Axis Position when Switching On

When the drive is switched off the current encoder data of the absolute motor encoder and/or of the absolute external encoder are stored:

- P-0-0177, Absolute encoder buffer 1 (motor encoder)
- P-0-0178, Absolute encoder buffer 2 (optional encoder)

When switching on a drive with an absolute motor encoder and/or an absolute external encoder, a check is run to determine in how far the current actual position value differs from the actual position value at the time of the last switch off. The maximum allowed difference is fixed in the following parameters:

- P-0-0095, Absolute encoder monitoring window for motor encoder
- P-0-0096, Absolute encoder monitoring window for opt. encoder

When the difference exceeds the determined value the respective error message is output:

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**Monitoring Mechanical Transfer Elements**

- F2074 Actual pos. value 1 outside absolute encoder window
- F2075 Actual pos. value 2 outside absolute encoder window

This monitoring function can be deactivated!

For motor control methods with encoder the motor encoder must be without slip and be rigidly connected to the moving part of the motor. The current quality of the motor encoder coupling is represented by the value of "P-0-0620, Encoder validation monitoring signal". The mechanical connection is sound, if the value is between the upper and the lower monitoring threshold ("P-0-0621, Encoder validation upper monitoring threshold" and "P-0-0622, Encoder validation lower monitoring threshold"). The monitoring sensitivity is set in "P-0-0520, Encoder validation error threshold factor".



This function is particularly relevant in connection with safety technology. In the case of Rexroth housing motors the monitoring function for reliable behavior is preset (medium sensitivity).

**Monitoring the Position Data Reference**

For axis drives that are equipped with an external encoder, the controller provides the possibility of monitoring the difference of the actual position values of motor encoder and external encoder with regard to a maximum value that can be set.

The maximum allowed difference of the actual position values of both encoders is defined in parameter "S-0-0391, Monitoring window feedback 2". When this value is exceeded the "F2036 Excessive position feedback difference" error message is generated. This monitoring function is active as of communication phase 4 and can be deactivated, too!

The position data reference of absolute encoders gets lost when:

- The parameter values of the mechanical drive system have been changed
- The encoder resolutions have been changed
- The scalings of the physical data have been changed
- The maximum travel range of an axis has been changed
- Hybrid position control has been activated ("measuring wheel mode")

During the transition from communication phase P2 to P4 (bb), the drive recognizes that the former position data reference of the encoder does no longer exist. It sets the parameter "S-0-0403, Position feedback value status" of the encoder or encoders to "relative" and signals the loss of position data reference by the following error messages:

- F2174 Loss of motor encoder reference
- F2175 Loss of optional encoder reference

**Monitoring for Spindle Encoders**

In the case of spindles, it is mostly high-resolution, external encoders that are used for C-axis operation, in order to obtain the required machining quality for interpolating operation (with low speeds).

In the case of regular spindle operation (high speeds), it is possible that the maximum input frequency of the respective encoder input is exceeded. If the maximum input frequency was exceeded, the reference will be cleared.

The external encoder is only required for C-axis operation, but would make regular spindle operation impossible. The encoder monitor can therefore be switched off in this case by the respective value in parameter "P-0-0185, Control word of encoder 2 (optional encoder)".

Determining the maximum frequency of the encoder (encoder output frequency):

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$$f_{out} = \frac{TP \times n_{max}}{60000 \frac{s}{min}}$$

$f_{out}$  encoder output frequency of encoder in kHz  
 DP number of lines of encoder per revolution  
 $n_{max}$  maximum speed of spindle in 1/min

Fig.5-44: Calculating the Output Frequency of the Encoder

In the firmware there are, for the different encoder types, maximum frequencies stored up to the values of which troublefree signal evaluation is guaranteed.

Value of P-0-0075	External encoder used	Maximum frequency stored in firmware
1	GDS/GDM encoder (Rexroth standard)	70 kHz
2	Incremental encoder with sine signals (signal specification of Heidenhain)	200 kHz
3	Resolver encoder with encoder data memory	2 kHz
4	Encoder with HIPERFACE® interface from Stegmann	200kHz
5	Incremental encoder with square-wave signals (signal specification of Heidenhain)	500 kHz
8	Encoders with EnDat interface from Heidenhain	200 kHz

Fig.5-45: Maximum Frequency for Troublefree Encoder Evaluation

When the maximum encoder output frequency reaches or exceeds the maximum frequency stored in the firmware, it makes sense to deactivate the spindle encoder monitor.



The maximum frequency stored in the firmware has a "safety distance" to the maximum input frequency of the respective optional input module (see separate documentation "Drive Controllers, Control Sections; Project Planning Manual").

Notes on Commissioning


See also Notes on Commissioning in section "Basics on Measuring Systems, Resolution"

Setting the Axis Position Monitor (Only with Absolute Encoder)

If monitoring the axis position is desired when the drive is switched on the values for the monitoring window have to be entered:

- P-0-0095, Absolute encoder monitoring window for motor encoder
- P-0-0096, Absolute encoder monitoring window for opt. encoder

The unit is that of the actual position value. The size of the monitoring window depends on application-specific aspects of operational safety. If this monitoring function is not desired you have to enter the value "0".

<b>Setting the Position Difference Monitor</b>	<p>If the actual position value difference of motor encoder and external encoder is to be monitored you first have to determine a useful value for the monitoring window, according to the following procedure:</p> <ol style="list-style-type: none"> <li>1. Accelerate the axis to maximum velocity with maximum acceleration, then decelerate it with maximum deceleration. If possible, let the maximum stationary machining load operate on the mechanical axis system.</li> <li>2. Determine the occurred maximum value of the actual position value difference by means of the display parameter "P-0-0391, Actual position value difference encoder1 - encoder2" .</li> <li>3. Multiply this value with a safety factor (recommended: 2-fold value) and enter it in parameter "S-0-0391, Monitoring window feedback 2". The unit is that of the actual position value.</li> </ol> <p>If this monitoring function is not desired you have to enter the value "0".</p>
<b>Configuring the Spindle Encoder Monitor</b>	<p>When using an optional encoder at a spindle you should first determine, during the initial commissioning procedure, whether the maximum input frequency of the respective encoder input is exceeded at maximum speed. To do this, accelerate the spindle to maximum speed.</p> <p>In order to prevent the drive from exceeding the maximum input frequency during operation and switching off, the spindle encoder monitoring should be deactivated. To do so, enter the respective value in parameter "P-0-0185, Control word of encoder 2 (optional encoder)"</p>
<b>Setting the Motor Encoder Connection Monitor</b>	<p>In general, Rexroth housing motors with motor encoder do not require setting of "P-0-0520, Encoder validation error threshold factor". Medium sensitivity is preset.</p> <p>In the case of Rexroth kit motors or third-party motors, this monitoring function has to be checked and "P-0-0520, Encoder validation error threshold factor" set to the appropriate sensitivity. See TN35, Encoder Validation Monitoring With IndraDrive Controllers</p>
<b>Diagnostic Messages</b>	<p>If the position deviation of a motor encoder or external encoder with absolute position data reference exceeds the value in P-0-0095 or P-0-0096 between the points of time the control voltage is switched off and on again, the drive generates the error message</p> <ul style="list-style-type: none"> <li>• F2074 Actual pos. value 1 outside absolute encoder window</li> <li>- or -</li> <li>• F2075 Actual pos. value 2 outside absolute encoder window.</li> </ul> <hr/> <p> The value in P-0-0095 or P-0-0096 has to be unequal zero; the value "0" deactivates the monitor!</p> <hr/> <p>When the actual position value difference of motor encoder and external encoder (P-0-0391) exceeds the value of S-0-0391, the drive generates the error message</p> <ul style="list-style-type: none"> <li>• F2036 Excessive position feedback difference.</li> </ul> <p>If, when switching the drive on, the loss of the position data reference of absolute encoders (motor encoder or optional encoder) is detected due to changes in the mechanical parameters, for example, the drive signals</p> <ul style="list-style-type: none"> <li>• F2174 Loss of motor encoder reference</li> <li>- or -</li> <li>• F2175 Loss of optional encoder reference.</li> </ul> <p>When temporarily incorrect encoder signals are detected the drive generates the warning</p>

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- E2074 Encoder 1: Encoder signals disturbed

- or -

- E2075 Encoder 2: Encoder signals disturbed.

The warning remains active until the drive is switched off or switched to communication phase P2!

When incorrect encoder signals are detected the drive generates the error message

- F8022 Enc. 1: Enc. signals incorr. (can be cleared in ph. 2)

- or -

- F2042 Encoder 2: Encoder signals incorrect.

When the voltage of the battery of the encoder data memory has fallen below the determined limit value, the drive generates the following error message:

- F2048 External power supply X15 error.

See also "Error Reactions"

If the sensitivity of the encoder connection monitor has been set too high, the motor encoder connection is incorrect or the motor power cable has not been connected, the drive will generate the error message

- F8023 Error mechanical link of encoder or motor connection

### 5.5.3 Absolute Measuring Systems

#### Brief Description

##### Evaluating Position Measurement

Depending on their design and the mechanical arrangement at the axis, position encoders can be evaluated by IndraDrive controllers as

- Relative encoders (incremental encoders)

- or -

- absolute encoders (absolute value encoders)

if they have the required signal specification.

Rexroth position encoders and motor encoders of Rexroth housing motors are available in one of the two designs:

- Single-turn encoders (absolute actual position values over one encoder shaft revolution)
- Multi-turn encoders (absolute actual position values over 4096 encoder shaft revolutions).

These encoders can be evaluated as absolute encoders if the travel range of the axis can be represented within the absolute actual position value range of the encoder:

- In the case of single-turn encoders within one encoder shaft revolution
- In the case of multi-turn encoders within 4096 encoder shaft revolutions

##### Encoders of Rexroth Housing Motors

As a standard, Rexroth housing motors are equipped with a position measuring system. The individual motor series have different measuring systems which allows offering cost-efficient motors depending on the application.

The following measuring systems are used:

- HSF ("high-resolution servo feedback"), single- or multi-turn type for MHD, MAD, MAF motors
- HIPERFACE® encoder (only such types authorized by Rexroth) for MSK motors
- Resolver, single- or multi-turn type for MKD, MKE motors



## Motor, Mechanical Axis System, Measuring Systems

**Absolute Encoders for Kit Motors and External Encoders**

For kit motors or directly at the mechanical axis system, the following measuring systems, that can be evaluated in absolute form, can be used:

- EnDat linear encoders (Heidenhain) for linear motors or linear axes
- Rotary EnDat encoders (Heidenhain) or Rexroth single-turn or Rexroth multi-turn encoders for rotary kit motors or rotary axes

**Establishing Axis-Related Absolute Distance**

The actual position values of an absolute encoder first only relate to the encoder itself. Due to the mostly undefined mounting situation of the encoder to the motor or the mechanical axis system, it is necessary to determine the position offset between encoder and axis zero point once at the initial commissioning (see also "Establishing the Position Data Reference: Establishing Position Data Reference for Absolute Measuring Systems").

**Hardware Requirements**

For the signal specification of third-party encoders for position and homing signals with regard to amplitude and phase angle, see the "Drive Controllers, Control Sections; Project Planning Manual".



Rexroth encoders correspond to the required signal specification!

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**Pertinent Parameters**

- S-0-0115, Position feedback 2 type
- S-0-0277, Position feedback 1 type
- S-0-0278, Maximum travel range
- S-0-0378, Absolute encoder range of motor encoder
- S-0-0379, Absolute encoder range of optional encoder
- P-0-0019, Initial position value

**Functional Description****Absolute Encoder Range and Absolute Encoder Evaluation**

Absolute encoders can only display a limited position range in absolute values. For encoders that can be evaluated in absolute form, the drive, depending on the connection of the encoder or the encoders to the axis and on the position data scaling, calculates the travel range of the axis that can be displayed in absolute actual position values.

The following parameters indicate the maximum extent of the travel range that can be selected so that an absolute motor encoder can be evaluated in absolute form:

- S-0-0378, Absolute encoder range of motor encoder
- S-0-0379, Absolute encoder range of optional encoder

On the user side, the travel range of the axis is fixed:

- S-0-0278, Maximum travel range

When the travel range is smaller than the absolute encoder range determined by the drive, the respective control encoder (motor encoder or external encoder; according to the selected operating mode) can be evaluated as an absolute encoder.

This is displayed in the respective bits of the following parameters:

- S-0-0277, Position feedback 1 type
- S-0-0115, Position feedback 2 type



If absolute evaluation of an encoder is possible but not desired, the absolute evaluation can be switched off by setting the respective bit in S-0-0277 or S-0-0115! The encoder can then only be evaluated in relative form!

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Motor, Mechanical Axis System, Measuring Systems

**Controlling the Dimensioning Regarding Absolute Encoder Evaluation**

To dimension absolute encoders it is necessary to check by the way of calculation whether the intended travel range of the axis, considering all mechanical transfer elements, can be displayed within the absolute encoder range.

The following condition must be fulfilled:

- Rotary encoders → Travel range of axis requires less encoder revolutions than preset in absolute encoder range!
- Linear encoders → Travel range of axis is smaller than preset in absolute encoder range!

**Actual Position Value of Encoders To Be Evaluated in Absolute Form After Switching On**

The actual position value of an absolute measuring system must be adjusted to the mechanical axis system once at initial commissioning.



The adjustment is made by determining an actual position value, related to the axis zero point, given a defined axis position (P-0-0012, C0300 Set absolute position procedure command). Thereby the offset between the actual position value that first is encoder-related and the required axis-related actual position value is internally determined and permanently stored! The respective encoder then is "in reference".

If only one absolute encoder (motor encoder) is available, there are the following cases to be distinguished for the actual position value after the drive has been switched on:

Absolute evaluation (S-0-0277, bits 6 and 7)	Actual pos. value of motor encoder when switching on (S-0-0051)	Notes on the commissioning status	Current position status (S-0-0403, bit 0 ... 2)
Active → Evaluation as absolute measuring system	Original position of motor encoder	Initial commissioning not yet carried out, motor encoder not "in reference".	0b ... 000
	Absolute value motor encoder	Initial commissioning was carried out, the motor encoder was set "in reference".	0b ... 01x
inactive → Evaluation as relative measuring system intended	P-0-0019	Initial commissioning not yet carried out, motor encoder is not "in reference".	0b ... 000
Not possible → Evaluation as relative measuring system, e.g. due to length of travel range	P-0-0019	Initial commissioning not yet carried out, motor encoder is not "in reference".	0b ... 000

P-0-0019 Initial position value (can be defined by user)

*Fig.5-46: Actual Position Value When Switching on a Drive With Absolute Motor Encoder (Without Optional Encoder)*

At first the actual position value is only encoder-related. If the drive has been equipped, for example, with only one measuring system (motor encoder can be evaluated in absolute form), the controller sets the actual position value to the original encoder position (the original encoder position is the addition of absolute position of the encoder and absolute encoder offset).



In the case of absolute evaluation, the absolute encoder offset 1 or 2 is stored in the encoder (P-0-1002 or P-0-1012). For modulo-scaled, absolute measuring systems, the absolute encoder offset is stored in "P-0-0177, Absolute encoder buffer 1 (motor encoder)" or "P-0-0178, Absolute encoder buffer 2 (optional encoder)".

**Initial Position Value** If the actual position value is to be initialized with an initial position value defined by the user, this can be done via "P-0-0019, Initial position value" in conjunction with bit 6 or 7 of the corresponding parameter for the type of position encoder.


If the drive, apart from the motor encoder, is equipped with an external encoder and at least one encoder can be evaluated in absolute form, the following actual position values, depending on the reference status of the encoder, are resulting after switching on:


Absolute evaluation		Actual position values when switching on		Notes on the commissioning status	Current position status (S-0-0403)
Motor encoder (S-0-0277)	External encoder (S-0-0115)	Motor encoder (S-0-0051)	External encoder (S-0-0053)		
Active	Active	<b>Original position</b> of motor encoder	<b>Original position</b> of external encoder	Initial commissioning has not been carried out, none of the encoders has "reference".	0b ... 000
		Absolute value motor encoder	Absolute value motor encoder	During the initial commissioning only the motor encoder was set "in reference".	0b ... 01x
		Absolute value ext. encoder	Absolute value ext. encoder	During the initial commissioning only the external encoder was set "in reference".	0b ... 10x
		Absolute value motor encoder	Absolute value ext. encoder	During the initial commissioning both encoders were set "in reference".	0b ... 111
Active	inactive	<b>Original position</b> of motor encoder	<b>Original position</b> of motor encoder	Initial commissioning not yet carried out, motor encoder not "in reference".	0b ... 000
		Absolute value motor encoder	Absolute value motor encoder	Initial commissioning was carried out, the motor encoder was set "in reference".	0b ... 01x
Active	Not possible	<b>Original position</b> of motor encoder	<b>Original position</b> of motor encoder	Initial commissioning has not been carried out, none of the encoders has "reference".	0b ... 000
		Absolute value motor encoder	Absolute value motor encoder	During the initial commissioning only the motor encoder was set "in reference".	0b ... 10x
inactive	Active	<b>Original position</b> of external encoder	<b>Original position</b> of external encoder	Initial commissioning has not been carried out, none of the encoders has "reference".	0b ... 000
		Absolute value ext. encoder	Absolute value ext. encoder	During the initial commissioning the external encoder was set "in reference".	0b ... 010x

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Absolute evaluation		Actual position values when switching on		Notes on the commissioning status	Current position status (S-0-0403)
Motor encoder (S-0-0277)	External encoder (S-0-0115)	Motor encoder (S-0-0051)	External encoder (S-0-0053)		
Not possible	Active	Original position of external encoder	Original position of external encoder	Initial commissioning has not been carried out, none of the encoders has "reference".	0b ... 000
		Absolute value ext. encoder	Absolute value ext. encoder	During the initial commissioning the external encoder was set "in reference".	0b ... 10x
inactive	inactive	P-0-0019	P-0-0019		0b ... 000

P-0-0019 Initial position value (can be defined by user)  
 Fig.5-47: *Actual Position Values When Switching on a Drive With Encoders to be Evaluated in Absolute Form*

 "S-0-0403, Position feedback value status" displays whether the encoders connected to the drive and the reference encoder selected via "S-0-0147, Homing parameter".

 After the measuring systems to be evaluated in absolute form were set "in reference" during the initial commissioning of the drive, their actual position values in the operational status of the drive, related to the mechanical system, are always absolute values. This is so, even when the drive is switched off and on again!

Notes on Commissioning

 The Notes on Commissioning for "Basics on Measuring Systems, Resolution" and "Monitoring the Measuring Systems" have to be observed, too!


Setting the Travel Range

Enter the travel range of the axis:

- S-0-0278, Maximum travel range

Check the absolute encoder range of the respective control encoder:

- S-0-0378, Absolute encoder range of motor encoder
- S-0-0379, Absolute encoder range of optional encoder

 The travel range and the absolute encoder ranges have the same position reference! They refer, depending on the scaling that was set, to the motor or to the load!

Absolute Encoder Evaluation Possible?

When the travel range is smaller than the absolute encoder range of the control encoder (determined by the active operating mode) the encoder can be evaluated as an absolute encoder. This is also displayed in the respective bits of the following parameters:

- S-0-0277, Position feedback 1 type
- S-0-0115, Position feedback 2 type

By means of these parameters it is possible to deactivate the absolute evaluation of an encoder. The actual position values then are only relative, i.e. the encoder has to be homed again each time the machine is restarted!

If the absolute encoder range of the control encoder is smaller than the value of S-0-0278 you have to check whether the travel range was correctly input or whether the default value is active!

#### Setting the Initial Position Value

If desired, it is possible to enter a defined initial position value for the actual position value of the encoder or the encoders in "P-0-0019, Initial position value". For encoders that can be evaluated in absolute form this value is only active the first time the drive is switched on. After an encoder that can be evaluated in absolute form was set "in reference", this value is insignificant even when the drive is switched on again!

## 5.5.4 Relative Measuring Systems

### Brief Description

#### Evaluating Position Measurement

IndraDrive controllers can evaluate the signals of both absolute and relative measuring systems, if the encoder signals correspond to the specification.

The **disadvantages** of relative encoders as opposed to encoders that can be evaluated in absolute form are as follows:

- Axes with relative position encoder must go through a homing procedure after switching on so that they can be operated in position control.
- Relative encoders are unsuitable as motor encoders for synchronous motors because each time the drive is restarted it has to go through a procedure for setting the commutation offset. Therefore, the immediate readiness for operation is not guaranteed for synchronous motors!

The **advantages** of relative encoders as opposed to encoders that can be evaluated in absolute form are as follows:

- Longer travel distances are possible for linear encoders.
- The costs of the encoder are mostly lower given equal absolute precision and number of lines or division period length.

#### Aspects of Use

Due to the above disadvantages, relative measuring systems are not used as motor encoders for synchronous Rexroth housing motors. For asynchronous motors there aren't any disadvantages when using relative motor encoders.

For kit motors it can be necessary, however, to use relative encoders as motor encoders if absolute encoders of the required design are not available:

- Great encoder lengths for long travel distances in the case of linear motors
- Hollow-shaft encoders with special bore diameters or encoders for high maximum speeds in the case of rotary kit motors

#### Establishing Axis-Related Absolute Distance

The actual position values of relative encoders first do not have any position reference. In any axis position the actual position value of the respective relative encoder, when switching the drive on, is written with the so-called initial position value, if no other encoder being in reference has been connected.

There are two ways to establish the axis-related absolute distance:

- Moving to a defined axis position with reproducible precision.
- or -
- detecting a defined axis position by "passing" two distance-coded reference marks of the encoder.

At a defined position, the actual position value of the encoder to be homed is written with the corresponding absolute value of the axis (see "Establishing the Position Data Reference: Establishing Position Data Reference for Relative Measuring Systems").

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**Hardware Requirements** For the signal specification for position and homing signals with regard to amplitude and phase angle, see the documentation "Drive Controllers, Control Sections; Project Planning Manual".


- Pertinent Parameters**
- S-0-0115, Position feedback 2 type
  - S-0-0116, Resolution of feedback 1
  - S-0-0117, Resolution of feedback 2
  - S-0-0165, Distance-coded reference offset A
  - S-0-0166, Distance-coded reference offset B
  - S-0-0277, Position feedback 1 type
  - P-0-0019, Initial position value

**Functional Description**

**Initial Position Value** When the drive is switched on, the actual position values of relative encoders are written with the initial position value (P-0-0019), if none of the encoders is an absolute value encoder that has already been set in reference.

Absolute evaluation possible?		Actual position values when switching on		Notes on the operating status	Current position status (S-0-0403, bit 0..2)
Motor encoder	External encoder	Motor encoder (S-0-0051)	External encoder (S-0-0053)		
No	No	P-0-0019	P-0-0019	Axis has not moved after switching on, axis has not yet been homed.	0b ... 000
		absolute value motor encoder	absolute value motor encoder	Axis was homed via motor encoder; at the home point, S-0-0053 is set to the value of S-0-0051.	0b ... 01x
		absolute value ext. encoder	absolute value ext. encoder	Axis was homed via external encoder; at the home point, S-0-0051 is set to the value of S-0-0053.	0b ... 10x
		absolute value motor encoder	absolute value ext. encoder	Axis was homed via motor encoder and external encoder.	0b ... 111

P-0-0019 Initial Position Value  
 Fig. 5-48: Actual Position Values After Switching on resp. After Homing (Drive With Exclusively Relative Encoders)

 "S-0-0403, Position feedback value status" displays whether the encoders connected to the drive and the reference encoder selected via "S-0-0147, Signal status word".

**Reference Marks** In order to establish the axis-related absolute distance ("reference") the controller monitors the signals of the relative encoder or of the axis sensors that contain absolute position information regarding the axis:

- Reference marks of the encoder, if necessary in combination with home point switch of the axis
- Distance-coded reference marks of the encoder
- Home point switch of the axis

The controller is told via the parameters "S-0-0277, Position feedback 1 type" or "S-0-0115, Position feedback 2 type" which homing signals the connected measuring system makes available.

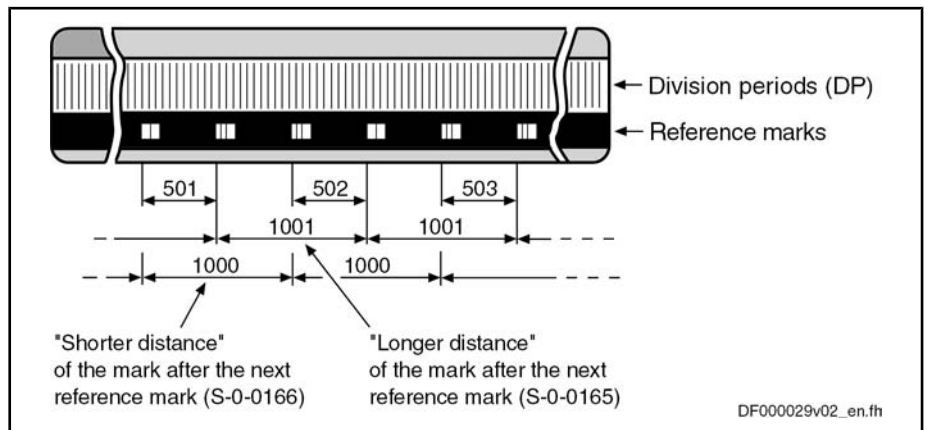
**Reference Marks, Not Distance-Coded** During the homing procedure, the controller automatically detects the reference mark if its signal corresponds to the specification and the reference mark is to be evaluated to establish the reference (see "Establishing the Position Data

Reference: Establishing Position Data Reference for Relative Measuring Systems").

If a relative encoder has several reference marks over the travel distance, a reference mark is to be identified by means of a home point switch at the axis for establishing the position reference (see "Establishing the Position Data Reference: Establishing Position Data Reference for Relative Measuring Systems").

**Distance-Coded Reference Marks**

In the case of relative encoders with distance-coded reference marks, several reference marks are distributed in equal distances over the entire travel distance. There is a "shorter distance" and a "longer distance" between one reference mark and the mark after the next. The the values of these two distances are available to the controller in the parameters "S-0-0165, Distance-coded reference offset A" and "S-0-0166, Distance-coded reference offset B".



S-0-0165 Distance-coded reference offset A  
S-0-0166 Distance-coded reference offset B

Fig. 5-49: Reference Mark Distances in the Case of a Distance-Coded Linear Encoder With a Distance Difference of 1 DP



The values for "distance-coded reference distance A" and "distance-coded reference distance B" have to be indicated by the manufacturer!

**Determining the "Distance-Coded Reference Distance A"**

If the value of "distance-coded reference distance A" is not directly indicated in the data sheet of the distance-coded encoder, the value can also be determined by means of calculation if the travel distance for establishing the absolute reference point is indicated in the data sheet of the encoder:

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Linear Encoders

General	S-0-0165	=	$\frac{x_{ref} + n \times DP}{DP}$
Motor encoder	S-0-0165	=	$\frac{x_{ref} + n \times (S-0-0116)}{(S-0-0116)}$
External encoder	S-0-0165	=	$\frac{x_{ref} + n \times (S-0-0117)}{(S-0-0117)}$

S-0-0165 Distance-coded reference offset A (in number of DP)  
 $x_{ref}$  Travel distance for establishing the absolute reference point (in mm)  
 n Number of DP of the distance difference (longer-shorter distance)  
 DP Division period of the relative linear encoder (in mm)  
 S-0-0116 Feedback 1 Resolution (division period in mm)  
 S-0-0117 Feedback 2 Resolution (division period in mm)  
*Fig. 5-50: Determining the Value for the "Longer Distance" of the Distance-Coded Reference Marks With a Relative Linear Encoder*

Rotary Encoders

General	S-0-0165	=	$\frac{N_{cyc} \times \varphi_{ref}}{360^\circ} + z$
Motor encoder	S-0-0165	=	$\frac{(S-0-0116) \times \varphi_{ref}}{360^\circ} + z$
External encoder	S-0-0165	=	$\frac{(S-0-0117) \times \varphi_{ref}}{360^\circ} + z$

S-0-0165 Distance-coded reference offset A (in number of cycles)  
 $N_{cyc}$  Number of cycles of the rotary encoder (per 360°)  
 $\varphi_{ref}$  Travel angle for establishing the absolute position data reference (in degrees)  
 z Number of cycles of the distance difference (longer-shorter distance)  
 S-0-0116 Feedback 1 Resolution (per 360°)  
 S-0-0117 Feedback 2 Resolution (per 360°)  
*Fig. 5-51: Determining the Value for the "Longer Distance" of the Distance-Coded Reference Marks With a Relative Linear Encoder*

**Determining the "Distance-Coded Reference Distance B"**

If the value of "distance-coded reference distance B" is not directly indicated in the data sheet of the distance-coded encoder, the value can only be determined by means of calculation if the distance difference (longer distance – shorter distance) is indicated in the data sheet of the encoder:



Linear Encoders

General	S-0-0166	$= \frac{x_{ref}}{DP}$
Motor encoder	S-0-0166	$= \frac{x_{ref}}{(S-0-0116)}$
External encoder	S-0-0166	$= \frac{x_{ref}}{(S-0-0117)}$

S-0-0166 Distance-coded reference offset B (in number of DP)  
 $x_{ref}$  Travel distance for establishing the absolute reference point (in mm)  
 DP Division period of the relative linear encoder (in mm)  
 S-0-0116 Feedback 1 Resolution (division period in mm)  
 S-0-0117 Feedback 2 Resolution (division period in mm)

Fig.5-52: Determining the Value for the "Shorter Distance" of the Distance-Coded Reference Marks With a Relative Linear Encoder

Rotary Encoders

General	S-0-0166	$= \frac{N_{cyc} \times \varphi_{ref}}{360^\circ}$
Motor encoder	S-0-0166	$= \frac{(S-0-0116) \times \varphi_{ref}}{360^\circ}$
External encoder	S-0-0166	$= \frac{(S-0-0117) \times \varphi_{ref}}{360^\circ}$

S-0-0166 Distance-coded reference offset B (in number of cycles)  
 $N_{cyc}$  Number of cycles of the rotary encoder (per 360°)  
 $\varphi_{ref}$  Travel angle for establishing the absolute position data reference (in degrees)  
 S-0-0116 Feedback 1 Resolution (per 360°)  
 S-0-0117 Feedback 2 Resolution (per 360°)

Fig.5-53: Determining the Value for the "Shorter Distance" of the Distance-Coded Reference Marks With a Relative Linear Encoder

Notes on Commissioning



The Notes on Commissioning in the sections "Basics on Measuring Systems, Resolution" and "Monitoring the Measuring Systems" have to be observed, too!

Setting the Initial Position Value

If the actual position value of relative encoders is not to be written with the default value "0" when the drive is switched on, "P-0-0019, Initial position value" has to be changed to have the desired value.

In the Case of Distance-Coded Measuring System

If the relative encoder possesses distance-coded reference marks the controller is informed on this by the respective bit in the following parameters:

- S-0-0277, Position feedback 1 type
- S-0-0115, Position feedback 2 type

The value for the "longer distance" of the distance-coded reference marks has to be entered in parameter "S-0-0165, Distance-coded reference offset A".

The value for the "shorter distance" of the distance-coded reference marks has to be entered in parameter "S-0-0166, Distance-coded reference offset B".

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## 5.5.5 Establishing the Position Data Reference

### General Information on Establishing the Position Data Reference

#### Brief Description

During the initial commissioning of a drive the actual position values transmitted by the measuring systems do not yet have any reference to the machine axis. This applies to

- Relative measuring systems and
- Absolute measuring systems.

For more detailed information on relative and absolute evaluation of measuring systems, see "Absolute Measuring Systems".

#### Relative Measuring Systems

The position data reference of a relative measuring system to the axis has to be reestablished after each time the drive is switched on or after the position data reference is lost. For this it is necessary to move to a defined axis position and the actual position value is set to an axis-related value in a defined position (exception: For relative encoders with distance-coded reference marks movement is only required via two marks!)

#### Absolute Measuring Systems

The position data reference of an absolute measuring system to the axis has to be established once during initial commissioning after replacing the motor or encoder (motor encoder or external encoder) and changes in the mechanical axis system. The position data reference still is maintained and the actual position values are axis-related immediately after the drive is switched on.

#### Establishing the Position Data Reference, Drive-Controlled

For establishing the position data reference in a drive-controlled way, the position data reference is automatically established by the drive by master-side triggering of a command. The procedure depends on the kind of measuring system:

- In the case of a relative measuring system without distance-coded reference marks, the axis moves to the reference point or to a dedicated point and then automatically switches to axis-related actual position values.
- In the case of a relative measuring system with distance-coded reference marks, the axis moves between two reference marks and then automatically switches to axis-related actual position values.
- In the case of an absolute measuring system, the automatic switching to the axis-related actual position value is carried out with the axis in standstill.

The presettings for establishing the position data reference are made via assigned parameters.

#### Establishing the Position Data Reference, NC-Controlled

For establishing the position data reference in an NC-controlled way, the drive makes available three commands to the master. The master has to generate the travel motion for searching the mark:


- The master starts the command "NC-controlled homing" and for searching the reference point or dedicated point of the axis has to move the axis by inputting command values.
- To calculate the offset and switch to axis-related actual position values it is necessary to start further commands.

The presettings for establishing the position data reference are made via assigned parameters.

#### Displaying the Position Data Reference

A position status parameter shows whether the position data reference of a measuring system evaluated by the controller has been established.

## Motor, Mechanical Axis System, Measuring Systems

<b>Motor Encoder and External Encoders</b>	<p>In addition to the motor encoder an external (optional) encoder can be available. Both encoders, in any combination of relative and absolute measuring systems, can</p> <ul style="list-style-type: none"> <li>• have position data reference to the axis independently of each other (both encoders have different actual position values)</li> </ul> <p>- or -</p> <ul style="list-style-type: none"> <li>• have position data reference to the axis depending on each other (both encoders have the same actual position values).</li> </ul> <p>This is configured via parameters and realized with the commands for establishing the position data reference.</p>
<b>Actual Position Value Offset</b>	<p>The difference of the actual position value before and after establishing the position data reference is displayed, related to the motor encoder or external encoder, in one parameter respectively.</p> <p>See also the following sections:</p> <ul style="list-style-type: none"> <li>• "Establishing Position Data Reference for Absolute Measuring Systems"</li> <li>• "Establishing Position Data Reference for Relative Measuring Systems"</li> </ul>
<b>Pertinent Parameters</b>	<ul style="list-style-type: none"> <li>• S-0-0115, Position feedback 2 type</li> <li>• S-0-0175, Offset parameter 1</li> <li>• S-0-0176, Offset parameter 2</li> <li>• S-0-0277, Position feedback 1 type</li> <li>• S-0-0403, Position feedback value status</li> <li>• P-0-0074, Encoder type 1 (motor encoder)</li> <li>• P-0-0075, Encoder type 2 (optional encoder)</li> </ul>
<b>Functional Description</b>	
<b>Encoder Types Supported</b>	<p>IndraDrive controllers can evaluate a multitude of standard position encoders. The encoder types that can be evaluated are listed in the descriptions of the following parameters (see documentation "Parameter Description"):</p> <ul style="list-style-type: none"> <li>• P-0-0074, Encoder type 1 (motor encoder)</li> <li>• P-0-0075, Encoder type 2 (optional encoder)</li> </ul>
<b>Procedures for Establishing the Position Data Reference</b>	<p>The kind of encoder and the travel range that has been set (S-0-0278) determine whether absolute evaluation is possible for this encoder. This is displayed by the respective bits of the following parameters:</p> <ul style="list-style-type: none"> <li>• S-0-0277, Position feedback 1 type</li> <li>• S-0-0115, Position feedback 2 type</li> </ul> <p>Depending on relative or absolute evaluation of the motor encoder or external encoder, the controller makes available different procedures for establishing the position data reference:</p> <ul style="list-style-type: none"> <li>• "Set absolute measuring" for encoders to be evaluated in absolute form</li> <li>• "Drive-controlled homing procedure" for relative encoders</li> <li>• "NC-controlled homing procedure" for relative encoders</li> </ul>
<div style="display: flex; align-items: flex-start;"> <div style="margin-right: 10px;">  </div> <div> <p>After having successfully established the position data reference, the actual position value of the respective encoder refers to the axis. The encoder then is 0 "in reference" or has been "homed".</p> </div> </div>	

See also "Absolute Measuring Systems" and "Relative Measuring Systems"

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**Status Check of Position Data Reference**

The current status of the position data reference of motor encoder and external encoder is displayed in parameter "S-0-0403, Position feedback value status" via the respective bits. They can be mapped to the drive status word (S-0-0135) by means of assignment. This enables the master to check the validity of the position data in every communication cycle!



The following applies to masters which check the validity of the actual position values via bit 0 of S-0-0403:

- The "encoder selection" in "S-0-0147, Homing parameter" determines the value of the respective position status bit of which encoder is mapped to bit 0 of S-0-0403!

**Position Data Reference with Motor Encoder and External Encoder**

If an external encoder is connected to the controller in addition to the motor encoder, there are the following possibilities for establishing the position data reference, independent of the evaluation (relative/absolute) of the encoder:

- The position data reference was only established for one of the two encoders. The actual position value of the other, non-homed encoder is set to the value of the homed encoder.
- The position data reference was established for both encoders. The actual position value of each encoder is an individual value that can be identical, but does not need to be identical.

Encoder evaluation		Current position status	Actual position values when switching on		Notes on the commissioning status
Motor encoder	External encoder	(S-0-0403, bit ..2,1,0)	Motor encoder (S-0-0051)	External encoder (S-0-0053)	
relative/absolute	relative/absolute	0b ... 01x	Absolute value motor encoder	Absolute value motor encoder	Position data reference only established for motor encoder.
relative/absolute	relative/absolute	0b ... 10x	Absolute value ext. encoder	Absolute value ext. encoder	Position data reference only established for external encoder.
relative/absolute	relative/absolute	0b ... 11x	Absolute value motor encoder	Absolute value ext. encoder	Position data reference established for motor encoder and external encoder.
relative/absolute	relative/absolute	0b ... 000	See "Absolute Measuring Systems" or "Relative Measuring Systems"		Position data reference was established neither for motor encoder nor for external encoder.

Fig.5-54: Actual Position Values After Establishing the Position Data Reference for Motor Encoder and External Encoder

**Actual Position Value Offset Before/After Establishing Position Data Reference**

When the position data reference was established for an encoder there mostly is a step change of the actual position value. The difference between the new and the old actual position value is displayed in the following parameters:

- S-0-0175, Offset parameter 1
- S-0-0176, Offset parameter 2 (external encoder)

The respective values are written to the offset parameters each time the position data reference is established. After the drive was switched on the value, however, is undefined, even if the position data reference has already been established!

## Notes on Commissioning

### Checking the Possibility of Absolute Encoder Evaluation

The possibility of absolute evaluation of motor encoder or external encoder is displayed by the respective bits of the following parameters:

- S-0-0277, Position feedback 1 type (motor encoder)
- S-0-0115, Position feedback 2 type (external encoder)

### Checking Whether Position Data Reference was Established

The position status of motor encoder and external encoder is displayed in:

- S-0-0403, Position feedback value status

If required by the master, the position status of one of the two encoders can be mapped to bit 0 of S-0-0403. This is done by setting the bit for encoder selection in "S-0-0147, Homing parameter"..



If

- on the master side the validity of the actual position values is checked via bit 0 of S-0-0403

and

- motor encoder and external encoder have been homed, the encoder selection in S-0-0147, in the position-controlled modes, should also be changed accordingly when changing the position encoder.

### Actual Position Value Offset

The change in the actual position value by establishing the position data reference is displayed in the following parameters:

- S-0-0175, Offset parameter 1 (motor encoder)
- S-0-0176, Offset parameter 2 (external encoder)

### Mapping the Position Reference Bits to the Drive Status Word

The respective bits of parameter "S-0-0403, Position feedback value status" can be assigned to the real-time status bits of "S-0-0135, Drive status word", if required.

### Clearing the Position Data Reference

By activating parameter "S-0-0191, C1500 Cancel reference point procedure command" it is possible to clear the position data reference of the encoder selected via bit 3 of "S-0-0147, Homing parameter". The respective bits of parameter "S-0-0403, Position feedback value status" are thereby reset (cleared), too.

## Establishing Position Data Reference for Absolute Measuring Systems (Set Absolute Measuring)

### Brief Description



**Base package** of all variants in **closed-loop** characteristic

See also section "General Information on Establishing the Position Data Reference"

The position data reference of an absolute measuring system to the axis has to be established once during initial commissioning, after replacing the motor or encoder (motor encoder or external encoder) and changes in the mechanical axis system.

### Establishing Position Data Reference via Drive Commands

In the case of measuring systems to be evaluated in absolute form, the position data reference is automatically established by the drive by starting the "set absolute measuring" command.

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In the case of measuring systems to be evaluated in absolute form, the position data reference can be automatically established by the drive by starting the command

- "Set absolute measuring"

- or -

- "Drive-controlled homing procedure".

The position data reference once established is maintained until one of the two commands is started again. The actual position values therefore are axis-related ("homed") immediately after the drive is switched on.

**Motor Encoder and External Encoder**

If two absolute measuring systems have been connected to the controller, the position data reference can be separately established for both measuring systems. If the position data reference was only set for one of the measuring systems, both actual position values are equal at the position at which the position data reference was established.



If the position data reference was only set for one encoder, the actual position values of both encoders remain equal as long as mechanical axis system and encoder systems are mechanically connected without slip (slip control is possible!).

**"Set Absolute Measuring" Command**

It is recommended to start the "set absolute measuring" command when the axis is in standstill without drive enable. In the cases in which the axis, for establishing the position data reference, is to be brought to a defined position on the master side and be held in this position by the drive, "set absolute measuring" can also be executed with active drive.

**"Drive-Controlled Homing Procedure" Command**

When the command "drive-controlled homing procedure" (without previous start of "set absolute measuring") is started, the drive automatically moves the axis to a dedicated position, defined by a home switch and/or the zero position of the absolute encoder, and at this position establishes the position data reference.

For absolute encoders, the command "drive-controlled homing procedure" can be advantageously used after loss of position data reference after:

- encoder replacement in conjunction with a home switch,
- encoder error with peripheral causes in the case of modulo-scaled axes (e.g. encoder cable damage).



"Active drive" means the drive that is in control. Drive enable ("AF") has been set.

**Assigning the Axis-Related Actual Position Value with "Set Absolute Measuring"**

By starting the "set absolute measuring" command the previous actual position value of an encoder at a dedicated position of the axis is set to a new value. This value is the current axis position related to the coordinate system of the machine.

The dedicated position is defined by:

- the current axis position

- or -

- The positioning of the axis at a "striking" axis position (e.g. value "0")

The required assignments and configurations for "setting absolute measuring" are realized via parameter settings.

**Assigning the Axis-Related Actual Position Value With "Drive-Controlled Homing Procedure"**

By starting the "drive-controlled homing procedure" command the previous actual position value of an encoder at a dedicated position of the axis is set to a new value. This value is the current axis position related to the coordinate system of the machine.

## Motor, Mechanical Axis System, Measuring Systems

The required assignments and configurations for "drive-controlled homing" are realized via parameter settings (see information on "Drive-Controlled Homing Procedure" in section "Establishing Position Data Reference for Relative Measuring Systems").

- Pertinent Parameters**
- S-0-0052, Reference distance 1
  - S-0-0054, Reference distance 2
  - P-0-0012, C0300 Set absolute position procedure command
  - P-0-0177, Absolute encoder buffer 1 (motor encoder)
  - P-0-0178, Absolute encoder buffer 2 (optional encoder)
  - P-0-0612, Set absolute position control
  - P-0-1002, Absolute encoder offset 1, encoder memory
  - P-0-1012, Absolute encoder offset 2, encoder memory

- Pertinent Diagnostic Messages**
- C0300 Set absolute position procedure command
  - C0301 Measuring system unavailable
  - C0302 Absolute evaluation of measuring system impossible
  - C0303 Absolute encoder offset cannot be saved

### Functional Description

#### "Drive-Controlled Homing Procedure" Command With Absolute Measuring Systems

The command "drive-controlled homing procedure" is mainly used for homing relative measuring systems. The position data reference of a relative encoder must be reestablished each time the drive is switched on again (or when changing from communication phase "P2" to "bb" or "Ab").



The function "Drive-Controlled Homing Procedure" is described in section "Establishing Position Data Reference for Relative Measuring Systems".

**Application Aspect, Requirement** In the case of absolute measuring systems, the position data reference to the axis only has to be established once during initial commissioning (or after encoder replacement or encoder error, for example). If "S-0-0148, C0600 Drive-controlled homing procedure command" is to be used for homing an absolute measuring system, the corresponding bit must have been set in parameter "P-0-0612, Set absolute position control".

**Absolute Offset** When "C0600 Drive-controlled homing procedure command" was successfully completed, an absolute offset value could be determined. This value is used for calculation together with the encoder-side absolute values, stored in the encoder and the reference bit is set in parameter "S-0-0403, Position feedback value status". The position data reference has now been established and the actual position value is valid. This, too, applies immediately each time after the drive has been switched on again.

#### "Set Absolute Measuring" Command

**Dedicated Position** By starting the "set absolute measuring" command the previous actual position value of an encoder at a dedicated position of the axis is set to a new value. The dedicated position corresponds to the current axis position at the start of the command.

The new actual position value at the dedicated position after "set absolute measuring" is the value of parameter

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- S-0-0052, Reference distance 1 (for motor encoder)
- or -
- S-0-0054, Reference distance 2 (for external encoder).

Motor encoder	S-0-0051 <sub>new</sub>	=	S-0-0052
External encoder	S-0-0053 <sub>new</sub>	=	S-0-0054

S-0-0051 Position feedback 1 value  
 S-0-0052 Reference distance 1  
 S-0-0053 Position feedback 2 value  
 S-0-0054 Reference distance 2

Fig. 5-55: Actual Position Values After "set Absolute Measuring"

**Selecting the Absolute Encoder to be Homed**

If several encoders to be evaluated in absolute form are connected to the controller, it is possible to select, via "P-0-0612, Set absolute position control", the encoder for which the "set absolute measuring" command is to take effect.

**Storing the Absolute Encoder Offset**

In order that an encoder to be evaluated in absolute form maintains the position data reference to the axis after "set absolute measuring", the absolute encoder offset is stored in the encoder data memory (P-0-1002/P-0-1012) and in the parameter memory (P-0-0177/P-0-0178).



Storing the absolute encoder offset in the encoder data memory and in the parameter memory allows recognizing whether the absolute encoder that was homed was replaced!

**Possible Operating States Before "Set Absolute Measuring"**

The "set absolute measuring" command can be activated in the following operating states:

- Drive is ready for operation, but not active ("AB")
- Drive is active in position control ("AF")
- Drive is active and in "Drive HALT" ("AH")

**"Set Absolute Measuring" Procedure**

When the "set absolute measuring" command is started, the reference of the selected encoder is cleared first (S-0-0403).

**... With Inactive Drive ("AB") or in "Drive Halt (AH)"**

After the reference was cleared, the new actual position value (S-0-0051/S-0-0053), with inactive drive ("AB" or "bb") and with drive in "Drive HALT (AH)", is set according to the preselected dedicated position (see formula "Actual position values after "set absolute measuring"). The new position reference takes immediate effect.

**... with Drive Enable ("AF")**

After the reference was cleared, there are the following possibilities, with active drive, regarding the switching of the actual position value to the new position reference:

- Deactivating drive enable
  - When the drive goes to the inactive state, the new actual position value (S-0-0051/S-0-0053) is set according to the preselected dedicated position (see formula "Actual position values after "set absolute measuring").
- Starting the "drive-controlled homing procedure" command:
  - The drive no longer follows the command values. The new position command value (S-0-0051/S-0-0053) is set (see formula "Actual position values after "set absolute measuring") and the "drive-controlled homing procedure" command is signaled by the drive to have been executed. The master now has to "synchronize" to the new actual position value of the encoder used in the active operating mode. After the master cleared the



"drive-controlled homing procedure" command, the drive returns to master-controlled operation.

...After Position Reference Has Been Established

When the new position reference of the selected encoder has been established, the reference of the respective encoder is displayed in "S-0-0403, Position feedback value status" and the absolute encoder offset is stored. Finally, the "set absolute measuring" command has to be cleared by the master!

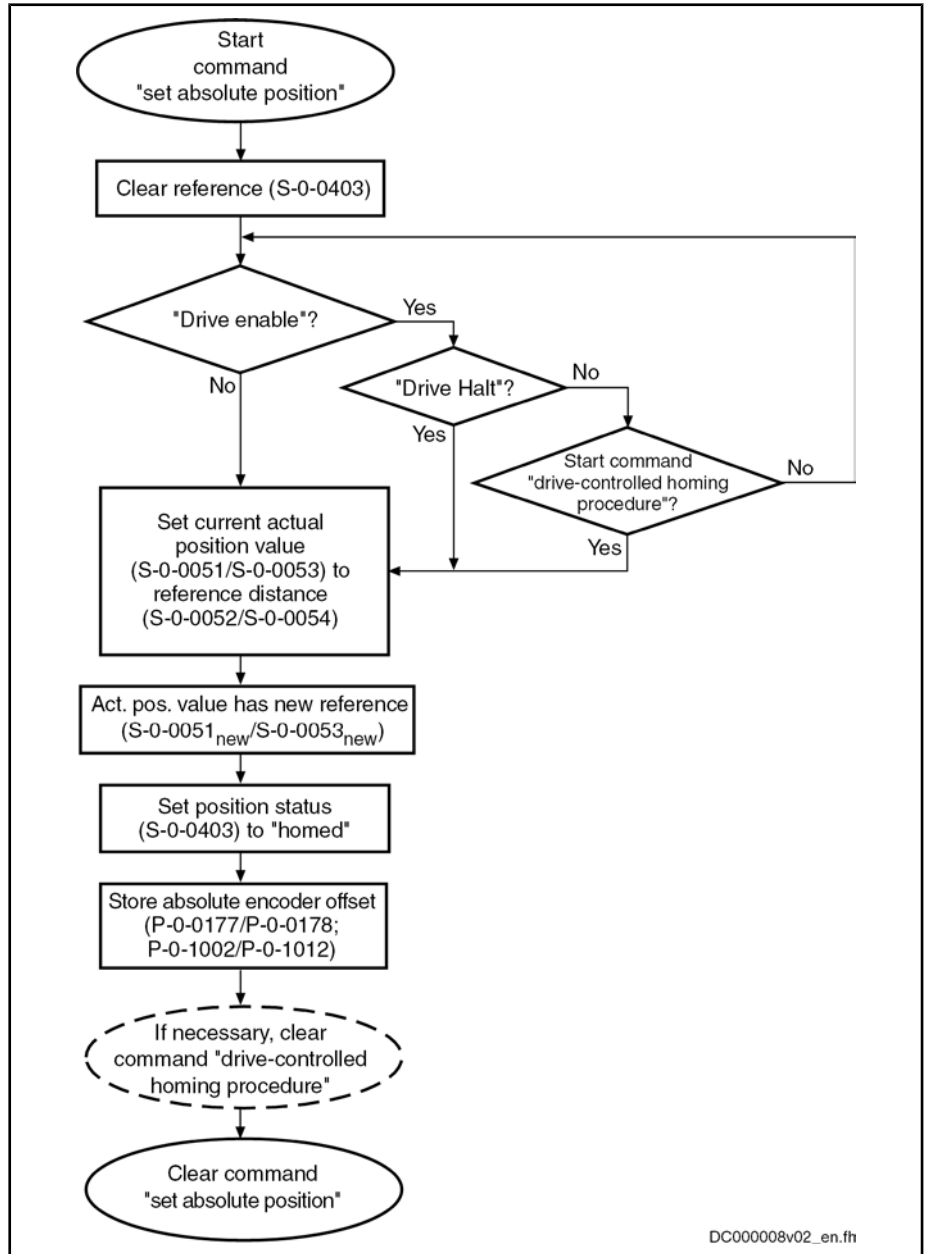


Fig.5-56: Sequence of "set Absolute Measuring" Command Execution

**Notes on Commissioning**

See also Notes on Commissioning for "General Information on Establishing the Position Data Reference"

Checking the Possibility of Absolute Encoder Evaluation

The possibility of absolute evaluation of motor encoder and external encoder is displayed by the respective bits of

- S-0-0277, Position feedback 1 type (motor encoder)

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- or -

- S-0-0115, Position feedback 2 type (external encoder).

See also "Absolute Measuring Systems" and "Relative Measuring Systems"

**Presetting**

Make the presetting for "set absolute measuring" by determining the encoder for "set absolute measuring" in "P-0-0612, Set absolute position control". Also set in this parameter whether the execution of "S-0-0148, C0600 Drive-controlled homing procedure command" is to be possible with absolute measuring system.

See Notes on Commissioning for "Drive-Controlled Homing Procedure" in section "Establishing Position Data Reference for Relative Measuring Systems"

**"Set Absolute Measuring" Start**

Start command "P-0-0012, C0300 Set absolute position procedure command".

See also "Command Processing"

**Starting "Drive-Controlled Homing Procedure", if Necessary**

If "set absolute measuring" is to be carried out with active drive, you either have to start the command "S-0-0148, C0600 Drive-controlled homing procedure command" or bring the drive to the status "Drive HALT" (AH) to switch the actual position value. Removing drive enable (inactive drive), too, causes the actual position value to be switched (see fig. "Sequence of "set Absolute Measuring" Command Execution").

See also "Command Processing"

**Checking Whether Position Data Reference was Established**

The respective bit of parameter "S-0-0403, Position feedback value status" displays whether the encoder selected via S-0-0612 has been homed.



If the absolute encoder had already been homed, the respective bit only changes for a short time during command execution!

When "set absolute measuring" was executed again for an absolute encoder, a value for the "offset" of the actual position values before and after command execution is entered in:

- S-0-0175, Offset parameter 1 (motor encoder)
- S-0-0176, Offset parameter 2 (external encoder)

**Clearing the Executed Commands**

After the commands have been executed (diagnosis possible via parameter "S-0-0403, Position feedback value status"), the commands started have to be cleared again in reverse order when "set absolute measuring" is carried out via command "drive-controlled homing procedure".

**Detecting Encoder Replacement**

If an absolute encoder was replaced, the following error message is generated:

- F2074 Actual pos. value 1 outside absolute encoder window

- or -

- F2075 Actual pos. value 2 outside absolute encoder window

The position data reference has to be established again!

**Establishing Position Data Reference for Relative Measuring Systems (Homing)**

**Brief Description**



**Base package** of all firmware versions in **closed-loop** characteristic.

See also section "General Information on Establishing the Position Data Reference"

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<b>Actual Position Value of Relative Measuring Systems when Switching On</b>	<p>After the drive is switched on the actual position values signaled by relative measuring systems do not yet have any reference to the machine axis. Measuring systems can be installed at the motor (motor encoder) and directly at the mechanical axis system (external or optional encoder).</p>
<b>Establishing the Position Data Reference, Drive-Controlled</b>	<p>For information on encoder arrangement and mechanical axis system see also "Mechanical Axis System and Arrangement of Measuring Systems"</p> <p>The position data reference of relative measuring systems to the axis has to be established again each time after the drive was switched on or after all procedures that cause the position data reference to get lost (homing procedure).</p>
<b>Establishing the Position Data Reference, NC-Controlled</b>	<p>After start of the respective command by the master, the drive can automatically establish the position data reference.</p> <p>To do this, the drive moves the axis until the controller can detect a dedicated point. The actual position values then are automatically switched to axis reference. The presettings for the sequence for establishing the position data reference are made via assigned parameters.</p>
<b>Dedicated Point for Establishing the Position Data Reference</b>	<p>As an alternative to establishing the position data reference in a drive-controlled way, the NC ("master") can control the homing procedure.</p> <p>In this case the master inputs the command values for moving the axis to the dedicated point and controls the homing procedure via commands and assigned parameters.</p> <p>The NC-controlled homing procedure can be advantageous for drives with a rigid mechanical connection (e.g. for Gantry axes), because the master can input coordinated command values for the drives for the homing motion.</p>
<b>Reference Mark for Relative Measuring Systems</b>	<p>The dedicated point for establishing the position data reference, in the case of linear axes, is at one end of the travel range. This allows finding the dedicated point from any axis position (situation when switched on) by moving in a defined direction. Rotary axes do not have an axis end position, the dedicated point is at a defined position within the travel range.</p>
<b>Reference Mark and Home Switch</b>	<p>The precision with which this dedicated point is detected considerably influences the absolute precision of the axis. Apart from the signals for position detection, relative measuring systems therefore also provide a signal for exact determination of a dedicated point. This signal is called "reference marker". Depending on their type, relative measuring systems have one or several reference marks over the range of measurement.</p>
<b>Dedicated Point and Reference Point of an Axis</b>	<p>Especially in the case of rotary measuring systems (e.g. motor encoder) at axes moved in a linear way, the reference mark of the encoder can occur several times over the entire travel range. In this case it is required, by axis-side activation of a switch contact at the end of the travel range, to identify <b>one</b> reference mark signal. This defines an unequivocal dedicated point that can be found with reproducible precision. This operating status is called "home switch". A possibly available travel range limit switch can be used like a home switch, too.</p> <p>In addition, a reference mark signal can be identified by detecting axis blocking when positive stop at the end of the axis has been reached.</p> <p>Independent of the number of reference marks over the travel range, an axis-side additional device (home switch or travel range limit switches or positive stop), is indispensable for linear axes for detecting the axis end position!</p> <p>If only one reference mark occurs over the travel range in the case of rotary axes, the home switch in most cases is not required!</p> <p>The dedicated point identified by an encoder reference mark and, if necessary, by a home switch, in most cases is not identical to the reference point of the axis. The distance between reference point and zero point normally is determined on the machine side. Especially in the case of serial machines, this</p>

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distance should be equal for axes of the same kind. The position of the dedicated point, however, is influenced by the kind of encoder arrangement and therefore differs from axis to axis.

**Reference Offset** The position difference between dedicated point and reference point of the axis can be compensated by an offset value (reference offset).

See also section "General Information on Establishing the Position Data Reference"

**Pertinent Parameters** Parameters for relative measuring systems:

- S-0-0041, Homing velocity
- S-0-0042, Homing acceleration
- S-0-0052, Reference distance 1
- S-0-0054, Reference distance 2
- S-0-0108, Feedrate override
- S-0-0147, Homing parameter
- S-0-0148, C0600 Drive-controlled homing procedure command
- S-0-0150, Reference offset 1
- S-0-0151, Reference offset 2
- S-0-0173, Marker position A
- S-0-0174, Marker position B
- S-0-0191, C1500 Cancel reference point procedure command
- S-0-0298, Reference cam shift
- S-0-0299, Home switch offset
- S-0-0349, Bipolar jerk limit
- S-0-0400, Home switch
- S-0-0403, Position feedback value status
- P-0-0153, Optimum distance home switch-reference mark

Parameters for NC-controlled homing:

- S-0-0146, C4300 NC-controlled homing procedure command
- S-0-0171, C4400 Calculate displacement procedure command
- S-0-0172, C4500 Displacement to referenced system procedure command
- S-0-0175, Offset parameter 1
- S-0-0176, Offset parameter 2
- S-0-0404, Position command value status
- S-0-0407, Homing enable
- S-0-0408, Reference marker pulse registered

Parameters for relative measuring systems, distance-coded:

- S-0-0165, Distance-coded reference offset A
- S-0-0166, Distance-coded reference offset B
- S-0-0177, Absolute offset 1
- S-0-0178, Absolute offset 2

Parameters for homing at travel range limit switches:

- P-0-0090, Travel range limit parameter

- P-0-0222, Travel range limit switch inputs

Parameters for homing at positive stop:

- S-0-0082, Torque/force limit value positive
- S-0-0083, Torque/force limit value negative
- S-0-0092, Bipolar torque/force limit value
- S-0-0124, Standstill window
- S-0-0331, Status "n\_feedback = 0"
- S-0-0333, Status "T >= Tx"

#### Pertinent Diagnostic Messages

Diagnostic messages for drive-controlled homing:

- C0600 Drive-controlled homing procedure command
- C0601 Homing only possible with drive enable
- C0602 Distance home switch - reference mark erroneous
- C0604 Homing impossible with absolute encoder
- C0606 Reference mark not detected
- C0607 Home switch input not assigned

Diagnostic messages for NC-controlled homing:

- C4302 Distance home switch - reference mark erroneous
- C4304 Homing impossible with absolute encoder
- C4306 Reference mark not detected
- C4307 Home switch input not assigned
- C4308 Pos. stop a. HW lim. switch not allowed f. modulo axes
- C4400 Calculate displacement procedure command

### Functional Description

#### General Information

#### Type and Arrangement of Reference Marks

With regard to the type and arrangement of the reference marks, relative measuring systems can be divided into 4 groups:

- **Group 1**
  - Single-turn measuring systems with absolute range, such as single-turn HSF or resolvers. These measuring systems have an absolute position measuring range of one encoder revolution or parts of one encoder revolution (resolver) and do not have their own reference mark signal. The controller, however, recognizes the zero position (0 dgr) of the actual position value as the reference mark signal.
  - These properties apply to:
    - Single-turn motor encoders of Rexroth motors of the MHD, MKD, MKE, MSK, MSH, MAD and MAF lines
    - GDS measuring system from Bosch Rexroth
    - Single-turn encoder from Heidenhain (with EnDat interface)
- **Group 2**
  - Incremental rotary measuring systems with one reference mark per encoder revolution, such as the ROD or RON types from Heidenhain
- **Group 3**

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→ Incremental linear measuring systems with one or several reference marks, such as the LS linear scales from Heidenhain

- **Group 4**

→ Incremental measuring systems with distance-coded reference marks, such as the LSxxxC linear scales from Heidenhain

For measuring systems with distance-coded reference marks, see also "Relative Measuring Systems"!

#### Action of the Axis Drive to Establish Position Data Reference

In order to establish the position data reference of relative measuring systems through an automated sequence, the drive has to be able to identify an unequivocal dedicated point within the travel range of the axis. To do this, the axis has to carry out the following motion (drive-controlled or NC-controlled):

- Pass the dedicated point (encoders of group 1, 2 or 3)

- or -

- Pass two neighboring distance-coded reference marks (encoders of group 4)

For example for manual purposes, the position data reference of a relative measuring system (group 1, 2, 3) can also be established without identifying the dedicated point, i.e. without motion, if the precise axis position of the axis slide in standstill or locked in place. In this case neither the reference marker of the encoder nor an axis-side additional device (home switch) are required. Via command "S-0-0148, C0600 Drive-controlled homing procedure command" the position data reference can be established with the drive being in standstill and inactive (without AF).



In this connection, adequate values have to be selected for the reference distance and the reference offset!

---

#### Motion Range for Homing

The motion range required for homing depends on the encoder used:

- For encoders of group 1, 2 or 3 motion over the entire travel distance of the axis can be required.
- For encoders of group 4, the axis as a maximum has to move over the double reference mark distance (see below "Motion Range for Homing Encoders with Distance-Coded Reference Marks").



For encoders of group 4 it is possible to calculate the position of the dedicated point on the basis of the detected position difference of two neighboring distance-coded reference marks!

---

#### Identifying a Dedicated Point

To identify a dedicated point of an axis the following signals can be used:

- Reference marks of the encoder
- Home switch at the axis
- Travel range limit switches
- Axis blocking when positive stop at the end of travel range has been reached (positive stop detection)

The reference mark signal of an encoder is generally used for detecting the position of the dedicated point because this signal allows detecting the position within the scope of the encoder precision.

Depending on the encoder type and the mechanical arrangement of the encoder in the mechanical drive system, reference mark signals can occur **once or several times** within the travel range of an axis.

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If the reference marks occur several times, only one reference mark signal may determine the dedicated point at unequivocal axis position. Identifying a mark signal requires one of the following axis-side additional devices:

- Travel range limit switches
- Home switch (if there isn't any travel range limit switch available)
- Positive stop at the end of the axis (if there isn't any switch to be used)



The mentioned axis-side additional devices are also used for detecting the end of the axis during the homing procedure.

Relative encoder of ...	Number of reference mark signals occurring over the travel range			
	One signal		Several signals	
	Rotary axis	Linear axis	Rotary axis	Linear axis
... group 1, 2 (rotary encoder)	AD: No	AD: Yes	AD: Yes (home switch)	AD: Yes
... group 3 (linear encoder)	---	AD: Yes	---	AD: Yes
... group 4 (rotary/linear encoder)	---	---	AD: No	AD: Yes

AD Additional device

Fig. 5-57: Recommendation for Axis-Side Additional Devices (AD) for Determining the Dedicated Point

In "S-0-0147, Homing parameter" select which signals are to be evaluated by the controller for determining the dedicated point (reference marks and/or home switches, travel range limit switches or positive stop).



If there isn't any reference mark signal available on the encoder side, the edge reversal of the home switch signal or the travel range limit switch signal or the detection of positive stop can also be used for detecting the dedicated point. This has to be set in S-0-0147 by deactivating the reference mark evaluation (only possible with drive-controlled homing!).

**Reference Point, Axis Zero Point and Dedicated Point for Encoders of Groups 1, 2, 3**

The axis zero point and the reference point are positions determined on the machine side. The position of the dedicated point ideally is identical to the reference point, the position of the dedicated point, however, mostly is influenced by the encoder arrangement. The position difference between reference point and dedicated point is transmitted to the controller via the so-called reference offset.

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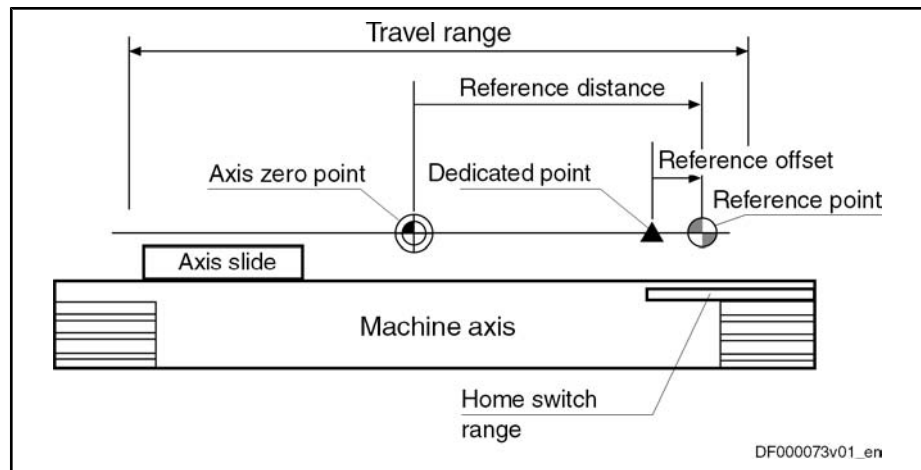


Fig.5-58: Example of Positions of Axis Zero Point, Dedicated Point and Reference Point for Encoders of Groups 1, 2, 3

As the position data reference can be established both for the motor encoder and for the external encoder, there is one independent parameter available for the respective reference offset of both encoders:

- S-0-0150, Reference offset 1 (motor encoder)
- S-0-0151, Reference offset 2 (external encoder)

The reference distance is the distance between the reference point and the axis zero point. There is one independent parameter available for the respective reference distance of both encoders:

- S-0-0052, Reference distance 1 (motor encoder)
- S-0-0054, Reference distance 2 (for external encoder)

**Axis Zero Point, Encoder Zero Point and Dedicated Point for Encoders of Group 4**

For distance-coded measuring systems (of group 4) the axis-side reference point is not used. The controller can calculate the position of the dedicated point (in this case the encoder zero point) on the basis of the detected position difference of two neighboring distance-coded reference marks. The position difference between axis zero point and encoder zero point is transmitted to the controller via the so-called absolute offset.

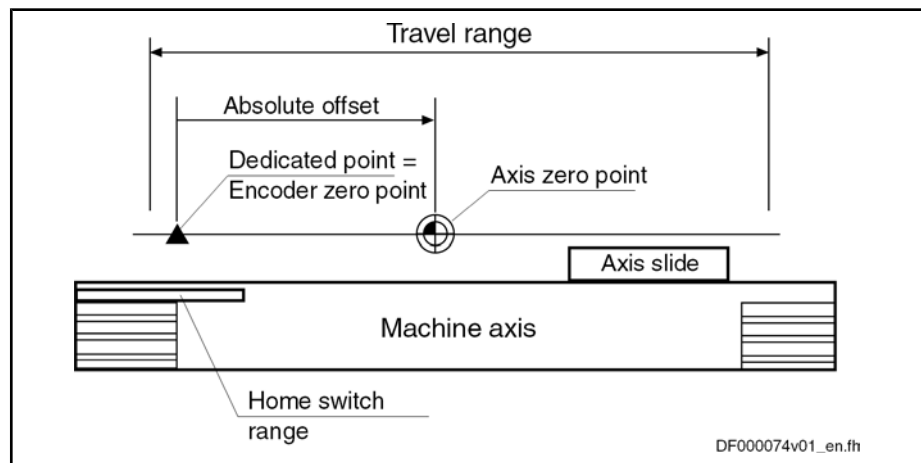


Fig.5-59: Example of Positions of Axis Zero Point and Dedicated Point for Encoders of Group 4

As motor encoder and external encoder can be realized as distance-coded measuring system and the position data reference can be established for both encoders, there is one parameters for the absolute offset available for each encoder:



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- S-0-0177, Absolute offset 1 (motor encoder)
- S-0-0178, Absolute offset 2 (external encoder)



Only one distance-coded measuring system can be connected!

**Motion Range for Encoders with Distance-Coded Reference Marks**

For the homing procedure, relative measuring systems with distance-coded reference marks require a motion range corresponding as a maximum to the double distance of two neighboring reference marks.

**Reference Mark Distance of Linear Encoders**

Distances of neighboring reference marks of encoders with distance-coded reference marks:

Motor encoder	$s_{\text{RefMarks}}$	=	S-0-0165	×	S-0-0116
External encoder	$s_{\text{RefMarks}}$	=	S-0-0165	×	S-0-0117

$s_{\text{RefMarks}}$  distance of neighboring reference marks  
 S-0-0165 Distance-coded reference offset A  
 S-0-0116 Feedback 1 Resolution  
 S-0-0117 Feedback 2 Resolution

Fig. 5-60: Distance of Neighboring Reference Marks of Linear Encoders with Distance-Coded Reference Marks

**Reference Mark Distance of Rotary Encoders**

Motor encoder	$s_{\text{RefMarks}}$	=	$\frac{\text{S-0-0165} \times 360^\circ}{\text{S-0-0116}}$
External encoder	$s_{\text{RefMarks}}$	=	$\frac{\text{S-0-0165} \times 360^\circ}{\text{S-0-0117}}$

$s_{\text{RefMarks}}$  distance of neighboring reference marks  
 S-0-0165 Distance-coded reference offset A  
 S-0-0116 Feedback 1 Resolution  
 S-0-0117 Feedback 2 Resolution

Fig. 5-61: Distance of Neighboring Reference Marks of Rotary Encoders With Distance-Coded Reference Marks

**Motion Range for Homing**

The actual motion range for homing the axis corresponds either

- to the distance of neighboring, distance-coded reference marks including the distance until detection of the first reference mark and the braking distance at the end of the homing procedure, when the option "stop" has been selected in S-0-0147:

Linear scaling	$s_{\text{Ref\_max}}$	=	$s_{\text{Ref\_1}} + s_{\text{RefMarks}} + \frac{v^2}{2 \times a}$
Rotary scaling	$s_{\text{Ref\_max}}$	=	$s_{\text{Ref\_1}} + s_{\text{RefMarks}} + \frac{\omega^2}{2 \times \alpha}$

$s_{\text{Ref\_max}}$  maximum motion range  
 $s_{\text{Ref\_1}}$  distance to the first reference mark  
 $s_{\text{RefMarks}}$  distance of neighboring reference marks  
 $v, \omega$  homing velocity (S-0-0041)  
 $a, \alpha$  homing acceleration (S-0-0042)

Fig. 5-62: Maximum Motion Range for Homing Encoders With Distance-Coded Reference Marks in Case of "Stop" (S-0-0147)

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The motion range for "stop" is between the single and double reference mark distance plus the braking distance!

- or -

- To the double reference mark distance plus the braking distance at the end of the homing procedure, when "run path" has been selected in S-0-0147:

Linear scaling	$s_{\text{Ref\_max}} = 2 \times s_{\text{RefMarks}} + \frac{v^2}{2 \times a}$
Rotary scaling	$s_{\text{Ref\_max}} = 2 \times s_{\text{RefMarks}} + \frac{\omega^2}{2 \times \alpha}$

$s_{\text{Ref\_max}}$	maximum motion range
$s_{\text{RefMarks}}$	distance of neighboring reference marks
$v, \omega$	homing velocity (S-0-0041)
$a, \alpha$	homing acceleration (S-0-0042)

Fig. 5-63: *Maximum Motion Range for Homing Encoders With Distance-Coded Reference Marks in Case of "Run Path" (S-0-0147)*



The motion range of the axis in the case of "run path" is always the same! This is advantageous for homing Gantry axes!

### Detecting the End of the Travel Range

When homing relative measuring systems, the axis always has to be moved in defined direction so that the dedicated point can be reliably identified. As a prerequisite the axis has to be within the allowed travel range.

But the axis, when the search of the dedicated point is started, can also already be at that end of the axis at which the dedicated point is situated. For fail-safe detection of the dedicated point the drive has to be able to recognize this situation. This is only possible by means of axis-side additional devices (AD):

- Home switch at end of axis
- Travel range limit switches
- Positive stop at end of axis for axis blocking (detection of positive stop)

One of these devices has to be mounted at the end of axis of the dedicated point their signals have to be evaluated by the drive controller.



For NC-controlled homing a home switch is obligatory! For NC-controlled homing, travel range limit switches and positive stop can neither be used for detecting the end of the travel range nor for identifying the dedicated point.

The status "activated" (switching logic) of home switch and travel range limit switch is set in the following parameters:

- "S-0-0147, Homing parameter" for the home switch ("edge evaluation ...")
- "P-0-0090, Travel range limit parameter" for the travel range limit switch ("signal behavior")

### Identifying the Dedicated Point by Means of Reference Mark and Home Switch

#### Home Switch for Selecting a Reference Mark

If several reference mark signals can occur over the travel distance of an axis and the dedicated point is to be determined by one of the marks (see table "Recommendation for Axis-Side Additional Devices (AD) for Determining the Dedicated Point"), a home switch can be used, for drive-controlled homing, as axis-side additional device for selecting a reference marker.

For using the NC-controlled homing an axis-side home switch is obligatory!

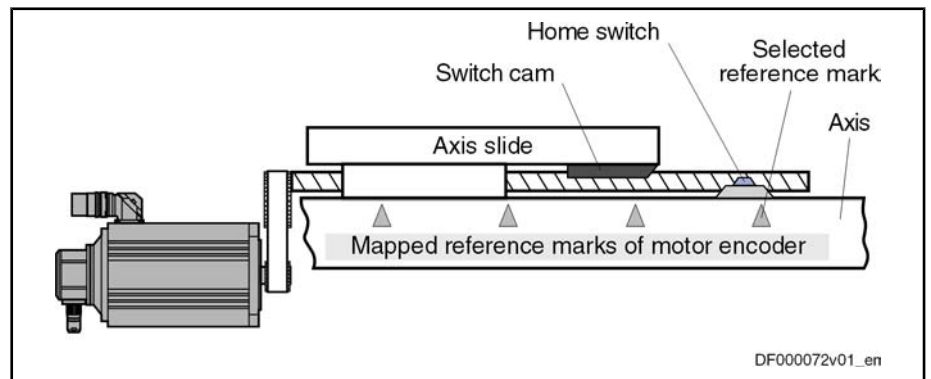


Fig.5-64: Selecting a Reference Mark via Home Switch in the Case of a Linear Axis

After the start of the drive-controlled or NC-controlled homing, the dedicated point is detected when the first reference mark signal occurs after the "activated" signal of the home switch.

#### Arranging the Home Switch

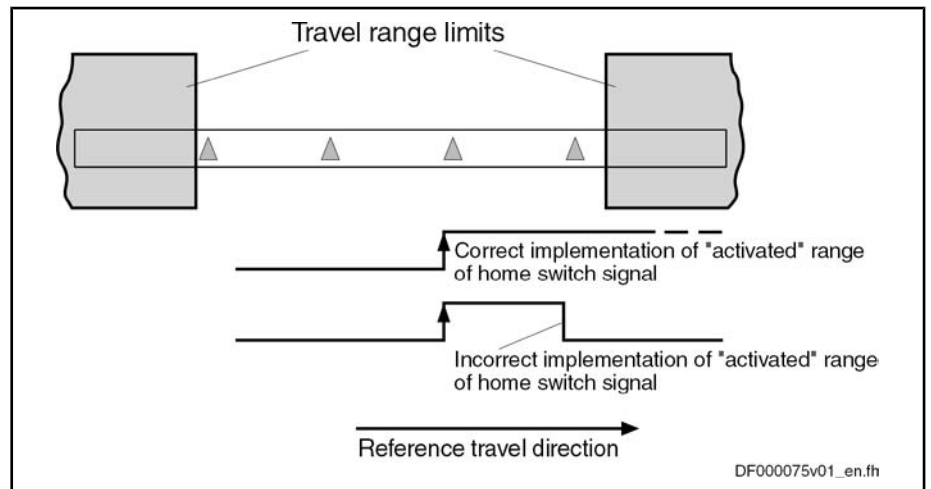


Fig.5-65: Arranging the Home Switch With Regard to Travel Range Limits in the Case of Linear Axes

In the case of linear axes, the "activated" range of the home switch has to reach beyond the next travel range limit. The home switch signal thereby indicates the proximity of the end of the travel range if the reference travel direction was appropriately selected. The travel range limit is not passed during the homing procedure when the "activated" range of the home switch signal begins with sufficient distance to the travel range limit!

#### Distance Dedicated Point – Travel Range Limit for Linear Axes with Home Switch

The distance between dedicated point (first reference mark after home switch signal) and travel range limit is sufficient, if the drive can safely shutdown the axis out of maximum homing velocity (S-0-0041 for drive-controlled homing) with homing acceleration (S-0-0042 for drive-controlled homing), within the


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travel range. The following applies to the minimum distance home switch-travel range limit:

$$x_{RS\_VbLimit} \geq x_{RefMarks} + \frac{v^2}{2 \times a}$$

- $x_{RS\_VbLimit}$  minimum distance to travel range limit
- $x_{RefMarks}$  distance of the reference marks occurred at the axis or reference distance (S-0-0165) for distance-coded measuring system
- $v$  homing velocity (value of S-0-0041 or preset by NC)
- $a$  homing acceleration (value of S-0-0042 or preset by NC)

Fig.5-66: Minimum Distance of Home Switch Signal to Travel Range Limit

 Generally, several reference marks may occur in the "activated" range of the home switch signal!

 For rotary axes a home switch is only required when a gear with a gear ratio unequal "1" was mounted between axis and motor shaft!

**Axis Position when Switching On, Detection of End of Travel Range**

When the axis drive is switched on, the moving part of the axis can be at any position within the travel range, but it can also be at the end of the travel range. The home switch mounted at the end of the axis can be activated.

It must be possible to carry out the homing procedure even from this start position:

- In the case of drive-controlled homing, the drive, independent of the signal status and the settings for the "activated" signal of the home switch, automatically passes the dedicated point.
- In the case of NC-controlled homing, the master has to set the required command values so that the dedicated point can be unequivocally detected.

**Searching for Dedicated Point for Non-Distance-Coded Encoder and Axis with Home Switch**

For axes with non-distance-coded encoders, the drive has to move the axis to the end of the axis in determined reference travel direction, in order to start the search for the dedicated point after the "activated" signal was detected. The end of the travel range is also detected via the signal status of the home switch.

Determined edge evaluation (S-0-0147)	Signal status of home switch (bit in S-0-0400)	Drive action
positive	0 ("Not activated")	motion in reference travel direction until home switch is activated, then search for dedicated point after positive signal edge was detected
negative	1 ("Not activated")	motion in reference travel direction until home switch is activated, then search for dedicated point after negative signal edge was detected

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Determined edge evaluation (S-0-0147)	Signal status of home switch (bit in S-0-0400)	Drive action
negative	0 ("Activated")	motion against reference travel direction until home switch is not activated, then reversal of motion; search for dedicated point after negative signal edge was detected
positive	1 ("Activated")	motion against reference travel direction until home switch is not activated, then reversal of motion; search for dedicated point after positive signal edge was detected

*Fig.5-67: Drive motions for search for dedicated point in the case of non-distance-coded measuring system and home switch, depending on the axis position (drive-controlled or NC-controlled)*

**Searching for Dedicated Point for Distance-Coded Encoder and Axis with Home Switch**

For axes with distance-coded encoder, the drive has to move the axis over two neighboring distance-coded reference marks in order to find the dedicated point:

- For drive-controlled homing, if the drive has not yet detected any or only one reference mark when the home switch is activated, it changes the direction of motion. The position data reference is established over the next two detected reference marks.
- For NC-controlled homing, the drive stores the non-homed position of the first detected reference mark in "S-0-0173, Marker position A", the non-homed position of the neighboring reference mark is stored in "S-0-0174, Marker position B".

If at the start of the homing procedure the axis is already at the end of the travel range and the home switch is detected as having been "activated", a command value has to be generated that leads the axis back to the allowed travel range:

- For drive-controlled homing, the drive moves the axis against the determined reference travel direction and over the next two distance-coded reference marks determines the axis position relative to the dedicated point.
- For NC-controlled homing, the master-side command value has to move the axis against the reference travel direction determined in the NC. The next two distance-coded reference marks are evaluated for determining the dedicated point.

Signal status of home switch (S-0-0400)	Drive action
0 ("Not activated")	Motion for search of dedicated point in determined reference travel direction
1 ("Activated")	Motion for search of dedicated point against determined reference travel direction

*Fig.5-68: Drive Motions for Search for Dedicated Point in the Case of Distance-Coded Measuring System and Home Switch, Depending on the Axis Position (Drive-Controlled or NC-Controlled)*

**Connecting the Home Switch**

For drive-controlled homing, the home switch has to be connected to the assigned digital input of the control section of the drive controller. Observe the allowed signal levels! The signal status of the home switch is displayed in "S-0-0400, Home switch".

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For "NC-controlled homing", the obligatory home switch can be connected either to the drive controller or to the master (NC control unit)!

See "Digital Inputs/Outputs"

**Activating the Evaluation of Reference Marks and Home Switch**

The evaluation of the reference marks and the home switch signal have to be activated in the respective bit of "S-0-0147, Homing parameter". The evaluation of travel range limit switch and positive stop mustn't be activated at the same time!



If the evaluation of the reference marks has not been activated, the dedicated point is determined only by the signal of the home switch!

**Identifying the Dedicated Point by Means of Reference Mark and Travel Range Limit Switch**

**Travel Range Limit Switch for Selecting a Reference Mark**

A travel range limit switch, too, can be used as axis-side additional device (AD) for selecting a reference mark, if several reference mark signals can occur over the travel distance of an axis and the dedicated point is to be determined by one of the marks (see table "Recommendation for Axis-Side Additional Devices (AD) for Determining the Dedicated Point").

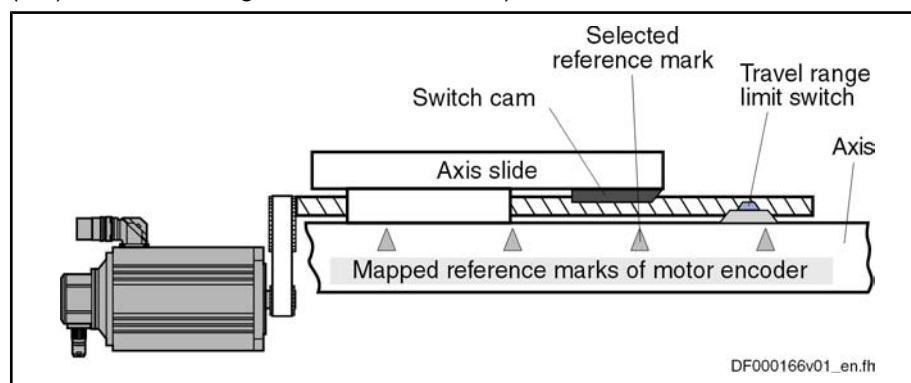


Fig.5-69: Selecting a Reference Mark via Travel Range Limit Switch

After the start of drive-controlled homing (command C0600), the axis is moved in determined direction of motion until the travel range limit switch is activated. The drive then changes the direction of motion, the dedicated point is detected when the first reference mark signal occurs.



If the travel range limit switches for hardware-side limitation of the allowed travel range have been activated, this monitoring function is deactivated during the homing procedure!

**Axis Position when Switching On; Detecting the End of the Travel Range**

When the axis drive is switched on, the moving part of the axis can be at any position within the travel range, but it can also be at the end of the travel range. The travel range limit switch mounted at the end of the axis can be activated.

It must be possible to carry out the homing procedure even from this start position. In the case of drive-controlled homing, the drive, independent of the signal status and the settings for the "activated" signal of the travel range limit switches, automatically passes the dedicated point.

**Searching for Dedicated Point for Non-Distance-Coded Encoder and Axis with Travel Range Limit Switch**

For axes with non-distance-coded encoders, the drive has to move the axis to the end of the axis in determined reference travel direction, in order to start the search for the dedicated point after a signal change of the travel range limit switch was detected.

Determined signal behavior of travel range limit switch (P-0-0090)	Signal status of travel range limit switch (P-0-0222)	Drive action
not inverted	0 ("Not activated")	motion in reference travel direction when limit switch activated, reversal of motion and search for dedicated point
inverted	1 ("Not activated")	as row above
inverted	0 ("Activated")	motion against reference travel direction until limit switch isn't activated, then search for dedicated point
not inverted	1 ("Activated")	as row above

*Fig. 5-70: Drive Motions for Search for Dedicated Point at Start of Command C0600 (in the Case of Non-Distance-Coded Measuring System and use of Travel Range Limit Switches), Depending on the Axis Position*

**Searching for Dedicated Point for Distance-Coded Encoder and Axis with Travel Range Limit Switch**

In order to find the dedicated point, the drive, for axes with distance-coded encoder, has to move the axis in the determined reference travel direction over two neighboring distance-coded reference marks.

If at the start of the drive-controlled homing procedure (command C0600) the axis is already at the end of the travel range and detects a travel range limit switch as having been "activated", a drive-internal command value is generated that leads back to the allowed travel range and the axis position relative to the dedicated point is determined over the next two reference marks.

Signal status of travel range limit switches (P-0-0222)	Drive action
0 ("Not activated")	Motion for search of dedicated point in reference travel direction
1 ("Activated")	Motion for search of dedicated point in direction of allowed travel range

*Fig. 5-71: Drive Motions for Search for Dedicated Point at Start of Command C0600 (in the Case of Distance-Coded Measuring System and use of Travel Range Limit Switches), Depending on the Axis Position*

**Connecting the Travel Range Limit Switches**

The travel range limit switches have to be connected to the assigned digital inputs of the control section of the drive controller. Observe the allowed signal levels! The signal status of the respective travel range limit switches is displayed in "P-0-0222, Travel range limit switch inputs":

See "Digital Inputs/Outputs"

**Activating the Evaluation of Reference Marks and Travel Range Limit Switch**

The evaluation of the reference marks and the travel range limit switch as additional devices for homing has to be activated in the respective bit of "S-0-0147, Homing parameter". The evaluation of home switch and/or positive stop mustn't be activated at the same time!



If the evaluation of the reference marks has not been activated, the dedicated point is determined only by the signal of the travel range limit switch!

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### Identifying the Dedicated Point by Means of Reference Mark and Positive Stop

#### Positive Stop for Selecting a Reference Mark

A positive stop at an axis, too, can be used as axis-side additional device (AD) for selecting a reference mark, if several reference mark signals can occur over the travel distance of an axis and the dedicated point is to be determined by one of the marks (see table "Recommendation for Axis-Side Additional Devices (AD) for Determining the Dedicated Point").

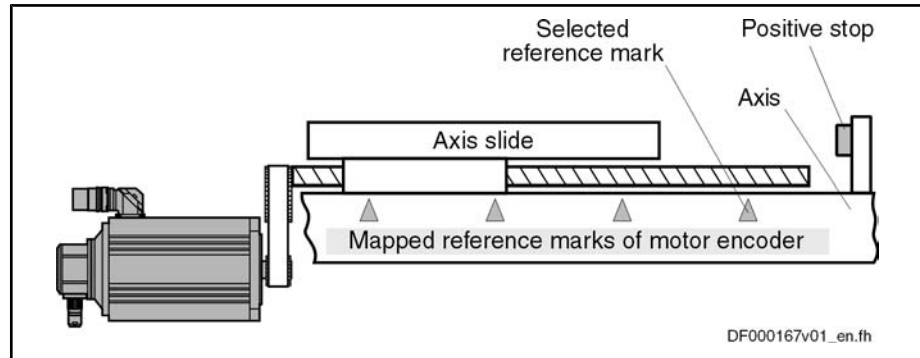


Fig.5-72: Selecting a Reference Mark via Positive Stop at the end of the Axis

#### Detecting the End of Travel Range by Axis Blocking (Positive Stop)

After the start of drive-controlled homing (command C0600), the drive first moves the moving part of the axis in the determined reference travel direction (see S-0-0147). There is no switch signal required for identifying the end of the axis!

#### Search for Dedicated Point For Non-Distance-Coded Encoders

In the case of non-distance-coded encoders, the axis moves until it is blocked by positive stop. After the actual torque value (S-0-0084) of the drive has exceeded the torque limit value (minimum of S-0-0092 and S-0-0082 or S-0-0092 and S-0-0083) that was set and standstill of the drive was detected ("S-0-0331, Status "n\_feedback = 0""), the drive changes the direction of motion; the dedicated point is determined by the occurrence of the first reference mark signal.

#### Search for Dedicated Point For Distance-Coded Encoders

In the case of distance-coded encoders, the axis only moves to positive stop, if there is none or only one distance-coded reference mark in the determined reference travel direction before blocking. After blocking was detected (see paragraph above), the drive changes the direction of motion and over the next two reference marks determines the axis position with regard to the dedicated point.



If evaluation of the reference marks has not been activated, the dedicated point is only determined by detection of positive stop (S-0-0333, S-0-0331, see above).

#### Activation of Axis Blocking Detection (Positive Stop) for Homing Procedure

The evaluation of the reference markers and the positive stop as additional devices for homing has to be activated in the respective bit of "S-0-0147, Homing parameter". The evaluation of home switch and/or travel range limit switch mustn't be activated at the same time!



The monitoring of position command value, actual position value and acceleration is switched off during the homing procedure!



If travel range limit switches for hardware-side limitation of the allowed travel range have been activated, the monitoring of this limitation is deactivated during the homing procedure!



### Requirements for Selecting a Reference Mark

If an axis-side additional device (AD), such as home switch, travel range limit switch or positive stop at the end of the axis, is to be used for selecting a reference mark signal (in the case of several signals occurring over the travel range), you have to make sure that it is always the same reference mark signal that is evaluated by the controller for detecting the position of the dedicated point!

Activation of the home switch or the travel range limit switch or detection of positive stop is detected by the controller with a position inaccuracy inherent in the system. This inaccuracy depends on the following factors:

- The input clock of the digital input via which the home switch or the travel range limit switch is evaluated (corresponding to the position loop clock when command C0600 is executed; see "Performance Data")
- Position loop clock when using a positive stop when command C0600 is executed (see "Performance Data")
- Actual velocity value at which the axis moves during the homing procedure

Within the range of inaccuracy of the position detection there mustn't occur any encoder reference mark, because reliably reproducible detection of the dedicated point is impossible within this range!

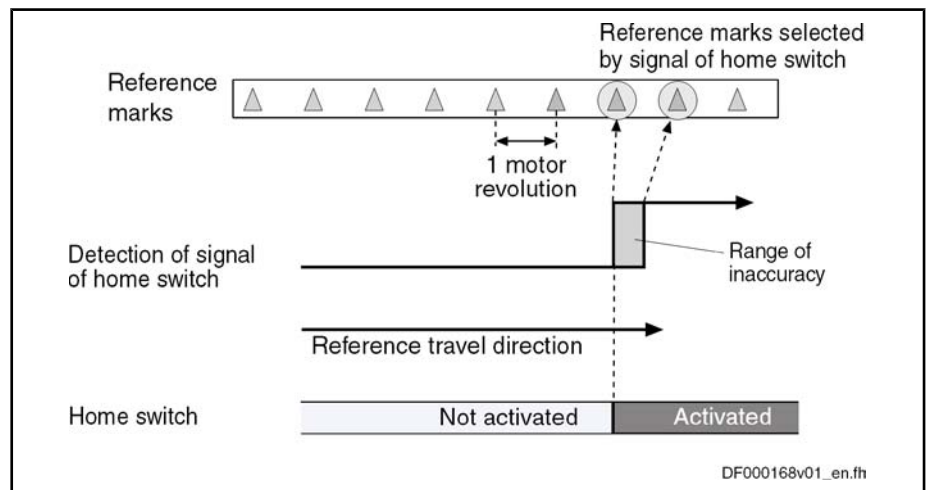


Fig. 5-73: Ambiguous Detection of Reference Marks in Range of Inaccuracy of Home Switch Detection

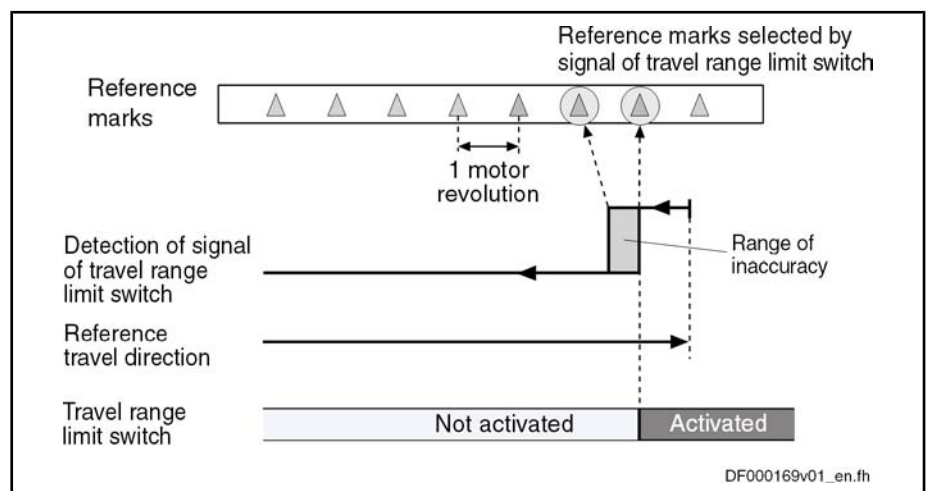


Fig. 5-74: Ambiguous Detection of Reference Marks in Range of Inaccuracy of Travel Range Limit Switch or Positive Stop Detection

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**Distance Monitoring Switch Edge or Positive Stop Detection/Reference Mark**

Due to the range of position inaccuracy of the switch edge or positive stop detection, the distance to the position of the next reference mark is monitored. If the distance falls below a certain value, the error message "C0602 Distance home switch - reference mark erroneous" will be generated.

Classification of distance	Distance	Drive reaction
Critical distance	$< 0.25 \times$ reference mark distance	Shutdown with message C0602
Optimum distance	$0.5 \times$ reference mark distance	--
Allowed distance range	$(0.25 \dots 0.75) \times$ reference mark distance	--

Fig.5-75: Data Regarding the Distance Between Switch Edge or Positive Stop Detection and Reference mark

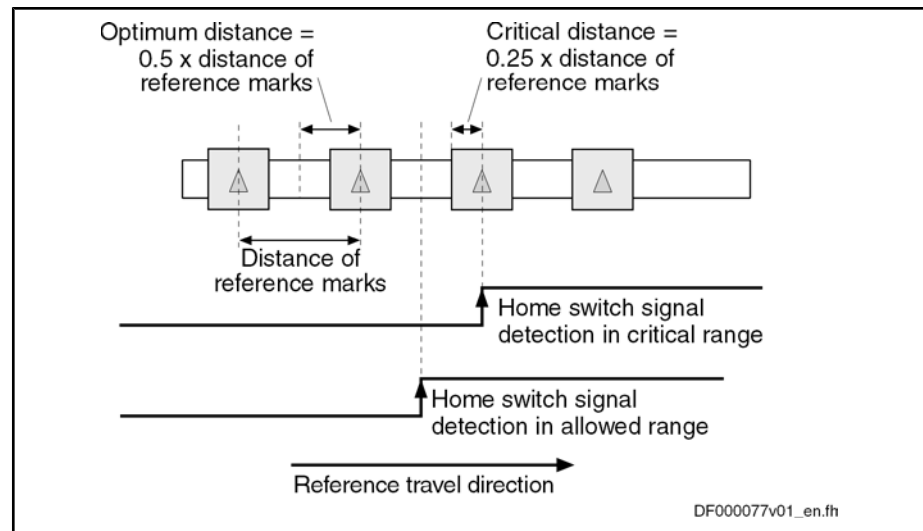


Fig.5-76: Critical and Optimum Distance of Switch Edge and Reference Mark in the Case of the home Switch

For monitoring the distance the optimum distance has to be specified in "P-0-0153, Optimum distance home switch-reference mark".



When using the motor encoder of Rexroth motors of the MHD, MKD, MKE, MSK, MSH, MAD and MAF lines the optimum distance is automatically calculated internally. The value for P-0-0153 has to be left in its default status!



For default values of P-0-0153 for distance monitoring to the next reference mark in the case of switch edge or positive stop detection, see separate documentation "Parameter Description"

**Distance Correction**

For each homing procedure with home switch, travel range limit switch or positive stop detection, as well as reference mark evaluation, the difference between the actual distance to the next reference mark and the optimum distance is monitored. This difference is stored in "S-0-0298, Reference cam shift". For optimum setting of the home switch or travel range limit switch, it can be mechanically shifted by the value of S-0-0298.

The distance can also be optimized drive-internally without mechanical shifting. The controller in this case shifts the activation of the reference mark evaluation after detection of the switch edge or the axis blocking (positive stop) by the

value in "S-0-0299, Home switch offset". For this purpose, the value of S-0-0298 has to be entered in S-0-0299.

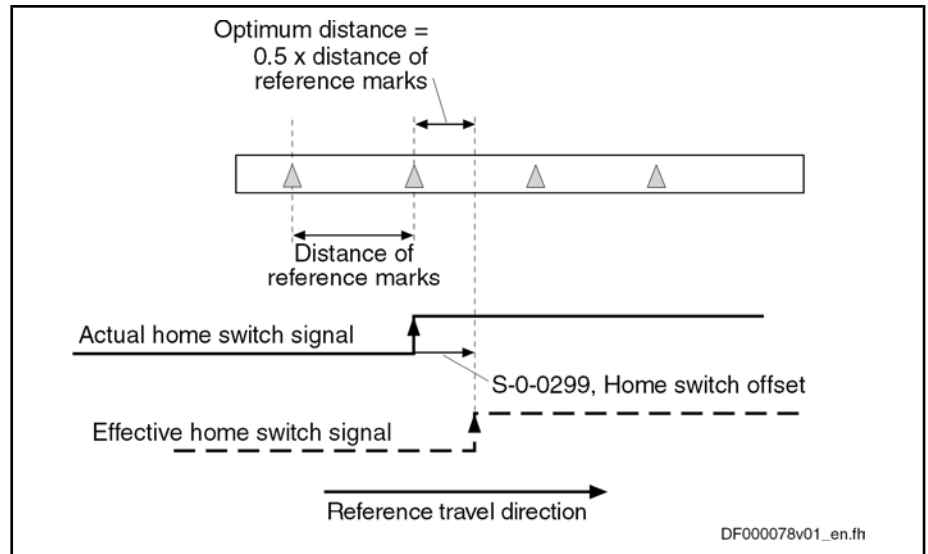


Fig.5-77: Operating Principle of Parameter S-0-0299 in the Case of Home Switch Signal

#### Distance Monitoring of Reference Mark Signals

The position distance of the reference mark signals is monitored during the homing procedure. The position distance to be expected for the motor encoder or external encoder is determined by the controller, depending on the type of encoder used and the value of "P-0-0153, Optimum distance home switch-reference mark". This allows detecting:

- parameter values for reference mark evaluation have been correctly set
- or -
- reference mark signals are correctly input



P-0-0153 refers to the encoder to be homed according to the setting in "S-0-0147, Homing parameter". If a second encoder has to be homed that requires different values in P-0-0153, the parameter P-0-0153 has to be adjusted to the respective encoder by the control master before the command C0600 is started!

## Drive-Controlled Homing Procedure

### General Information

#### Basic Sequence of "Search for Dedicated Point"

After activation of "S-0-0148, C0600 Drive-controlled homing procedure command", the drive for searching the dedicated point moves the axis according to the reference travel direction set in "S-0-0147, Homing parameter". When the controller has detected the position of the dedicated point, e.g. by reference mark detection of the encoder selected in S-0-0147, the position data reference of the actual position values to the axis can be established.

Determining the homing appropriate procedure for the existing axis type (settings in S-0-0147) ensures that during the search for the dedicated point the axis only moves within the allowed travel range!

For information on the actual position value after establishing the position data reference for motor encoder and external encoder see section "General Information on Establishing the Position Data Reference"

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**Functional Sequence "Drive-Controlled Homing Procedure"****Command Value Profile for Homing Procedure**

After activation of "S-0-0148, C0600 Drive-controlled homing procedure command", the drive moves the axis according to the reference travel direction set in "S-0-0147, Homing parameter". The command value profile generated by the controller depends on:

- S-0-0041, Homing velocity
- S-0-0042, Homing acceleration
- S-0-0108, Feedrate override

The controller ignores command values of the control master during the execution of command C0600!



If the respective encoder, at the start of command C0600, should have already been homed, the reference is cleared first!

See also Parameter Description "S-0-0437, Position feedback value status"

---

**Homing Motion**

At the start of command C0600, two situations have to be distinguished with regard to the initial position of a linear axis. The moving part of the axis is

- within the travel range, the home switch or travel range limit switch has not been activated,

- or -

- near the end of the travel range, the home switch or travel range limit switch has been activated, the positive stop, possibly used for homing, is almost reached.

If the switch has not been activated or positive stop has not yet been reached, the drive moves the axis in reference travel direction.

When the home switch has already been activated, the drive moves the axis against the reference travel direction.

In the case of non-distance-coded encoders, the drive reverses the direction of motion for searching the dedicated point as soon as the home switch is detected to be "not activated".

In the case of distance-coded encoders, the search for the dedicated point is carried out against the determined reference travel direction.

When positive stop is used for homing, the search for the dedicated point, after axis blocking has been detected, is always carried out against the reference travel direction!

**Jerk Limitation**

To limit acceleration jumps it is possible to additionally activate a jerk limit. This is made by the input in "S-0-0349, Bipolar jerk limit".

**Motion Range for Homing**

The process for searching the dedicated point requires axis motion. The axis motion to be expected depends on the selected measuring system and on the position of the axis at the start of drive-controlled homing (for information on axis motion see above under the description of the respective paragraph "Identifying the Dedicated Point by Means of ...").

**Maximum Velocity**

As in the case of all drive-controlled functions, the maximum velocity can be directly influenced with a feedrate factor when executing the homing procedure. The effective maximum velocity then results from the product of the values of "S-0-0041, Homing velocity" and "S-0-0108, Feedrate override".

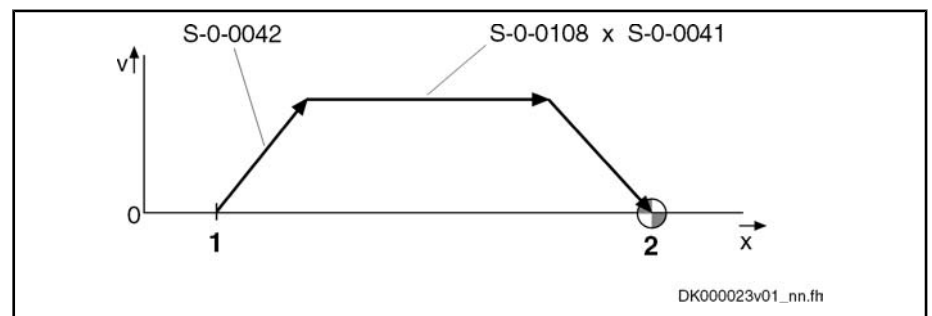
**Shutdown**

After the controller has detected the dedicated point of the axis by the homing procedure, the actual position values are switched to axis-related values. The

drive then shuts down the axis with the homing acceleration (S-0-0042). Shut-down can be carried out as:

- "Stopping"
  - Non-target-oriented immediate braking motion that possibly is of shorter duration
- or -
- "positioning"
  - Target-oriented motion to the reference point (axis-related value in "S-0-0052, Reference distance 1" or "S-0-0054, Reference distance 2"), if the reference point is within the allowed travel range
- or -
- "Run path" (only possible for distance-coded encoders!)
  - Moving over a defined path (double reference mark distance), even if the dedicated point had already been detected

The kind of shutdown ("positioning", "stop" or "run path") is set in "S-0-0147, Homing parameter".



1	start point
2	reference point
S-0-0041	Homing velocity
S-0-0042	Homing acceleration
S-0-0108	Feedrate override

Fig. 5-78: Command Value Profile for Drive-Controlled Homing With Constant Feedrate Factor and "Positioning" Shutdown



If "S-0-0108, Feedrate override" starts with zero, the warning "E2055 Feedrate override S-0-0108 = 0" will be output.

### Actions of the Control Unit in the Case of Drive-Controlled Homing

<b>Starting Command C0600</b>	The control master starts the command by writing to "S-0-0148, C0600 Drive-controlled homing procedure command". The command has to be set and enabled. The command acknowledgment has to be taken from the data status of the same parameter. The command execution is completed when the command change bit in "S-0-0135, Drive status word" has been set and the acknowledgment changes from "in process" to "command executed" or to "command error".
<b>Interrupting Command C0600</b>	If the command is interrupted by the control master during its execution, the drive reacts by activating the "Drive HALT" function. The command execution is continued by removing the interruption. See also "Drive HALT"
<b>Completing Command C0600</b>	When the control master wants to operate the drive in position control after resetting command C0600, it has to read the drive-internal position command value from "P-0-0047, Position command value control" and preset it as the

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position command value. By resetting the command the control master takes over the axis without jerk or position offset occurring.

## NC-Controlled Homing Procedure

### General Information

#### Sequence of NC-Controlled Homing

For NC-controlled homing the master (NC control unit) controls the homing motion for searching the dedicated point of the axis. To do this the master activates

- S-0-0146, C4300 NC-controlled homing procedure command

and presets the command value for axis motion, according to the active operating mode.

When the drive has detected the dedicated point, it informs the master of this fact and stores the position of the dedicated point. The master then completes the execution of command C4300 and afterwards activates

- S-0-0171, C4400 Calculate displacement procedure command.

The required displacement of the actual position values is now calculated in the drive controller, in order to establish the reference of the actual position value to the axis zero point.

When the displacement required for establishing the position data reference has been determined, the master completes the execution of command C4400 and then activates

- S-0-0172, C4500 Displacement to referenced system procedure command.

Drive-internally the actual position value now is changed by the calculated absolute displacement value and thereby the reference of the actual position value to the axis zero point is established. The master has to adjust its command value input to the changed actual position value, before it completes the NC-controlled homing procedure by deactivating command C4500.

### Functional Sequence "NC-Controlled Homing Procedure"

#### Searching the Dedicated Point, Basic Procedure

After the master has started NC-controlled homing by activating "S-0-0146, C4300 NC-controlled homing procedure command", it has to preset a command value for the drive for the axis motion to identify the dedicated point.

For non-distance-coded encoders, the dedicated point can only be identified, if "S-0-0407, Homing enable" has been set on the master side. If a home switch was connected to the drive controller (setting in parameter S-0-0147), it has to be detected as "activated". For distance-coded encoders, the master-side homing enable (S-0-0407) is not required, because the dedicated point can be unequivocally identified by arbitrary neighboring reference marks.

For details on the search for the dedicated point in the case of NC-controlled homing, see section above "Identifying the Dedicated Point by Means of Reference Mark and Home Switch".

When the drive has found the dedicated point of the encoder selected in "S-0-0147, Homing parameter", this is displayed in "S-0-0408, Reference marker pulse registered". The position of the dedicated point or the detected reference marks is stored:

- For non-distance-coded encoders, the detected dedicated position is stored in "S-0-0173, Marker position A".
- For distance-coded encoders, the first detected reference mark is stored in parameter "S-0-0173, Marker position A", the second one in "S-0-0174, Marker position B".

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**Drive-Side Calculation of Actual  
Position Value Displacement for  
Zero Point Reference**

The correct, time-optimized sequence of the execution of command C4300 requires the following assignments:

- Bit "homing enable" (S-0-0407) in real-time control bit of "S-0-0134, Master control word"
- Bit "reference mark detected" (S-0-0408) in real-time status bit of "S-0-0135, Drive status word"

When the bit "reference mark detected" (S-0-0408) has been set, the master can complete the execution of the command C4600.

By master-side activation of "S-0-0171, C4400 Calculate displacement procedure command" the actual position value offset is calculated for the encoder selected in "S-0-0147, Homing parameter".

Basis for the calculation of displacement:

- For non-distance-coded encoders, the non-homed actual position value at the dedicated point (S-0-0173) and the values of reference distance 1/2 (S-0-0052/S-0-0054) and reference offset 1/2 (S-0-0150/S-0-0151).
- For distance-coded encoders, the non-homed actual position values of the detected reference marks (S-0-0173 and S-0-0174) and the values of "S-0-0177, Absolute offset 1" (motor encoder) or "S-0-0178, Absolute offset 2" (external encoder).

The calculated displacement value is displayed in

- S-0-0175, Offset parameter 1 (motor encoder)

- or -

- S-0-0176, Offset parameter 2 (external encoder).

When the required displacement of the actual position value has been determined, the master can complete the execution of the command C4400.



The displacement could also be calculated on the master side and directly preset for the drive via the parameters S-0-0175 or S-0-0176. In this case the execution of command C4400 wouldn't be required!

**Displacement of Actual Position  
Value for Zero Point Reference**

To switch the actual position values to axis reference the master now activates "S-0-0172, C4500 Displacement to referenced system procedure command". The displacement of the actual position value for the encoder selected in "S-0-0147, Homing parameter" is thereby carried out.

The calculated displacement value (S-0-0175 or S-0-0176) is now added to the non-homed actual position value; the new actual position value is displayed in:

- S-0-0051, Position feedback value 1

- or -

- S-0-0053, Position feedback value 2.

The homing status of the encoders connected to the drive is also displayed in parameter "S-0-0403, Position feedback value status". By means of this parameter the master recognizes when the position command value is to be switched to axis reference. When the switching to the homed position command value was carried out, the master indicates this to the drive in parameter "S-0-0404, Position command value status". The drive then signals the execution of command C4500 to have been completed and the master on its part can complete the execution of command C4500.

The correct, time-optimized execution of the command C4500 requires the following assignments:

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- Position command value status bit (S-0-0404) in real-time control bit of "S-0-0134, Master control word"
- Reference encoder status bit (S-0-0403) in real-time status bit of "S-0-0135, Drive status word"

For information on the actual position value after establishing the position data reference for motor encoder and external encoder see section "General Information on Establishing the Position Data Reference"

**Notes on Commissioning****Notes on Commissioning, General**

See also Notes on Commissioning for "General Information on Establishing the Position Data Reference"

**Settings for Connected Encoders**

The required settings with regard to the encoders used need to have been made so that establishing the position data reference is possible.

See also Notes on Commissioning for "Basics on Measuring Systems, Resolution"

For measuring systems with distance-coded reference marks, see also Notes on Commissioning for "Relative Measuring Systems"

**General Settings for Drive-Controlled Homing**

In "S-0-0147, Homing parameter", it is necessary to make basic settings regarding encoder selection and use of axis-side additional devices:

- Selection of encoder to be homed
  - Select which of the connected encoders is to be homed.
- Activation/deactivation of reference mark evaluation
  - Select whether the dedicated point is determined by one encoder reference mark or by two neighboring encoder reference marks (distance-coded encoders) (to be selected for drive-controlled homing, automatically active for NC-controlled homing).
- Setting for use of axis-side additional device for identification of dedicated point:
  - Home switch
  - or -
  - Travel range limit switch as a replacement for home switch (optional for drive-controlled homing, not possible for NC-controlled homing)
  - or -
  - Activation of detection of axis blocking for positive stop drive procedure (optional for drive-controlled homing, not possible for NC-controlled homing)

**Settings for Axis-Side Additional Devices (if Available)**

Depending on whether axis-side additional devices are used, further settings have to be made.

**Home switch:**

- Activation of home switch evaluation in "S-0-0147, Homing parameter"
- Setting for edge evaluation of home switch signal in "S-0-0147, Homing parameter"

**Travel range limit switch:**

- activation of travel range limit switch evaluation in "S-0-0147, Homing parameter"
- Setting of switching performance in "P-0-0090, Travel range limit parameter"



**Detection of axis blocking (positive stop):**

- Setting of torque/force threshold for detection of blocking in "S-0-0092, Bipolar torque/force limit value" resp. "S-0-0082, Torque/force limit value positive" or "S-0-0083, Torque/force limit value negative"
- Setting of standstill threshold for detection of blocking in "S-0-0124, Standstill window"

**Distance Monitoring of Reference Mark Signals**

With active reference mark evaluation (obligatory for NC-controlled homing, optional for drive-controlled homing), encoder-specific values for the monitoring of the reference mark signals have to be entered in "P-0-0153, Optimum distance home switch-reference mark". Monitoring takes place during the homing procedure (see Parameter Description P-0-0153).

**WARNING**

Property damage at the installation caused by home switch edge incorrectly set!

⇒ Make sure the home switch edge was correctly set and is within the travel range!

**Distance Control Home Switch Edge-Travel Range Limit**

In the case of home switch evaluation, first control whether the minimum distance between home switch edge and travel range limit has been complied with:

- search for switch point of home switch, e.g. by jogging the axis to switch cam; control switch status in "S-0-0400, Home switch"; retain actual position value (S-0-0051/S-0-0053)
- Jog axis to travel range limit, retain actual position value (S-0-0051/S-0-0053)

The minimum distance has to be calculated on the basis of the values for velocity and acceleration intended for the homing procedure (see also section above "Identifying the Dedicated Point by Means of Reference Mark and Home Switch"):

- For drive-controlled homing, determine the minimum distance with "S-0-0041, Homing velocity" and "S-0-0042, Homing acceleration"
- For NC-controlled homing determine the minimum distance while taking the homing velocity and homing acceleration into account

If the distance between home switch edge and travel range limit is smaller than the calculated minimum distance, the home switch has to be mechanically brought to the respective distance!

**Checking and, If Necessary, Correcting the Distance to Reference Mark**

When using axis-side additional devices (optional), such as home switch, travel range limit switches or positive stop (setting in S-0-0147), you have to check whether the distance switch edge – reference mark or positive stop – reference mark is within the allowed range.

How to proceed for checking the distance:

- Make presettings for activation of reference marks, for use of axis-side additional devices and for encoder selection in "S-0-0147, Homing parameter"
- Make settings for respective axis-side additional device that might be used (see above)
- Check whether encoder-specific value has been entered in "P-0-0153, Optimum distance home switch-reference mark"

**Note:** The value in P-0-0153 refers to the encoder to be homed as determined in parameter S-0-0147. If a second encoder has to be homed that requires different values in P-0-0153, this parameter has to be adjusted

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to the respective encoder to be homed before the C0600 command is started!

- Execution of the drive-controlled homing procedure (command C0600) with "S-0-0299, Home switch offset" = 0 and the setting "Stop" in S-0-0147. If the distance lies within the allowed range ( $0,25 \dots 0,75 \times (2 \times P-0-0153)$ ), the drive will not generate a respective error message after standstill.

If the message "C0602 Distance home switch - reference mark erroneous" is generated, the distance has to be corrected:

1. Enter value from "S-0-0298, Reference cam shift" in "S-0-0299, Home switch offset".
2. Check: When homing is repeated value "0" should be displayed for parameter S-0-0298.

### Notes on Commissioning "Drive-Controlled Homing Procedure"

#### Settings for Homing Motion

For drive-controlled homing motion, settings for kinematics have to be made:

- S-0-0041, Homing velocity
- S-0-0042, Homing acceleration

#### Settings for Drive-Controlled Homing

Apart from general settings, further settings for drive-controlled homing have to be made in "S-0-0147, Homing parameter":

- Reference travel direction
  - Determine direction of motion in which search for dedicated point take place, if axis is not at end of axis
- Activation/deactivation of reference mark evaluation
  - Determine whether dedicated point is determined by one encoder reference mark or by two neighboring encoder reference marks (distance-coded encoders)
- Setting for use of axis-side additional device for identification of dedicated point:
  - Use of a home switch and setting for edge evaluation of home switch signal
  - or -
  - Use of a travel range limit switch as a replacement for home switch
  - or -
  - Activation of blocking detection for positive stop drive procedure

**Note:** Only one of the possible axis-side additional devices for drive-controlled homing may be selected!

- Setting for shutting axis down after detection of dedicated point ("stop", "positioning" or "run path")

#### Axis-Related Settings for Establishing the Position Data Reference

Depending on the kind of reference mark of the encoder, the axis-related parameter settings for establishing the position data reference are explained in the following sections.

### Notes on Commissioning for Drive-Controlled Homing with Relative Encoders (Reference Marks Non-Distance-Coded)

#### Manual Establishment of Position Data Reference

If the position data reference of an encoder (according to group 1, 2, 3) is to be established, for example, during initial commissioning of an axis in a simple manner, this can be made with the axis slide in standstill without "AF". To do so, perform the following steps:

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1. Enter correct actual position value of the axis slide at the current axis position n S-0-0052, Reference distance 1 or S-0-0054, Reference distance 2
2. Enter value "0" in S-0-0150, Reference offset 1/S-0-0151, Reference offset 2
3. Do not activate encoder reference marker evaluation or evaluation of home switch or travel limit switch or positive stop of axis in "S-0-0147, Homing parameter"
4. Execute "C0600 Drive-controlled homing procedure command" (S-0-0148), the drive does not have to be in "AF".

The position data reference of the axis has now been established via the current position of the axis slide.



Before repeating the manual homing procedure, ensure that the value in S-0-0052, reference distance 1 or S-0-0054, Reference distance 2 receives the correct position of the current axis slide position!

#### Search for the Dedicated Point of the Axis (for automated Sequence)

To establish the position data reference of an encoder (of groups 1, 2, 3) to the axis through an automated sequence, the distance between the dedicated point identified on the drive side and the reference point of the axis, as well as the position of the reference point compared to the axis zero point have to be entered.

To do this the following steps have to be carried out:

1. First set parameters below to value "0":
  - S-0-0052, Reference distance 1/S-0-0054, Reference distance 2
  - S-0-0150, Reference offset 1/S-0-0151, Reference offset 2
2. If encoder reference marks are not to be evaluated but only either home switch or travel limit switch or the positive stop of the axis, make corresponding settings in "S-0-0147, Homing parameter" (default settings: Encoder reference marks are evaluated!).
3. For initial commissioning set parameters for automated search of dedicated point of axis to small values:
  - S-0-0041, Homing velocity (e.g. 10rpm)
  - S-0-0042, Homing acceleration (e.g. 10rad/s<sup>2</sup>)
4. Execute "C0600 Drive-controlled homing procedure command" (S-0-0148) with drive in "AF".



#### CAUTION

#### Property damage caused by step change of actual position value!

⇒ By clearing the command, the original operating mode becomes active again. When the "drive-internal interpolation" mode was set, for example, the drive immediately moves to the position according to the value in "S-0-0258, Target position". Take change in actual position value into consideration!

#### Axis Zero Point and Dedicated Point

After the command was executed the axis zero point is at the same axis position as the dedicated point, because the reference distance (S-0-0052/S-0-0054) and the reference offset (S-0-0150/S-0-0151) were set to the value "0". The actual position value in "S-0-0051, Position feedback value 1" or "S-0-0053, Position feedback value 2" now has absolute reference to this preliminary axis zero point.

#### Settings for the Reference Point

The reference point normally has an actual position value determined on the axis-side and related to the axis zero point. Ideally the dedicated point identified

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on the drive-side has the same position as the reference point. As the dedicated point position is considerably influenced by the mounting situation of the encoder, dedicated point and reference point are different. The distance between dedicated point and reference point for the motor encoder or external encoder is entered in the parameter for reference offset 1 or reference offset 2.

To determine the reference offset the following steps have to be carried out, based on the initial status after the proposed identification of the dedicated point:

- Jog axis to determined reference point and enter actual position value displayed at the reference point in "S-0-0150, Reference offset 1" or "S-0-0151, Reference offset 2" with same preceding sign.

In order to establish the position reference to the real axis zero point, enter the desired axis-related actual position value of the reference point in "S-0-0052, Reference distance 1" or "S-0-0054, Reference distance 2" This can be directly done by entering the value defined on the axis-side if this value is known. If not, the axis-related actual position value of the reference point has to be determined:

- Jog axis to desired axis zero point. Enter displayed actual position value in the respective reference distance parameter with inverted sign.

- or -

- Jog axis to actual position value = 0; axis then is at reference point. Axis-related position of reference point can be determined by measuring distance between current position and determined axis zero point. Enter measured distance as axis-related actual position value for reference point in respective reference distance parameter with the correct sign.

After repeated execution of the command C0600 ("drive-controlled homing procedure" command) the actual position values refer to the axis zero point.

**Settings for Drive-Controlled Homing Motion**

Set the parameter values reduced for initial commissioning to their definite values:

- S-0-0041, Homing velocity
- S-0-0042, Homing acceleration

For the purpose of control carry out command "C0600 Drive-controlled homing procedure command" again!

For non-distance-coded encoders, drive-controlled homing can be completed with "stop" or "positioning":

**"Stop" After Detecting the Dedicated Point**

When "stop" after detecting the dedicated point (default setting) was set in "S-0-0147, Homing parameter", the drive stops the axis after the dedicated point was detected.

**"Positioning" After Detecting the Dedicated Point**

If the axis, after the dedicated point was detected, is to position to the reference point of the encoder selected in S-0-0147, this too has to be determined in S-0-0147. The position can be preset via "S-0-0052, Reference distance 1" or "S-0-0054, Reference distance 2".



**CAUTION**

**Property damage possible at the installation, if the reference point is outside the allowed travel range and the position limit hasn't been activated yet!**

⇒ Make sure that reference point is within the travel range and activate the position limit!

## Notes on Commissioning for Drive-Controlled Homing with Relative Encoders with Distance-Coded Reference Marks

### Settings for Axis-Side Position Data Reference of Actual Position Values

To establish the position data reference of an encoder with distance-coded reference marks to the axis, the position of the axis zero point related to the dedicated point defined on the encoder side (encoder zero point) has to be entered in:

- S-0-0177, Absolute offset 1 (motor encoder)
- S-0-0178, Absolute offset 2 (external encoder)

To do this the following steps have to be carried out:

1. First set parameters for absolute offset (see above) to value "0":
2. For initial commissioning set parameters for homing procedure to low values:
  - S-0-0041, Homing velocity (e.g. 10rpm)
  - S-0-0042, Homing acceleration (e.g. 10rad/s<sup>2</sup>)
3. Execute "C0600 Drive-controlled homing procedure command" (S-0-0148) with drive in "AF".



**CAUTION**

### Property damage caused by step change of actual position value!

⇒ By clearing the command, the original operating mode becomes active again. When the "drive-internal interpolation" mode was set, for example, the drive immediately moves to the value in "S-0-0258, Target position". Take change in actual position value into consideration!

### Axis Zero Point and Dedicated Point

After the command was executed, the axis zero point is at the same axis position as the dedicated point, because the absolute offset (S-0-0177/S-0-0178) was set to the value "0". The actual position value in "S-0-0051, Position feedback value 1" or "S-0-0053, Position feedback value 2" now has absolute reference to this preliminary axis zero point.

### Settings for the Axis Zero Point

An axis-side reference point possibly available is not used for establishing the position data reference for distance-coded measuring systems. In order to establish the position reference to the real axis zero point, enter the desired axis-related actual position value of the dedicated point in "S-0-0177, Absolute offset 1" or "S-0-0178, Absolute offset 2". The axis-related actual position value of the dedicated point has to be determined:

- Jog axis to desired axis zero point. Enter displayed actual position value in the respective absolute offset parameter with **inverted** sign.

- or -

- Jog axis to actual position value = 0. Axis then is at dedicated point. Determine axis-related position of dedicated point by measuring distance between current position and determined axis zero point. Enter measured distance as axis-related actual position value for dedicated point in respective absolute offset parameter with the correct sign.

After repeated execution of command "C0600 Drive-controlled homing procedure command" (S-0-0148), the actual position values refer to the axis zero point.

### Settings for Drive-Controlled Homing Motion

Set the parameter values reduced for initial commissioning to their definite values:

- S-0-0041, Homing velocity
- S-0-0042, Homing acceleration

For the purpose of control carry out "C0600 Drive-controlled homing procedure command" again!

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The direction of motion during the homing procedure of distance-coded measuring systems can be against the reference travel direction selected in S-0-0147, if the axis is in the "activated" range of the home switch!

For non-distance-coded encoders, drive-controlled homing can be completed with "stop" "positioning" or "run path":

**"Stop" at End of Homing Procedure**

If the setting "stop" (default setting) was made in "S-0-0147, Homing parameter", the drive stops the axis as soon the controller has detected two neighboring reference marks. The motion range of the axis, depending on the initial position, is the single to double reference mark distance (S-0-0165).

**"Positioning" at End of Homing Procedure**

If the axis, after the dedicated point was detected, is to position to the reference point of the encoder selected in S-0-0147, this too has to be determined in S-0-0147. The position can be preset via "S-0-0052, Reference distance 1" or "S-0-0054, Reference distance 2".



When homing distance-coded encoders, the value in S-0-0052/ S-0-0054 is insignificant for establishing the position data reference! In this case, it can possibly be used for presetting a homing target position.

**CAUTION**

**Property damage possible at the installation, if the reference point is outside the allowed travel range and the position limit hasn't been activated yet!**

⇒ Make sure that reference point is within the travel range and activate the position limit!

**"Run Path" During Homing Procedure**

If the setting "run path during homing procedure" has been made in "S-0-0147, Homing parameter", the motion range of the axis is always the double reference mark distance (S-0-0165) plus the braking distance for shutting the axis down. The controller therefore can always detect two neighboring reference marks which is required for establishing the position data reference.



"Run path" supports homing of Gantry axes when distance-coded encoders are used for both axes!

**Checking the Detection of End of Travel Range**

For linear axes with distance-coded measuring system a home switch is required for detecting the end of the travel range. If the home switch is activated at the start of command C0600, the axis slide, to establish the position data reference, has to move against the reference travel direction selected in S-0-0147.

The signal status of the home switch is displayed in "S-0-0400, Home switch".  
Procedure for checking the detection of the end of travel range:

- Move axis to "activated" range of home switch
- Start command C0600
  - Axis now must move against reference travel direction, until position data reference has been established.

**Notes on Commissioning "NC-Controlled Homing Procedure"****Settings for NC-Controlled Homing**

Apart from general settings (encoder selection, "activated" signal of home switch), further specific settings for NC-controlled homing have to be made in parameter "S-0-0147, Homing parameter":

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**Axis-Related Settings for Establishing the Position Data Reference**

- Setting for whether home switch is connected to drive or master (NC control unit)
- Setting for activation of dedicated point detection:
  - Master-side homing enable
  - or -
  - master-side homing enable and "activated" signal of home switch (for this purpose, home switch has to be connected to drive)

The following axis-related parameter values have to be determined for relative, non-distance-coded measuring systems:

- S-0-0052, Reference distance 1
- S-0-0054, Reference distance 2
- S-0-0150, Reference offset 1
- S-0-0151, Reference offset 2

The following axis-related parameter values have to be determined for relative, distance-coded measuring systems:

- S-0-0177, Absolute offset 1
- S-0-0178, Absolute offset 2

Depending on the kind of reference mark of the encoder, the axis-related parameter settings for establishing the position data reference are explained in the following sections:

- "Notes on Commissioning for Drive-Controlled Homing with Relative Encoders (Reference Marks Non-Distance-Coded)", see above
- "Notes on Commissioning for Drive-Controlled Homing with Relative Encoders with Distance-Coded Reference Marks"; see above



The axis-related settings for establishing the position data reference are basically the same for drive-controlled and NC-controlled homing! For determining the axis-related parameter values it is advantageous to use drive-controlled homing!

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**Search for the Dedicated Point**

The master starts "C4300 NC-controlled homing procedure command" and sets the command value for the homing motion (if drive in "AF").

Detection of dedicated point takes place when:

- Homing enable (S-0-0407) has been set
- or -
- "S-0-0407, Homing enable" has been set and the home switch is in the "activated" status (S-0-0400)

For non-distance-coded encoders the non-homed position of the detected dedicated point is stored in:

- S-0-0173, Marker position A

For distance-coded encoders the non-homed position of the detected dedicated reference marks is stored in:

- S-0-0173, Marker position A
  - First detected distance-coded reference mark
- S-0-0174, Marker position B
  - second detected distance-coded reference mark

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**Drive-Side Calculation of Actual  
Position Value Displacement for  
Zero Point Reference**

When the dedicated point was detected, this is displayed by a bit in "S-0-0408, Reference marker pulse registered" and the master then completes the execution of command C4300.

The master starts "C4400 Calculate displacement procedure command" (S-0-0171).

The calculated displacement value is displayed in the following parameters:

- S-0-0175, Offset parameter 1 (motor encoder)
- S-0-0176, Offset parameter 2 (external encoder)

When the required displacement of the actual position value has been determined, the master completes the execution of the command C4400.



It is also possible to calculate the displacement on the master side and directly preset it for the drive via the parameters S-0-0175 or S-0-0176. In this case the execution of the drive command C4400 is not required!

**Actual Position Value Displacement for Zero Point Reference**

The master starts "C4500 Displacement to referenced system procedure command" (S-0-0172).

The calculated displacement value (S-0-0175 or S-0-0176) is now added to the non-homed actual position value; the new actual position value is displayed in the following parameters:

- S-0-0051, Position feedback value 1
- S-0-0053, Position feedback value 2.

The actual position values thereby change from a non-homed to a homed value, because the corresponding displacement value was taken into account.

When the reference of the encoder selected in S-0-0147 is displayed in "S-0-0403, Position feedback value status", the master changes the position command value from the non-homed value to the homed value:

- P-0-0047, Position command value control

In "S-0-0404, Position command value status", the master at the same time signals the homed status of the position command value to the drive and completes the execution of command C4500.

**Possible Error Messages during Drive-Controlled Homing**

While command C0600 is executed, the following command errors can occur:

- C0601 Homing only possible with drive enable
- C0602 Distance home switch - reference mark erroneous
- C0604 Homing impossible with absolute encoder
- C0606 Reference mark not detected
- C0607 Home switch input not assigned

**Possible Error Messages during NC-Controlled Homing**

While NC-controlled homing is executed, the following command errors can occur:

- C4302 Distance home switch - reference mark erroneous
- C4304 Homing impossible with absolute encoder
- C4306 Reference mark not detected
- C4307 Home switch input not assigned



## Shifting the Position Data Reference for Absolute and Relative Measuring Systems (Shift Coordinate System Procedure)

### Brief Description



Expansion package **servo function** (order code **SRV**) of all firmware variants in **closed-loop** characteristic.

The existing position data reference of the measuring systems to the axis can be shifted if the respective command was activated by the master. It is possible to shift the data reference in standstill or while the axis is moving. This does not affect the position reference of the axis because it is only the actual position values output for the master that are displayed in "shifted" form. Internally the original ("non-shifted") position data reference is maintained.

Shifting the position data reference affects the motor encoder and, if available, the external encoder, independent of which encoder is the active encoder for position control. If different actual position values are valid for the encoders (both encoders possibly have position data reference independent of each other), the actual position values of both measuring systems are shifted by the same difference.

#### Pertinent Parameters

- S-0-0197, C3300 Set coordinate system procedure command
- S-0-0198, Initial coordinate value
- S-0-0199, C3400 Shift coordinate system procedure command
- S-0-0275, Coordinate offset value
- S-0-0283, Current coordinate offset

#### Pertinent Diagnostic Messages

- C3300 Set coordinate system procedure command
- C3400 Shift coordinate system procedure command

### Functional Description

#### Operating Principle of Function "Shifting Position Data Reference"

Shifting the position data reference affects the current actual position value of the encoders connected to the drive (motor encoder and external encoder). Whether the current actual position value has position data reference to the axis or not is irrelevant for the shifting of the position data reference! The shifting is carried out on the drive-side by means of a command started by the master.



The reference status of the actual position values is not affected by the shifting of the position data reference!

If the position data reference is shifted several times in succession without the drive having been switched to communication phase 2, the shifted values act in an additive way! The total offset with regard to the original actual position value is stored in "S-0-0283, Current coordinate offset".

#### Resetting "Shifting Position Data Reference"

The offset of the position data reference is reset by switching the drive to communication phase 2. Therefore, there cannot be any active offset of position data reference when the drive is switched on the first time, because former offsets are cleared when the drive is switched off.



After resetting the offset by switching to communication phase 2 the position data reference has to be established again for relative measuring systems, if necessary!

#### Establishing Position Data Reference for "Shifted" Measuring System

If after completion of shifting of actual position values (value in "S-0-0283, Current coordinate offset" unequal "0") the position data reference of the en-

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coder to the axis is established ("C0300 Set absolute position procedure command" or "C0600 Drive-controlled homing procedure command"), the current offset of the coordinate system is cleared and the value "0" is displayed in S-0-0283.

**"Set Coordinate System" Command**

When the control master triggers the "C3300 Set coordinate system procedure command" (S-0-0197), the drive becomes independent of the command values preset by the master and goes to standstill in a drive-controlled way. Deceleration takes place according to the "A0010 Drive HALT" function.



See also Troubleshooting Guide "A0010 Drive HALT"

In standstill, the actual position value is set to "S-0-0198, Initial coordinate value" and the difference between the new and original actual position value is stored in S-0-0283. The command then is acknowledged as having been "executed".

**"Shift Coordinate System" Command**

When the control master triggers "C3400 Shift coordinate system procedure command" (S-0-0199), the drive also becomes independent of the command values preset by the master but maintains the current velocity by internal input of the previous velocity command value. The actual position values now are shifted by addition of "S-0-0275, Coordinate offset value". The difference between the new and original actual position values is stored in S-0-0283. The command then is acknowledged as having been "executed".

**Action of Control Unit After Command Acknowledgment**

After the command acknowledgment the control master has to adjust to the shifted actual position values. This can be done by means of the actual position values of the encoder active for position control (S-0-0051 or S-0-0053) or the current offset value (S-0-0283). When the control master has adjusted its command values to the new actual position values, it can clear the command. The master then sets the command values again. In spite of the actual position value having been shifted with the drive active, there is no jerk when controlled!

**Change in Position Data by "Shifting Position Data Reference"**

**Measured position values**, generated by probe evaluation, for example, refer to the actual position value system in which they were measured, i.e.:

- When measured after the shifting, they refer to the "shifted" measuring system.
- When measured before the shifting, they refer to the original measuring system.

**Command values** (cyclic command values, target position, spindle angle position etc.) have to refer to the current actual position value system, i.e. to the possibly shifted position data reference.

**Unchanged Position Data after "Shifting Position Data Reference"**

**Travel range limit values** (S-0-0049 or S-0-0050) and **position correction values** (e.g. axis error correction values) are always in their original position data reference, i.e. the control unit, before writing these parameters, has to take the current offset into account and calculate the original position reference again.

**Notes on Commissioning**

Shifting the position data reference during commissioning can cause incorrect command values after the shifting has been carried out! Commissioning basically makes sense only in conjunction with the control master. Check whether the command value handling of the master is correct!



**CAUTION**

**Property damage caused by error in command value input after shifting the position data reference!**

⇒ Protect the travel range of the axis, activate axis limit switches and make sure they are working!

<b>"Set Coordinate System"</b>	<p>It is recommended to begin with "set coordinate system procedure". But first "S-0-0283, Current coordinate offset" should be read. When the shifting of the position data reference has not yet been carried out after the transition from "P2" to "AF" , the value has to be "0"!</p> <p>With master-side command value input, the "S-0-0197, C3300 Set coordinate system procedure command" has to be started by the master.</p> <p>See also "Command Processing"</p>
<b>Checking the Offset of Position Data Reference</b>	<p>When the command was acknowledged by the drive, the offset of the position data reference has to be checked:</p> <ul style="list-style-type: none"> <li>• The actual position value (S-0-0051 and possibly S-0-0053) has to correspond to "S-0-0198, Initial coordinate value".</li> <li>• Read "S-0-0283, Current coordinate offset". With value unequal "0" shifting took place; with value "0" shifting either has not taken place or the actual position value of the axis approximately equaled the value of S-0-0198 when the position data reference was shifted.</li> </ul>
<b>Checking the Command Value Input and Clearing the Command</b>	<p>To check the command value input the master has to preset a position command value that corresponds to the value of S-0-0198. Before the master resets the executed command, it is necessary to check whether the master-side command value corresponds to the current actual position value of the encoder active in position control (S-0-0051 or S-0-0053, shifted position data reference). If not, do not clear the command but reset "AF", if necessary, and search for the cause of the incorrect command value!</p>
<b>"Shift Coordinate System Procedure"</b>	<p>With "shift coordinate system procedure" it is recommended to control the axis on the master-side with velocity command value "0" or with very low velocity. But first read "S-0-0283, Current coordinate offset". When the shifting of the position data reference has not yet been carried out after the transition from "P2" to "AF" , the value has to be "0"!</p> <p>Subsequently, start "C3400 Shift coordinate system procedure command" on the master side.</p> <p>See also "Command Processing"</p>
<b>Checking the Offset of Position Data Reference</b>	<p>When the command was acknowledged by the drive, the offset of the position data reference has to be checked:</p> <ul style="list-style-type: none"> <li>• The values of "S-0-0283, Current coordinate offset" and "S-0-0275, Coordinate offset value" have to correspond.</li> </ul>
<b>Checking the Command Value Input and Clearing the Command</b>	<p>Before the master resets the executed command, it is necessary to check whether the master-side command value corresponds to the current actual position value of the encoder active in position control (S-0-0051 or S-0-0053, shifted position data reference). If not, do not clear the command but reset "AF", if necessary, and search for the cause of the incorrect command value!</p>

## Detecting the Marker Position

### Brief Description



**Base package** of all firmware versions in **closed-loop** characteristic.

The "get marker position" function, that is activated via the respective command, can be used for:

- Checking the correct detection of the reference mark of an incremental measuring system

- or -

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- Determining the position of the reference mark in case the homing procedure is carried out by the control master. In this case, the coordinate system is switched in the master with the position information of the reference mark.



A possibly available home switch is not evaluated with this function!

---

**Pertinent Parameters**

- S-0-0173, Marker position A
- P-0-0014, C1400 Command Get marker position

**Pertinent Diagnostic Messages**

- C1400 Command Get marker position

**Functional Description**

After the start of "P-0-0014, C1400 Command Get marker position", the following actions are carried out:

- "C1400 Command Get marker position" is generated.
- If an incremental measuring system was selected, the search for reference marks is activated and the drive waits for reaching the next reference mark.
- When a reference mark is detected (i.e. the drive passes the position of a reference mark) the actual position value of this mark is stored in "S-0-0173, Marker position A" and then the command execution is signaled to be completed.



The drive does not generate any command value. The operating mode active at the start of the command remains unchanged. In order to pass the reference mark the control master has to preset such command values (e.g. by means of jogging) that lead to a movement in direction of the reference mark to be detected.

---



The position of the reference marker is stored in "S-0-0173, Marker position A", even while "C0600 Drive-controlled homing procedure command" (S-0-0148) is being carried out. This position, however, refers to the "old" coordinate system (before switching the coordinate system when executing the homing procedure).

---

## 5.6 Mechanical Axis System and Arrangement of Measuring Systems

### 5.6.1 Brief Description

**Motor encoder** Controlled motor activation requires a position measuring system that measures the current rotor position or the position of the moving part as opposed to the static part of the motor.

This position measurement is required for the:

- Current control loop,
- velocity control loop and
- if required, position control loop.

The precision and resolution of the position measurement is decisive for the quality of the actual values, especially in the velocity and position control loop.

**External Encoders**

Depending on the mechanical properties of the mechanical system between driven motor shaft and machine axis it can be required to carry out the position

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control by means of an external position encoder (not integrated in the motor) directly at the moving part of the axis, e.g. in the case of

- mechanical system with slip,
- gear play or a low degree of stiffness of the mechanical system, etc.

The external (optional) encoder can also be used as a measuring wheel encoder (frictionally engaged on transported material).

See "Measuring Wheel Mode"

For information on encoder evaluation and encoder monitoring see also "Basics on Measuring Systems, Resolution" and "Monitoring the Measuring Systems"

**Motor Encoders of Rexroth Housing Motors**

Rexroth housing motors have integrated position measuring systems:

- HSF encoders for MHD motors of high precision requirements
- Resolver encoders for MKD and MKE motors for lower precision requirements

They are optionally available as

- Relative measuring system ("single-turn motor encoder")

- or -

- Absolute measuring system ("multi-turn motor encoders", range of values  $\pm 4096$  motor revolutions)

The measuring systems of Rexroth housing motors support the commissioning because the data for encoder type and resolution are stored in the encoder. They are loaded to the controller when the controller is switched on.

**Motor Encoders for Rexroth Kit Motors and Third-Party Encoders**

Rexroth kit motors are delivered as individual components and assembled in the machine to form the motor. It consists of a moving and a static part, the bearing and the motor encoder.

The following measuring systems can be used as a motor encoder:

- GDS/GDM encoders from Rexroth (rotary single-turn or multi-turn encoders with housing and shaft)
- Incremental encoders with sine signals (compatible with signal specification of Heidenhain)
- combined encoder of incremental encoder with sine signals (compatible with signal specification of Heidenhain) and "Hall sensor box SHL01.1" (Rexroth-compatible signal specification)
- Encoders with EnDat interface from Heidenhain
- Incremental encoders with square-wave signals (compatible with signal specification of Heidenhain)
- Combined encoder of incremental encoder with square-wave signal (compatible with signal specification of Heidenhain) and "Hall sensor box SHL01.1" (Rexroth-compatible signal specification)



Do not use incremental encoders with square-wave signals as motor encoders! Bad drive characteristics are to be expected!

The mentioned measuring systems can be used as motor encoders for third-party kit motors and third-party housing motors. The combined encoders are an exception; they can only be used for Rexroth synchronous linear motors (see also "Rexroth Kit Motors, Synchronous")!

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For synchronous kit motors or synchronous third-party motors it is recommended that you use a measuring system, which can be evaluated in absolute form, as a motor encoder so that you have to determine the commutation offset of the motor only once (during initial commissioning) (see also "Absolute Measuring Systems").

---

### Motor Encoder with Gear

Especially with rotary kit motors it is sometimes impossible to connect the motor encoder directly to the motor shaft. IndraDrive provides the possibility to evaluate a motor encoder connected via a gear.

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For synchronous motors in combination with a motor encoder which can be evaluated in absolute form, the advantage of setting the commutation offset only once (see above) can only be used with an encoder gear with  $i = 1$  or when there is no encoder gear available!

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### External Encoders at Machine Axes

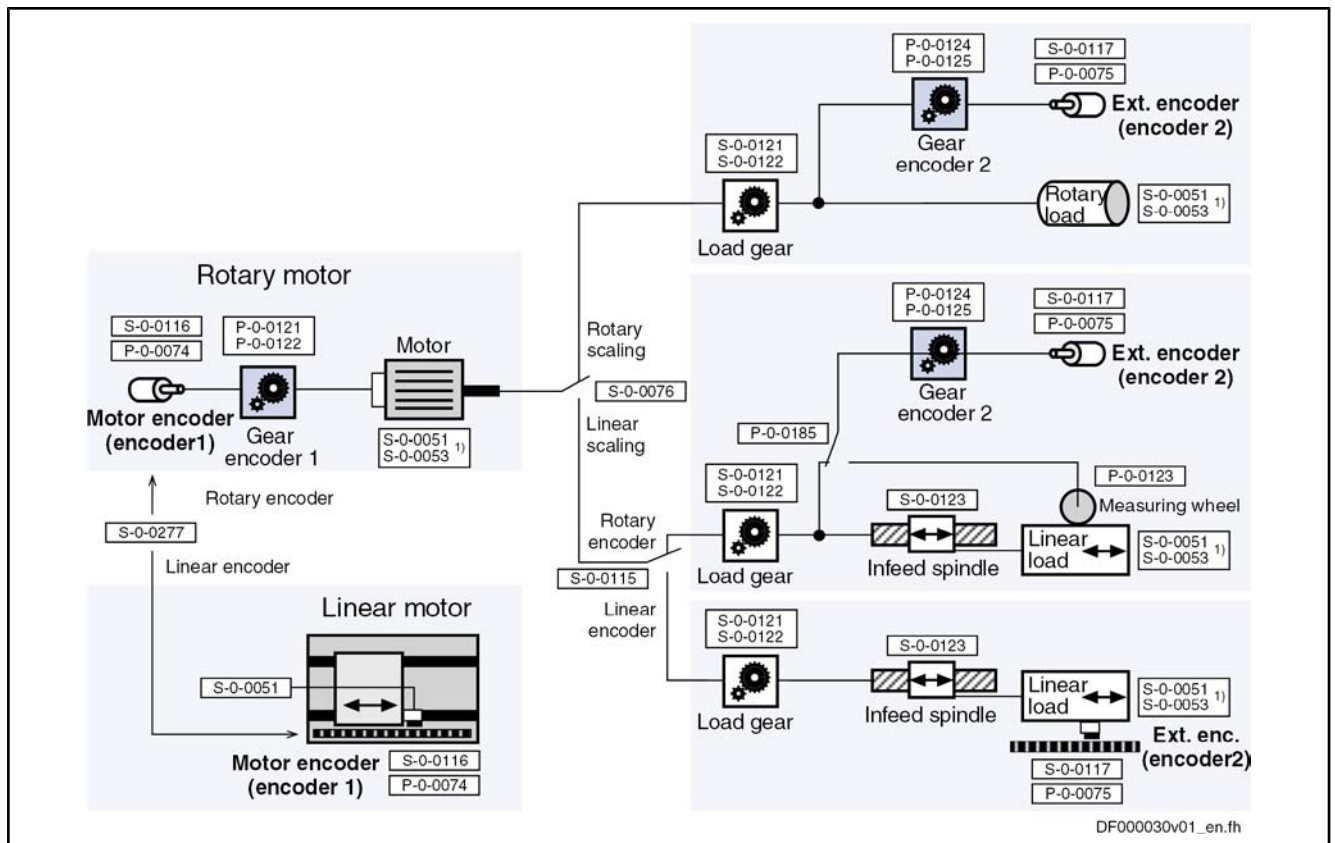
IndraDrive controllers can evaluate the following measuring systems as external encoders:

- GDS/GDM encoders from Rexroth (rotary single-turn or multi-turn encoders with housing and shaft)
- Incremental encoders with sine signals (compatible with signal specification of Heidenhain)
- Encoders with EnDat interface from Heidenhain
- Incremental encoders with square-wave signals (compatible with signal specification of Heidenhain)

### Possibilities of Arranging Measuring Systems

The figure below shows an overview of arrangement possibilities of mechanical drive system and measuring systems.

Motor, Mechanical Axis System, Measuring Systems



- 1) S-0-0051 or S-0-0053 depending on scaling (S-0-0076)
- S-0-0051 Position feedback 1 value
- S-0-0053 Position feedback 2 value
- S-0-0076 Position data scaling type
- S-0-0115 Position feedback type 2
- S-0-0116 Feedback 1 Resolution
- S-0-0117 Feedback 2 Resolution
- S-0-0121 Input revolutions of load gear
- S-0-0122 Output revolutions of load gear
- S-0-0123 Feed constant
- S-0-0277 Position feedback type 1
- P-0-0074 Encoder type 1 (motor encoder)
- P-0-0075 Encoder type 2 (optional encoder)
- P-0-0121 Gear 1 motor-side (motor encoder)
- P-0-0122 Gear 1 encoder-side (motor encoder)
- P-0-0124 Gear 2 load-side (optional encoder)
- P-0-0125 Gear 2 encoder-side (optional encoder)
- P-0-0123 Feed constant 2 (optional encoder)
- P-0-0185 Control word of encoder 2 (optional encoder)

Fig. 5-79: Overview of Arrangement Possibilities of Mechanical Drive System and Measuring Systems

**Hardware Requirements**

For connecting the measuring systems to the controller there are 3 optional interfaces available. The interface to which the respective encoder is connected is determined by writing to "P-0-007, Assignment motor encoder->optional slot" and "P-0-0078, Assignment optional encoder->optional slot". The interface must be equipped with the appropriate encoder input for the encoder (see also documentation "Control Sections for Drive Controllers; Project Planning Manual")!

**Pertinent Parameters**

- S-0-0115, Position feedback 2 type

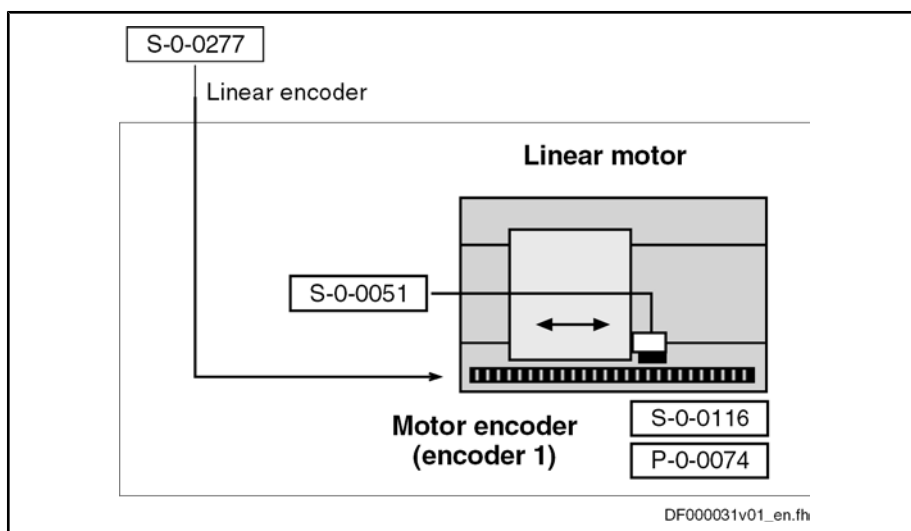
## Motor, Mechanical Axis System, Measuring Systems

- S-0-0121, Input revolutions of load gear
- S-0-0122, Output revolutions of load gear
- S-0-0123, Feed constant
- S-0-0277, Position feedback 1 type
- P-0-0121, Gear 1 motor-side (motor encoder)
- P-0-0122, Gear 1 encoder-side (motor encoder)
- P-0-0123, Feed constant 2 (optional encoder)
- P-0-0124, Gear 2 load-side (optional encoder)
- P-0-0125, Gear 2 encoder-side (optional encoder)
- P-0-0185, Control word of encoder 2 (optional encoder)

## 5.6.2 Functional Description

**Motor Encoder** The motion type of the motor encoder can either be rotary or linear. This information is given to the controller via "S-0-0277, Position feedback 1 type".

If "linear motor encoder" is set in S-0-0277, the encoder 1 gear parameters are inactive, the actual position value reference (S-0-0076, Position data scaling type) has to be set to "motor-related" and "linear". As the actual position values are determined directly at the moving part of the axis it does not make sense to use another external encoder!



S-0-0051	Position feedback 1 value
S-0-0116	Feedback 1 Resolution
S-0-0277	Position feedback type 1
P-0-0074	Encoder type 1 (motor encoder)

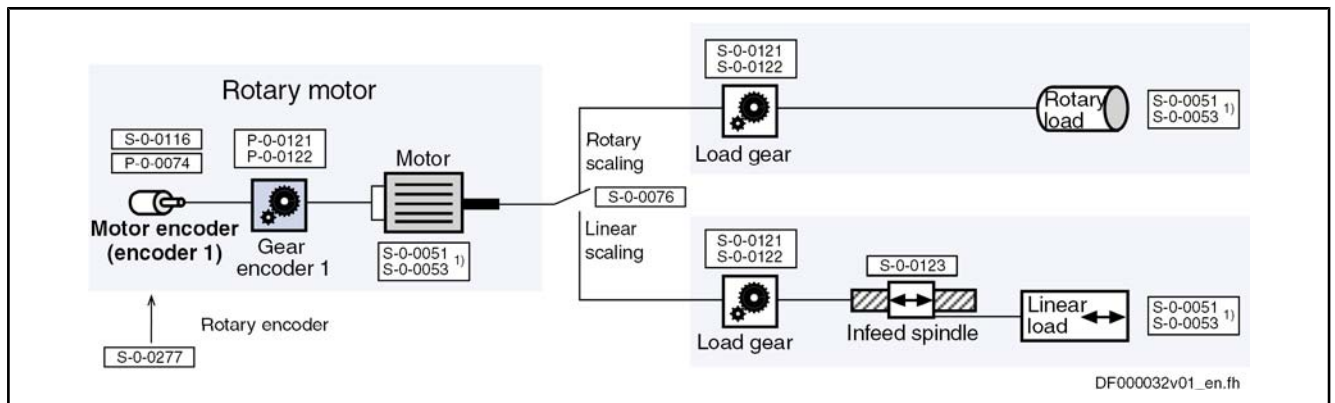
Fig.5-80: Motor Encoder Arrangement for Drive With Linear Motor

When "rotary motor encoder" is set the controller assumes an application with a rotary motor. This means:

- In the case of rotary kit motors, the motor encoder can be connected via a gear; Rexroth housing motors have a direct motor connection.
- The load side of the drive can be rotary or linear (S-0-0076).



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- 1) S-0-0051 or S-0-0053 depending on scaling (S-0-0076)
- S-0-0051 Position feedback 1 value
- S-0-0053 Position feedback 2 value
- S-0-0076 Position data scaling type
- S-0-0116 Feedback 1 Resolution
- S-0-0121 Input revolutions of load gear
- S-0-0122 Output revolutions of load gear
- S-0-0123 Feed constant
- S-0-0277 Position feedback type 1
- P-0-0074 Encoder type 1 (motor encoder)
- P-0-0121 Gear 1 motor-side (motor encoder)
- P-0-0122 Gear 1 encoder-side (motor encoder)

Fig. 5-81: Possible Drive Arrangements With Rotary Motor (Without External Encoder)

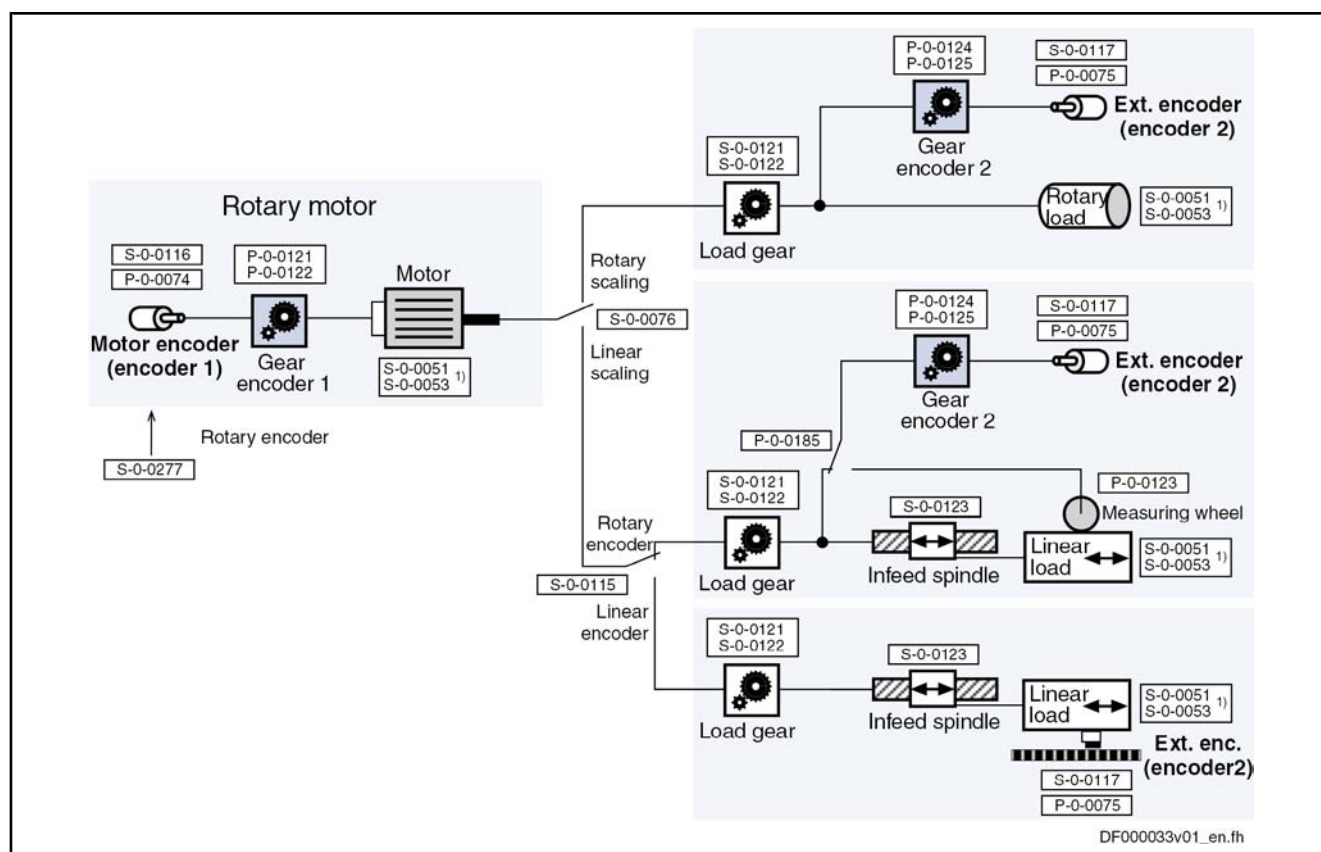
**External Encoder**

In the case of drives with rotary motor a rotary or linear load-side (external) encoder can be necessary, depending on the application:

- A rotary external encoder can be connected to the load via an encoder gear.
- A linear external encoder determines the actual position value directly at the linear load.

For drives with linear motor, it is impossible to connect an external encoder!

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- 1) S-0-0051 or S-0-0053 depending on scaling (S-0-0076)
- S-0-0051 Position feedback 1 value
- S-0-0053 Position feedback 2 value
- S-0-0076 Position data scaling type
- S-0-0115 Position feedback type 2
- S-0-0116 Feedback 1 Resolution
- S-0-0117 Feedback 2 Resolution
- S-0-0121 Input revolutions of load gear
- S-0-0122 Output revolutions of load gear
- S-0-0123 Feed constant
- S-0-0277 Position feedback type 1
- P-0-0074 Encoder type 1 (motor encoder)
- P-0-0075 Encoder type 2 (optional encoder)
- P-0-0121 Gear 1 motor-side (motor encoder)
- P-0-0122 Gear 1 encoder-side (motor encoder)
- P-0-0124 Gear 2 load-side (optional encoder)
- P-0-0125 Gear 2 encoder-side (optional encoder)
- P-0-0123 Feed constant 2 (optional encoder)
- P-0-0185 Control word of encoder 2 (optional encoder)

Fig. 5-82: Possible Drive Arrangements With Rotary Motor and External Encoder

### 5.6.3 Notes on Commissioning

The Notes on Commissioning in the sections "Basics on Measuring Systems, Resolution" and "Monitoring the Measuring Systems" have to be observed, too!

**Basic Settings** Set "linear" or "rotary" encoder type:

- S-0-0277, Position feedback 1 type

	Enter encoder type, hardware assignment and resolution:
	<ul style="list-style-type: none"> <li>• S-0-0116, Resolution of feedback 1</li> <li>• P-0-0074, Encoder type 1 (motor encoder)</li> <li>• P-0-0077, Assignment motor encoder-&gt;optional slot</li> </ul>
<b>Settings for Rotary Motors</b>	Enter motor encoder gear ratio:
	<ul style="list-style-type: none"> <li>• P-0-0121, Gear 1 motor-side (motor encoder)</li> <li>• P-0-0122, Gear 1 encoder-side (motor encoder)</li> </ul>
	Enter load gear ratio:
	<ul style="list-style-type: none"> <li>• S-0-0121, Input revolutions of load gear</li> <li>• S-0-0122, Output revolutions of load gear</li> </ul>
	For linear axes enter the feed constant:
	<ul style="list-style-type: none"> <li>• S-0-0123, Feed constant</li> </ul>
<b>Settings for External Encoders</b>	Set "linear" or "rotary" encoder type:
	<ul style="list-style-type: none"> <li>• S-0-0115, Position feedback 2 type</li> </ul>
	Enter encoder type, hardware assignment and resolution:
	<ul style="list-style-type: none"> <li>• P-0-0075, Encoder type 2 (optional encoder)</li> <li>• P-0-0078, Assignment optional encoder-&gt;optional slot</li> <li>• S-0-0117, Resolution of feedback 2</li> </ul>
	Enter gear ratio for the external (optional) encoder:
	<ul style="list-style-type: none"> <li>• P-0-0124, Gear 2 load-side (optional encoder)</li> <li>• P-0-0125, Gear 2 encoder-side (optional encoder)</li> </ul>
<b>Settings for Measuring Wheel Encoder</b>	Activate feed constant for measuring wheel:
	<ul style="list-style-type: none"> <li>• P-0-0185, Control word of encoder 2 (optional encoder)</li> </ul>
	Enter feed constant for measuring wheel:
	<ul style="list-style-type: none"> <li>• P-0-0123, Feed constant 2 (optional encoder)</li> </ul>

## 5.7 Scaling of Physical Data

### 5.7.1 Brief Description

The controller via data maps the drive to an internal mathematical model. The status variables of the drive are determined on the basis of the following measurements:

- Position Measurement
- Current measurement
- Temperature measurement

The measured values collected in this way are converted into physical data:

- Position, velocity, acceleration and jerk data
- Current data, torque and force data
- Temperature data and load data

The master transmits command values to the drive that are used by the controller for transforming them at the motor output shaft or mechanical axis system. The drive in return registers and transmits actual values, signals operating and command states and, if necessary, generates error messages and warnings.

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	Communication between drive and master also takes place by exchanging data.
<b>Scaling</b>	An operating data (numeric value) can only be evaluated as a physical value, when the numeric value is connected to a physical unit and the position of the decimal point (decimal places). The data thereby is "scaled" in a qualitative and quantitative way.
<b>Parameters</b>	All data are stored in parameters and transmitted as parameter values (for explanations on parameters see "Parameters, Basics"). The scaling of the parameters containing data of the following physical values can be defined by the customer: <ul style="list-style-type: none"> <li>• Position</li> <li>• Velocity</li> <li>• Acceleration</li> <li>• Torque/force</li> <li>• Temperature</li> </ul>
<b>Preferred Scaling/Parameter Scaling</b>	To simplify the scaling definition so-called "preferred scalings" were predefined. But physical data can also be exchanged in the control-internal format, i.e. without specific reference to physical units. To do this, the scaling for certain data can be freely set ("parameter scaling").
<b>Linear and Rotary Data</b>	Depending on the kind of motion of motor or load, the data can be displayed as follows: <ul style="list-style-type: none"> <li>• In linear form (linear axis or motor motion)</li> </ul> - or - <ul style="list-style-type: none"> <li>• In rotary form (rotary axis or motor motion)</li> </ul>
<b>Motor Reference/Load Reference</b>	In the drive firmware there are mechanical transfer elements between motor and load mapped by means of mathematical models. The physical data can thereby be referred to <ul style="list-style-type: none"> <li>• the point where the load takes effect (load-side data reference)</li> </ul> - or - <ul style="list-style-type: none"> <li>• the point where the force is input (motor-side data reference).</li> </ul>
<b>Absolute/Modulo Evaluation</b>	For technical reasons, the value range of the position data the controller can display is limited.  In the case of axes with limited travel range (e.g. linear axes), the current axis position within the controller-side value range can be unequivocally displayed (see "Basics on Measuring Systems, Resolution").  In the case of axes with unlimited travel range (e.g. rotary axes) it is useful to limit the infinite value range of the position data to a finite value. With continuous motion, the value range is recurrently run from minimum to maximum value ("modulo" evaluation of the actual position value).
<b>Pertinent Parameters</b>	<ul style="list-style-type: none"> <li>• S-0-0043, Velocity polarity parameter</li> <li>• S-0-0044, Velocity data scaling type</li> <li>• S-0-0045, Velocity data scaling factor</li> <li>• S-0-0046, Velocity data scaling exponent</li> <li>• S-0-0055, Position polarities</li> <li>• S-0-0076, Position data scaling type</li> <li>• S-0-0077, Linear position data scaling factor</li> <li>• S-0-0078, Linear position data scaling exponent</li> </ul>

- S-0-0079, Rotational position resolution
- S-0-0085, Torque/force polarity parameter
- S-0-0086, Torque/force data scaling type
- S-0-0093, Torque/force data scaling factor
- S-0-0094, Torque/force data scaling exponent
- S-0-0103, Modulo value
- S-0-0121, Input revolutions of load gear
- S-0-0122, Output revolutions of load gear
- S-0-0123, Feed constant
- S-0-0160, Acceleration data scaling type
- S-0-0161, Acceleration data scaling factor
- S-0-0162, Acceleration data scaling exponent
- S-0-0208, Temperature data scaling type

### 5.7.2 Functional Description

**Position, Velocity and Acceleration Data**

For position, velocity and acceleration data there are the following basic scaling types:

- Linear
- Rotary

It is possible to choose between preferred scaling (predefined scaling) and parameter scaling (scaling can be individually defined).

**Preferred Scalings (Predefined)**

Depending on the scaling type setting, there are the following predefined preferred scalings:

Physical Data	Preferred scaling		
	Linear for unit "m"	Linear for unit "inch"	Rotary
Position data	0.0001 mm	0.000025 mm	0.0001 dgr
Velocity data	0.001 mm/min	0.00001 inch/min	0.0001 1/min or 0.000001 1/s

Fig. 5-83: Overview: Preferred Scalings for Position Data and Velocity Data

Physical Data	Preferred scaling			
	Linear for unit "m"	Linear for unit "inch"	Rotary Unit "rad"	Ramp time Unit "s"
Acceleration data	0.001 mm/s <sup>2</sup>	0.00001inch/s <sup>2</sup>	0.001 rad/s <sup>2</sup>	0.001 s
jerk data	0.000001 mm/s <sup>3</sup>	0.00001inch/s <sup>3</sup>	0.001 rad/s <sup>3</sup>	0.001 s <sup>2</sup>

Fig. 5-84: Overview: Preferred Scalings for Acceleration Data and Jerk Data



The jerk data scaling is derived from the acceleration data scaling.

**To be Noticed: Ramp Time Scaling Type**

The acceleration data can also be scaled with reference to a velocity ramp:

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$$\begin{aligned} \text{reference vel. ramp} &= \frac{\text{S-0-0446}}{\text{ramp reference time}} \\ &= \frac{\text{S-0-0446}}{1.0 \text{ ms}} \quad (\text{with preferred scaling}) \end{aligned}$$

S-0-0446 ramp reference velocity for acceleration data  
 Fig. 5-85: Definition of the Velocity Reference Ramp for Scaling Acceleration Data in the Case of Preferred Scaling

**Settings for Preferred Scaling**

The scaling types, units and the selection of preferred scaling are determined in the respective bits of the following parameters:

- S-0-0076, Position data scaling type
- S-0-0044, Velocity data scaling type
- S-0-0160, Acceleration data scaling type

When using preferred scaling, the parameter values for scaling type, unit, scaling factor and scaling exponent as well as the number of decimal places are automatically set for the respective data. The following tables contain an overview.

Physical data	Scaling type	Unit	S-0-0076	S-0-0077	S-0-0078	Attribute number of decimal places
Position data	Linear	mm	..xx00.0001	1	-7	4
	Linear	inch	..xx01.0001	1	-6	6
	Rotary	dgr	..xx00.0010	1	-4	4

S-0-0076 Position data scaling type  
 S-0-0077 Position data scaling factor  
 S-0-0078 Position data scaling exponent  
 Fig. 5-86: Values of Scaling Parameters and Decimal Places of Position Data Determined by Preferred Scaling

Physical Data	Scaling type	Unit	S-0-0044	S-0-0045	S-0-0046	Attribute number of decimal places
Velocity data	Linear	mm/min	..0x00.0001	1	-6	3
	Linear	inch/min	..0x01.0001	1	-5	5
	Rotary	1/min	..0x00.0010	1	-4	4
	Rotary	1/s	..0x10.0010	1	-6	6

S-0-0044 Velocity data scaling type  
 S-0-0045 Velocity data scaling exponent  
 S-0-0046 Velocity data scaling exponent  
 Fig. 5-87: Values of Scaling Parameters and Decimal Places of Velocity Data Determined by Preferred Scaling

Motor, Mechanical Axis System, Measuring Systems

Physical Data	Scaling type	Unit	S-0-0160	S-0-0161	S-0-0162	Attribute number of decimal places
Acceleration data	Linear	mm/s <sup>2</sup>	..0x00.0001	1	-6	3
	Linear	inch/s <sup>2</sup>	..0x01.0001	1	-5	5
	Rotary	rad/s <sup>2</sup>	..0x00.0010	1	-3	3
	Ramp time	s	..0x00.0011	1	-3	3

S-0-0160 Acceleration data scaling type  
 S-0-0161 Acceleration data scaling factor  
 S-0-0162 Acceleration data scaling exponent  
*Fig. 5-88: Values of Scaling Parameters and Decimal Places of Acceleration Data Determined by Preferred Scaling*



For practical reasons, the metric measures of length in the case of preferred scaling are scaled in "mm". This when reading the respective parameter can also be seen from the corresponding "unit" data element. The decimal places are adjusted to the current unit.

**Parameter Scaling (Individually Defined)**

As an alternative to preferred scaling it is also possible to activate parameter scaling. For parameter scaling the least significant bit (LSB) of the respective operating data can be individually defined.



By means of parameter scaling it is possible to modify the range of values of physical data!

Example: The maximum value for "S-0-0278, Maximum travel range" can be increased by reducing the number of decimal places of the position data.

position data, linear	$LSB = \text{unit}^{1)} \times \text{scaling factor}^{1)} \times 10^{SE}$
position data, rotary	$LSB = \frac{360}{\text{rotational pos. resolution}^{2)}} \times \text{unit}^{2)}$
velocity data	$LSB = \frac{\text{unit (position data)}}{TU} \times \text{scaling factor} \times 10^{SE}$
acceleration data (linear, rotary)	$LSB = \frac{\text{unit (position data)}}{TU^2} \times \text{scaling factor} \times 10^{SE}$
acceleration data (ramp time scaling)	$LSB = \frac{S-0-0446}{\text{scaling factor} \times 10^{SE}}$
jerk data	$LSB = \frac{\text{unit (position data)}}{TU^3} \times \text{scaling factor} \times 10^{SE}$

1) With scaling factor ≠ 1 the unit is no longer indicated as in S-0-0076, but only "incrementally" (control-dependent unit reference).

2) With rotational position resolutions (S-0-0079) which do not result in powers of 10 of 360, the unit is no longer angular degrees (acc. to S-0-0076) but only "incremental" (control-dependent unit reference).

LSB least significant bit

SE scaling exponent

TU Unit of time

S-0-0446 Ramp reference velocity for acceleration data

*Fig. 5-89: Defining the Least Significant bit (LSB) for Parameter Scaling*

Motor, Mechanical Axis System, Measuring Systems

 The jerk data scaling is derived from the acceleration data scaling.

Respective units of measurement and time defined in the parameters:

- S-0-0076, Position data scaling type
- S-0-0044, Velocity data scaling type
- S-0-0160, Acceleration data scaling type

Respective scaling factor and scaling exponent defined in the following parameters:

- S-0-0077, Linear position data scaling factor
- S-0-0078, Linear position data scaling exponent
- S-0-0045, Velocity data scaling factor
- S-0-0046, Velocity data scaling exponent
- S-0-0161, Acceleration data scaling factor
- S-0-0162, Acceleration data scaling exponent


For rotary position data the value of the following parameter, in the case of parameter scaling, must be determined for defining the LSB:

- S-0-0079, Rotational position resolution

**Torque/Force Data**

For torque/force data there are the following basic scaling types:

- Linear
- Rotary
- Percentage-based

 It is only possible to select preferred scaling (predefined scaling)!

Physical value	Preferred scaling		
	Linear	Rotary	Percentage-based
Torque	--	0.01 Nm or 0.1 inlbf	0,1%
force	1 N or 0.1 lbf	--	0,1%

Fig.5-90: Preferred Scalings for Torque/Force Data

The scaling types and units can be determined in the respective bits of parameter

- S-0-0086, Torque/force data scaling type.


As individually defined scaling is impossible for torque/force data, the following parameters have fixed values corresponding to preferred scaling:

- S-0-0093, Torque/force data scaling factor und
- S-0-0094, Torque/force data scaling exponent

**Temperature Data**

For temperature data only the following units can be selected:

- Degree Celsius (°C)
- Fahrenheit (F)

 For temperature data is it only possible to select preferred scaling (predefined scaling)!



Physical value	Preferred scaling	
	Celsius	Fahrenheit
Temperature	0.1 °C	0.1 F

Fig.5-91: Preferred Scalings for Temperature Data

**Motor Reference/Load Reference**

The reference of position, velocity, acceleration, jerk and torque/force data can be selected for:

- Point where the motor force is input ("motor reference") or
- Point where the load takes effect ("load reference").

To do this, it is necessary to transmit the data of the mechanical transfer elements between motor, encoders and point where the load takes effect to the controller via the following parameters:

- S-0-0121, Input revolutions of load gear
- S-0-0122, Output revolutions of load gear
- S-0-0123, Feed constant
- S-0-0277, Position feedback 1 type
- S-0-0115, Position feedback 2 type
- P-0-0121, Gear 1 motor-side (motor encoder)
- P-0-0122, Gear 1 encoder-side (motor encoder)
- P-0-0124, Gear 2 load-side (optional encoder)
- P-0-0125, Gear 2 encoder-side (optional encoder)

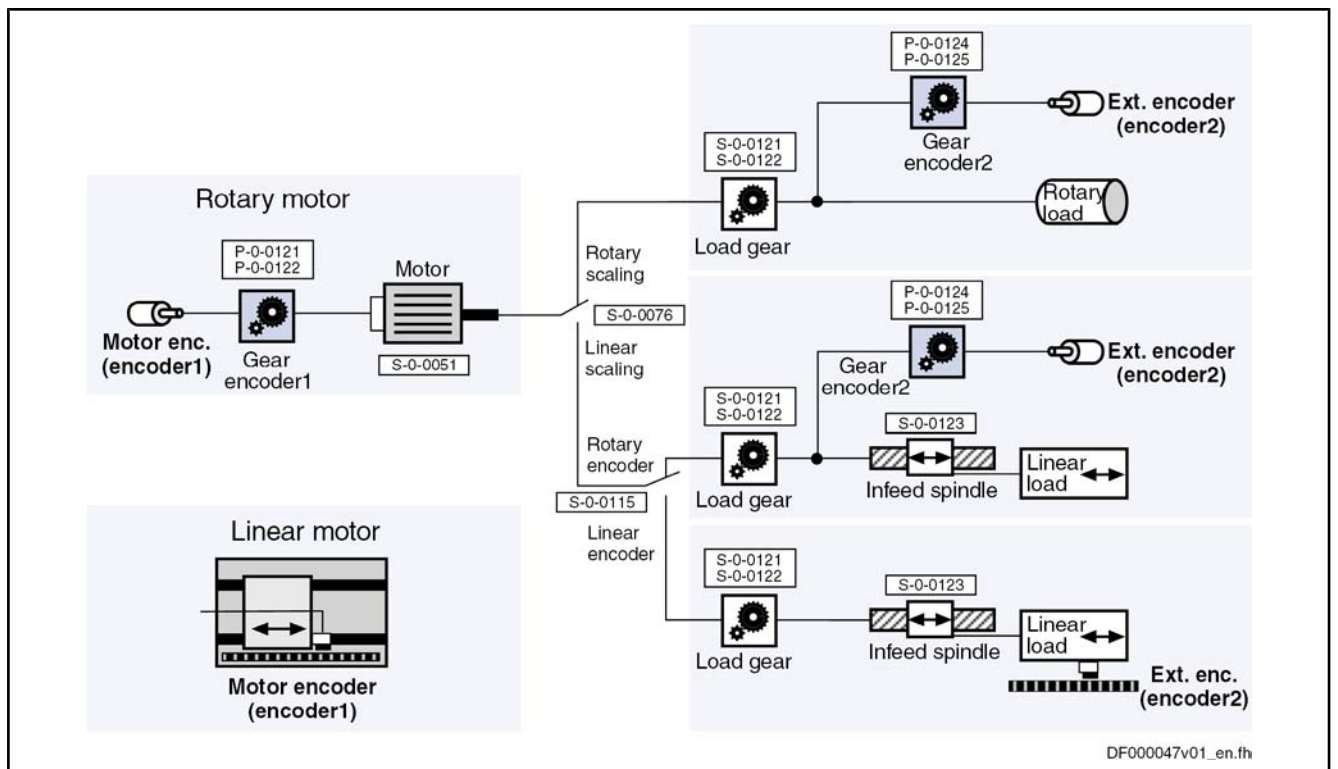


Fig.5-92: Mechanical Transfer Elements Between Motor, Encoders and Load



For linear motors the motor reference is the same as the load reference because the point where the force is input and point where the load takes effect are identical. There aren't any mechanical transfer elements!

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**Polarity** The polarity of the position, velocity and torque/force data can be changed from positive to negative polarity in the following parameters:

- S-0-0055, Position polarities
- S-0-0043, Velocity polarity parameter
- S-0-0085, Torque/force polarity parameter

Depending on the mounting situation (especially of kit motors and their respective motor encoder or external encoder), this allows determining the appropriate polarity of the respective data for the machine axis.

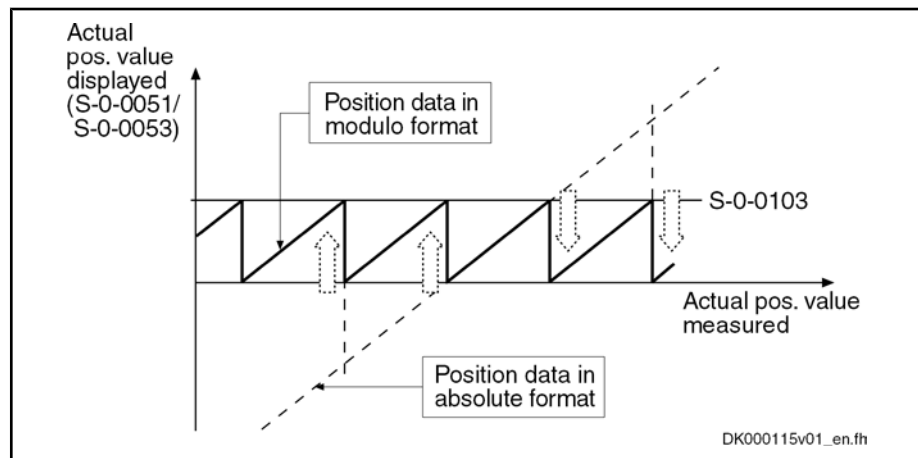
**Modulo Scaling** Via the respective bit of "S-0-0076, Position data scaling type" it is possible to select between two formats for the position data format:

- Absolute format
- Modulo format

If the position data of an axis with infinite travel range (e.g. rotary axis, spindle etc.) were processed in absolute format, the axis would risk to move beyond the value range of the position data. This would lead to invalid position data; operating modes with position control would not be safe to operate.

The value range for modulo format is limited, only position data between the value 0.00... and a maximum value to be determined in "S-0-0103, Modulo value" are possible.

When the measured actual position value exceeds the value range or falls below it, the actual position value displayed in parameter S-0-0051 or S-0-0053 behaves unsteadily, i.e. it changes by the absolute value of the modulo value range in such a way that the actual position value displayed always remains within the modulo value range.



- S-0-0051 Position feedback 1 value
- S-0-0053 Position feedback 2 value
- S-0-0103 Modulo value

Fig.5-93: Actual Position Value for Axis Motion With Constant Velocity for Absolute and Modulo Format

**Modulo Format - Requirements**

The "modulo format" selection for actual position values is only appropriate for rotary motors, because a mechanically unlimited travel range is only possible for axes with rotary motors. The "modulo format" therefore is only allowed for rotary motors, not for linear motors!



The condition "rotary motor" for selecting "modulo format" is checked when the drive progresses to the ready-for-operation status. If the condition has not been fulfilled, an error is signaled!

**Restrictions/Conditions for "Modulo Format"**

When using the modulo format, the following restrictions and conditions have to be observed and complied with:

- Due to the firmware-internal conversion of absolute format to modulo format, the allowed maximum velocity is as follows:

$$v_{\max} = \frac{(S-0-0103)}{2 \text{ ms}}$$

$v_{\max}$  maximum velocity or maximum angular velocity

S-0-0103 Modulo value

Fig. 5-94: Allowed Maximum Velocity for Modulo Format

**WARNING****Possible property damage caused by errors when controlling motors and moving parts!**

⇒ The value in "S-0-0091, Bipolar velocity limit value" must not be higher than the allowed maximum velocity for modulo format!

- In the case of encoders evaluated in absolute form, the mechanical drive system, with the drive switched off, may as a maximum be moved by a distance or angle corresponding to half the absolute encoder rang ("S-0-0378, Absolute encoder range of motor encoder" or "S-0-0379, Drive Halt acceleration bipolar")! The actual position value after switching on can otherwise be incorrect! This, however, cannot be diagnosed on the controller side!

**WARNING****Possible property damage caused by errors when controlling motors and moving parts!**

⇒ Block the mechanical system with drive switched off by self-holding holding brake or self-locking gear!

See also "Absolute Measuring Systems"

- The following conditions have to be complied with in the case of rotary modulo scaling:

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Scaling type of position data →	Modulo scaling, rotary position reference		
External encoder →	External encoder available		No external encoder available
Type of motion of external encoder →	Rotary	Linear not possible!	
Conditions (No.) to be complied with →	1; 2; 3; 4; 5; 6	---	1; 2; 4; 5
Conditions →	<p><b>No. 1:</b> <math>S-0-0079 \times S-0-0122 = 2^{64}</math></p> <p><b>No. 2:</b> <math>S-0-0079 \times P-0-0121 \times S-0-0122 = 2^{64}</math></p> <p><b>No. 3:</b> <math>S-0-0079 \times P-0-0124 \times S-0-0121 = 2^{64}</math></p> <p><b>No. 4:</b> <math>S-0-0103 \times P-0-0129 \times S-0-0121 = 2^{64}</math></p> <p><b>No. 5:</b> <math>S-0-0103 \times S-0-0116 \times P-0-0122 \times S-0-0121 = 2^{64}</math></p> <p><b>No. 6:</b> <math>S-0-0103 \times S-0-0117 \times P-0-0125 \times S-0-0122 = 2^{64}</math></p>		

- S-0-0079 Rotational position resolution
- S-0-0103 Modulo value
- S-0-0116 Feedback 1 Resolution
- S-0-0117 Feedback 2 Resolution
- S-0-0121 Input revolutions of load gear
- S-0-0122 Output revolutions of load gear
- P-0-0121 Gear 1 motor-side (motor encoder)
- P-0-0122 Gear 1 encoder-side (motor encoder)
- P-0-0124 Gear 2 load-side (optional encoder)
- P-0-0125 Gear 2 encoder-side (optional encoder)
- P-0-0129 Internal position data format

*Fig.5-95: Conditions for Modulo Scaling and Rotary Position Reference*



Rotary modulo scaling is impossible for linear external encoder!

- Only load reference is possible for linear modulo scaling. Depending on the use of an external encoder the following conditions have to be complied with:

Scaling type of position data →	Modulo scaling, linear position reference		
Reference →	Motor reference not possible!	Load reference	
External encoder →	---	External encoder available	No external encoder available
Type of motion of external encoder →	---	Rotary	Linear
Conditions (No.) to be complied with →	---	1; 2; 3; 4; 5; 6	1; 2; 3; 4; 5; 7
Conditions →	No. 1: $S-0-0103 \times S-0-0121 \times P-0-0129 = 2^{64}$ No. 2: $S-0-0123 \times S-0-0122 = 2^{64}$ No. 3: $S-0-0103 \times S-0-0121 \times P-0-0122 \times S-0-0116 = 2^{64}$ No. 4: $S-0-0123 \times S-0-0122 \times P-0-0121 = 2^{64}$ No. 5: $S-0-0103 \times P-0-0125 \times S-0-0117 = 2^{64}$ No. 6: $S-0-0123 \times P-0-0124 = 2^{64}$ No. 7: $S-0-0103 \times S-0-0077 \times 10^{(S-0-0078)} = 2^{64}$		

S-0-0077	Linear position data scaling position data
S-0-0078	Linear position data scaling position data
S-0-0103	Modulo value
S-0-0116	Feedback 1 Resolution
S-0-0117	Feedback 2 Resolution
S-0-0121	Input revolutions of load gear
S-0-0122	Output revolutions of load gear
S-0-0123	Feed constant
P-0-0121	Gear 1 motor-side (motor encoder)
P-0-0122	Gear 1 encoder-side (motor encoder)
P-0-0124	Gear 2 load-side (optional encoder)
P-0-0125	Gear 2 encoder-side (optional encoder)
P-0-0129	Internal position data format

Fig. 5-96: Conditions for Modulo Scaling and Linear Position Reference



Linear modulo scaling is impossible for motor reference!

### 5.7.3 Notes on Commissioning

#### General Information

##### Basic Scaling Settings

First make the basic scaling settings for position, velocity, acceleration and torque/force data. This is only possible in the parameter mode (communication phase 2).

You have to determine:

- Scaling type (rotary/linear/without scaling/percentage-based, if necessary)
- Unit of measurement and unit of time, if necessary
- Data reference (motor/load)
- Absolute/modulo format for position data
- Preferred scaling (predefined) or parameter scaling (can be individually defined)

To do this, set the respective bits in the following parameters:

- S-0-0076, Position data scaling type
- S-0-0044, Velocity data scaling type
- S-0-0160, Acceleration data scaling type
- S-0-0086, Torque/force data scaling type

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**Settings and Tips for Modulo Scaling** When selecting "modulo format" the value range limit has to be set in "S-0-0103, Modulo value".



For "modulo format" enter a value greater than or equal to the value of parameter S-0-0103 in "S-0-0278, Maximum travel range"!



**Danger of incorrect actual position value of encoders evaluated in absolute form after switching the drive on, when the mechanical drive system, with the drive switched off, was moved in the case of modulo scaling!**

⇒ Ensure that the mechanical axis system, with the drive switched off, is moved by a distance or an angle corresponding to half the absolute encoder rang as a maximum ("S-0-0378, Absolute encoder range of motor encoder" or "S-0-0379, Absolute encoder range of optional encoder")!

**Temperature Scaling** In addition, make the scaling settings for temperature data "S-0-0208, Temperature data scaling type".

## Individual Settings for Parameter Scaling

### Further Settings for Parameter Scaling

Position data:

- S-0-0077, Linear position data scaling factor
- S-0-0078, Linear position data scaling exponent

- or -

- S-0-0079, Rotational position resolution

Velocity data:

- S-0-0045, Velocity data scaling factor
- S-0-0046, Velocity data scaling exponent

Acceleration data:

- S-0-0161, Acceleration data scaling factor
- S-0-0162, Acceleration data scaling exponent

## Diagnostic Messages of Scaling Setting

If inadmissible scaling settings were made, they are detected when switching from parameter mode (communication phase 2) to operating mode (communication phase 4). The drive in this case does not reach the operating mode and, according to setting, displays the following command errors:

- C0101 Invalid parameters (-> S-0-0021)
- C0102 Limit error in parameter (-> S-0-0021)
- C0103 Parameter conversion error (->S-0-0021)
- C0122 Incorr. parameteriz. of motor enc. (mechanical system)
- C0123 Modulo value for motor encoder cannot be displayed
- C0127 Incorr. parameteriz. of opt. enc. (mechanical system)
- C0128 Modulo value for optional encoder cannot be displayed
- C0140 Rotary scaling not allowed

## Example of Scaling Settings

There are many possibilities to make settings for the scaling type. The table below shows useful settings for which there aren't any command errors to be expected:

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Mechanical system			Encoder		Useful scaling type settings		
Motor	Load gear	Feed spindle	Motor encoder	External encoder	Motor reference	Load reference	Modulo
Rotary	Available	Not available	Rotary	No	Rotary	Rotary	Possible
Rotary	Available/not available	Available	Rotary	No	Rotary	---	Possible
Rotary	Available/not available	Available	Rotary	No	---	Linear	Possible
Rotary	Available	Not available	Rotary	Rotary	Rotary	Rotary	Possible
Rotary	Available/not available	Available	Rotary	Rotary	Rotary	---	Possible
Rotary	Available/not available	Available	Rotary	Rotary	---	Linear	Possible
Rotary	Available/not available	Available	Rotary	Linear	Rotary	---	Possible
Rotary	Available/not available	Available	Rotary	Linear	---	Linear	Possible
Linear	Not available	Not available	Linear	---	---	Linear	Not possible

*Fig.5-97: Useful Scaling Type Settings Depending on Mechanical Drive System and Measuring Systems*





## 6 Drive Control

### 6.1 Overview of Drive Control

#### 6.1.1 Basic Principles and Terms

The IndraDrive firmware supports the following two basic principles of drive control:

- **Open-loop axis control** (U/f control, flux-controlled FXC operation)  
→ Open-loop-controlled operation without encoder information
- **Closed-loop axis control** (various methods of control)  
→ Closed-loop-controlled operation with encoder feedback (position, velocity and current)



When selecting the functional packages, take the desired method of control into account as you have to choose between "open-loop" and "closed-loop base package"!

Operation mode / command value adjustment	Control mode	Functional principle of motor	Encoder available	Required base package	Method of control
U/f control with command value adjustment of the velocity control	Voltage-controlled operation	Asynchronous	Yes	Closed-loop	Not relevant
			No	Open-loop	U/f control
Torque/force control	Field-oriented current control	Asynchronous	Yes	Closed-loop	FOC control
			No	--	No procedure available
		Synchronous	Yes	Closed-loop	FOC control
			No	--	No procedure available
Velocity control / velocity synchronization	Velocity control	Asynchronous	Yes	Closed-loop	FOC control
			No	Open-loop	FXC control
		Synchronous	Yes	Closed-loop	FOC control
			No	Open-loop	FXC control
Position control, drive-controlled positioning, positioning block mode, phase synchronization, electronic cam	Position control	Asynchronous	Yes	Closed-loop	FOC control
			No	Closed-loop	FXC control <sup>1)</sup>
		Synchronous	Yes	Closed-loop	FOC control
			No	Closed-loop	FXC control <sup>1)</sup>

1) Only with external encoder

Fig. 6-1: Overview: Operation Modes and Available Control Methods



For scaling the drive firmware, we distinguish between the functional base packages with "open-loop" and "closed-loop" characteristic; in this case, however, the meaning is not identical to how the terms are used in conjunction with drive control!

See also section "Overview of Functions/Functional Packages"

## Drive Control

## 6.1.2 Principles of Drive Control

## Overview of Open-Loop Axis Control

Open-loop axis control allows open-loop-controlled operation of the drive without motor encoder (U/f control).

The primary operation mode "velocity control" is configured, but only the command value processing specific to this operation mode takes effect. Closed-loop control (position and velocity) and functions and operation modes depending thereof are not possible.

See "Voltage-Controlled Open-Loop Operation (U/f Control)"

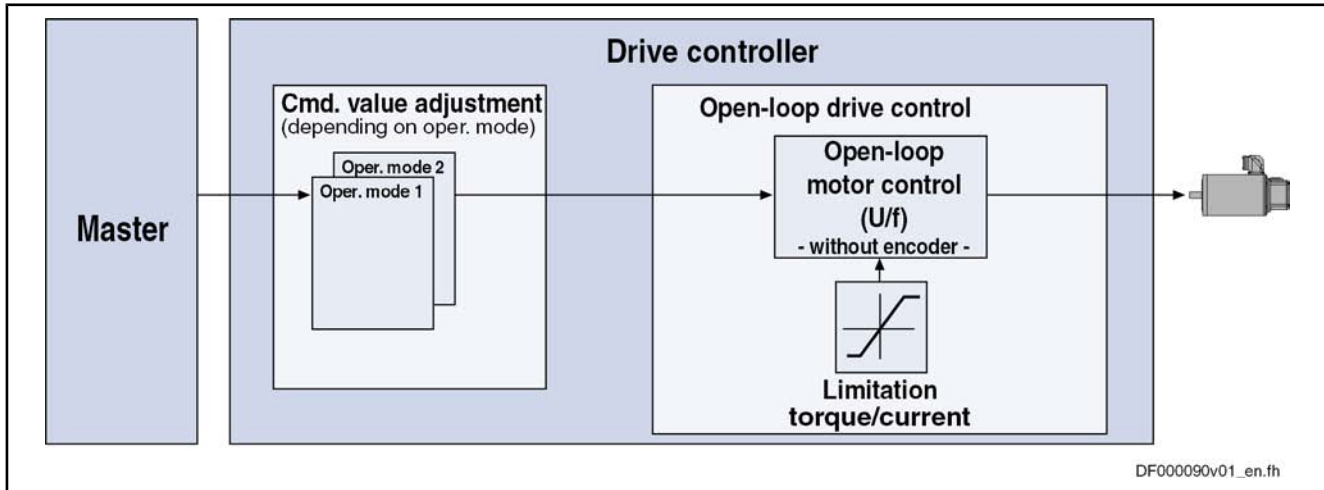


Fig. 6-2: Principle of Drive Control (Open-Loop Operation)

See also section "Closed-Loop Axis Control (Closed-Loop Operation)"

See also section "Overview of Functions/Functional Packages"

## Overview of Closed-Loop Axis Control



The base package "closed-loop" also contains the functions of the base package "open-loop".

Closed-loop axis control allows closed-loop controlled operation of the drive; we distinguish between two principles of drive control:

- **Operation with encoder**

The velocity control loop and the position control loop are closed by means of the encoder feedback so that the following operation modes are supported by field-oriented current control with encoder feedback:

- Velocity control
- Position control with cyclic command value input
- Positioning modes (e.g. drive-controlled positioning)
- Synchronization modes

- **Operation without encoder**

The velocity control loop is closed by means of a motor model (monitor) so that field-oriented current control without encoder feedback supports velocity control without encoder.

See section "Field-Oriented Current Control"

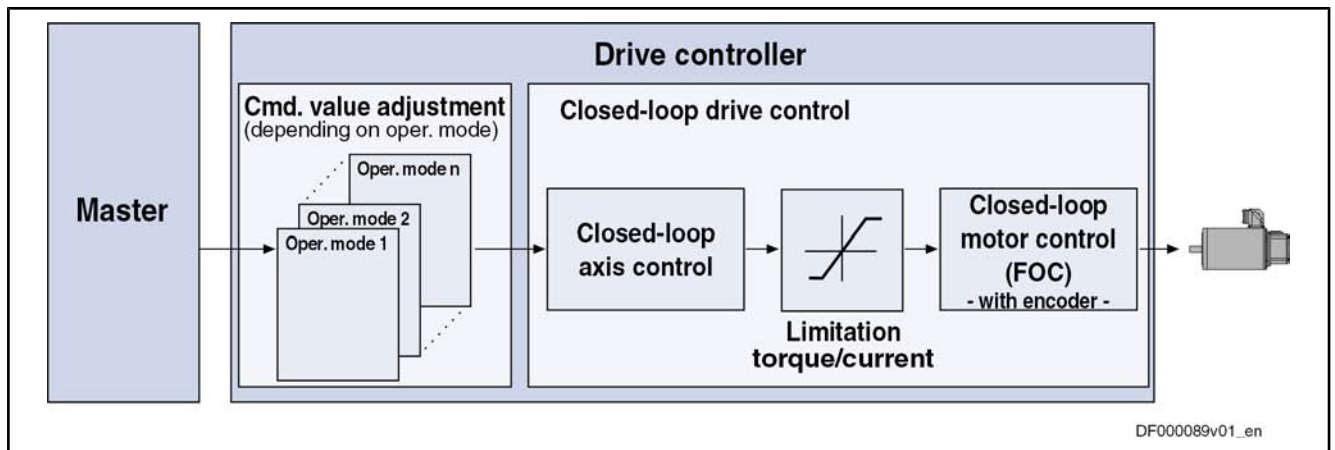


Fig.6-3: Principle of Drive Control (Closed-Loop Operation)

See also section "Open-Loop Axis Control (Open-Loop Operation)"

See also section "Overview of Functions/Functional Packages"

## 6.1.3 Control Loop Structure

### General Information

The drive controller has a so-called cascade structure, i.e. the individual loops (position, velocity and current) are interconnected in cascaded form. Depending on the active operation mode, only the torque/force control loop, the torque/force control loop and the velocity control loop or, in addition to these two control loops, the position control loop are closed in the drive.

**Torque/Force Control** The "torque/force control" mode actually is not torque or force control but current control. Therefore, only the current control loop is closed in the drive.

See also "Torque/Force Control"

**Velocity Control** In the "velocity control" mode, the velocity control loop, apart from the current control loop, is closed in the drive, too.

See also "Velocity Control"

**Position Control** For the following position control modes, the position control loop, apart from the current and velocity control loops, is closed internally (in the drive):

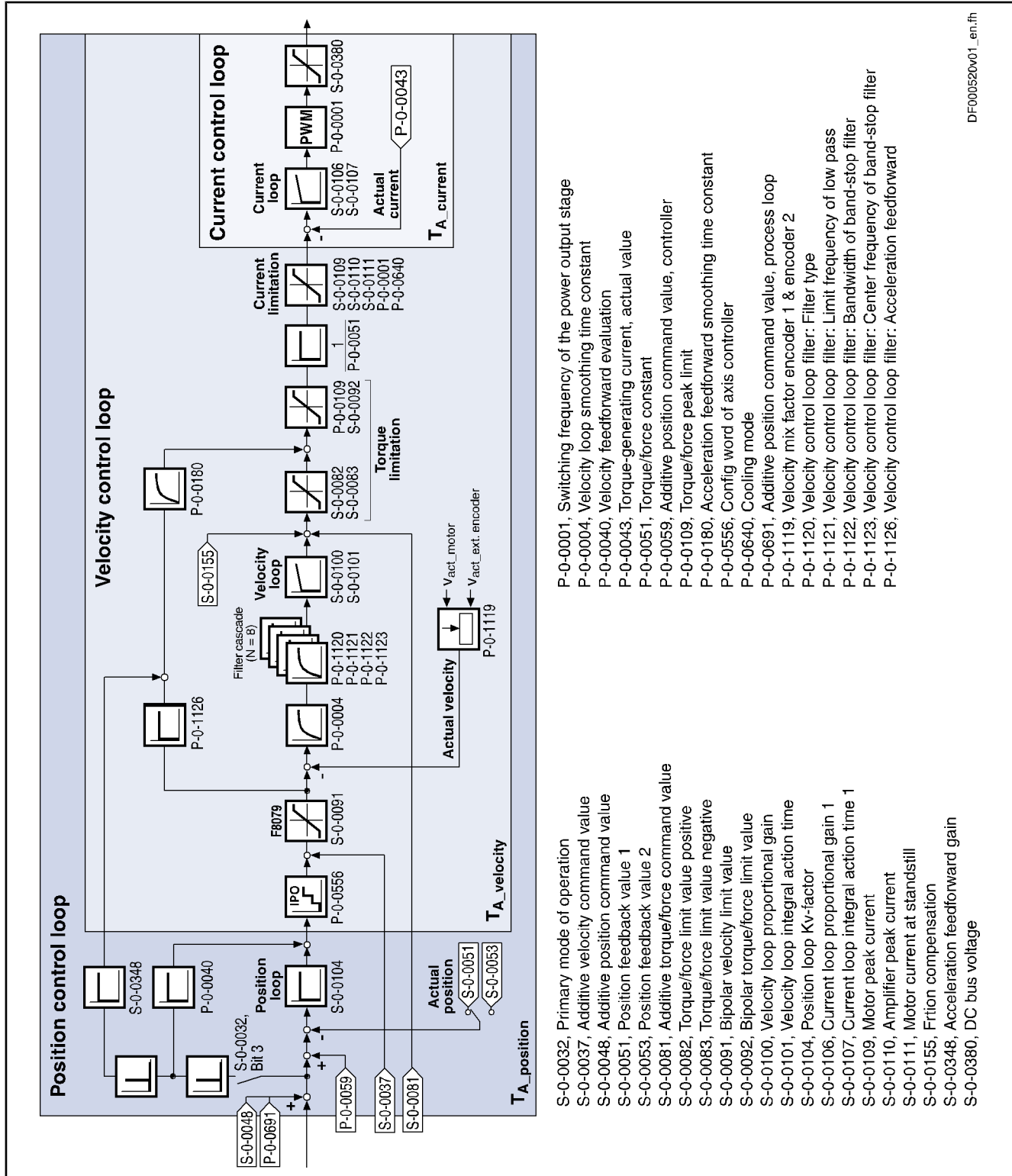
- Position control with cyclic command value input
- Drive-internal interpolation
- Drive-controlled positioning

See also description of the respective operation mode

The figures in the following two paragraphs contain an overview of the structure and the interaction of the control loops (distinguished according to the illustration of the setting parameters and the display parameters).

Drive Control

Control Loop Structure With Setting Parameters



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$T_A$

Sampling times (see table in the chapter "Features of the Control Loops")

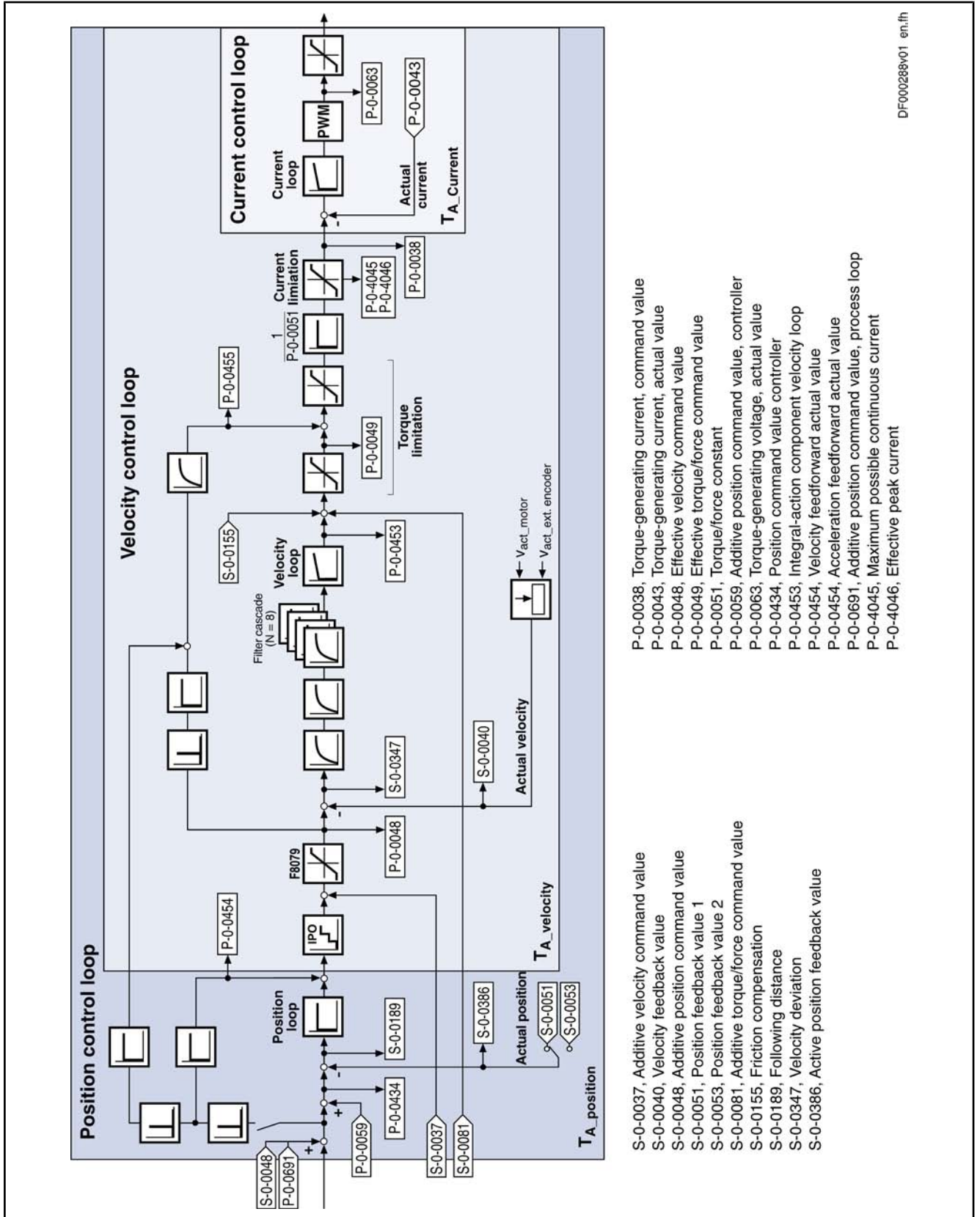
Fig. 6-4:

Overall Structure of the Control Loops With Points at Which the Setting Parameters Take Effect (Example for Field-oriented Control With Encoder)

- P-0-0001, Switching frequency of the power output stage
- P-0-0004, Velocity loop smoothing time constant
- P-0-0040, Velocity feedforward evaluation
- P-0-0043, Torque-generating current, actual value
- P-0-0051, Torque/force constant
- P-0-0059, Additive position command value, controller
- P-0-0109, Torque/force peak limit
- P-0-0180, Acceleration feedforward smoothing time constant
- P-0-0556, Config word of axis controller
- P-0-0640, Cooling mode
- P-0-0691, Additive position command value, process loop
- P-0-1119, Velocity mix factor encoder 1 & encoder 2
- P-0-1120, Velocity control loop filter: Filter type
- P-0-1121, Velocity control loop filter: Limit frequency of low pass
- P-0-1122, Velocity control loop filter: Bandwidth of band-stop filter
- P-0-1123, Velocity control loop filter: Center frequency of band-stop filter
- P-0-1126, Velocity control loop filter: Acceleration feedforward

- S-0-0032, Primary mode of operation
- S-0-0037, Additive velocity command value
- S-0-0048, Additive position command value
- S-0-0051, Position feedback value 1
- S-0-0053, Position feedback value 2
- S-0-0081, Additive torque/force command value
- S-0-0082, Torque/force limit value positive
- S-0-0083, Torque/force limit value negative
- S-0-0091, Bipolar velocity limit value
- S-0-0092, Bipolar torque/force limit value
- S-0-0100, Velocity loop proportional gain
- S-0-0101, Velocity loop integral action time
- S-0-0104, Position loop Kv-factor
- S-0-0106, Current loop proportional gain 1
- S-0-0107, Current loop integral action time 1
- S-0-0109, Motor peak current
- S-0-0110, Amplifier peak current
- S-0-0111, Motor current at standstill
- S-0-0155, Friction compensation
- S-0-0348, Acceleration feedforward gain
- S-0-0380, DC bus voltage

Control Loop Structure With Display Parameters



$T_A$  Sampling times (see table in the chapter "Features of the Control Loops")

Fig. 6-5: Overall Structure of the Control Loops With Display Parameters (Exam-

- P-0-0038, Torque-generating current, command value
- P-0-0043, Torque-generating current, actual value
- P-0-0048, Effective velocity command value
- P-0-0049, Effective torque/force command value
- P-0-0051, Torque/force constant
- P-0-0059, Additive position command value, controller
- P-0-0063, Torque-generating voltage, actual value
- P-0-0434, Position command value controller
- P-0-0453, Integral-action component velocity loop
- P-0-0454, Velocity feedforward actual value
- P-0-0454, Acceleration feedforward actual value
- P-0-0691, Additive position command value, process loop
- P-0-4045, Maximum possible continuous current
- P-0-4046, Effective peak current

- S-0-0037, Additive velocity command value
- S-0-0040, Velocity feedback value
- S-0-0048, Additive position command value
- S-0-0051, Position feedback value 1
- S-0-0053, Position feedback value 2
- S-0-0081, Additive torque/force command value
- S-0-0155, Friction compensation
- S-0-0189, Following distance
- S-0-0347, Velocity deviation
- S-0-0386, Active position feedback value

## Drive Control

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## 6.1.4 Features of the Control Loops

### Performance (Controller Cycle Times)

The internal controller cycle times (current, velocity and position) depend on the following conditions and parameters:

- Control section design (CSH, CSB or CDB)
- Activation of the functional packages
- P-0-0001, Switching frequency of the power output stage
- P-0-0556, Config word of axis controller (bits 2 and 5)

Depending on these factors, the following cycle and switching times can be achieved:

	ADVANCED control sections	BASIC control sections
PWM switching frequency	Max. 16 kHz	Max. 8 kHz
Current loop clock ( $T_{A\_current}$ )	62.5 $\mu$ s	125 $\mu$ s
Velocity loop clock ( $T_{A\_velocity}$ )	125 $\mu$ s	250 $\mu$ s
Position loop clock ( $T_{A\_position}$ )	250 $\mu$ s	500 $\mu$ s

Fig. 6-6: Cycle and Switching Times to be Achieved With IndraDrive



All performance data are listed under "System Overview: Performance Data".

### Current Loop

The current loop is characterized by the following features:

- PI loop for d-axis and q-axis of the field-oriented d-q coordinate system (S-0-0106, S-0-0107)
- Inductance feedforward for decoupling d-axis and q-axis (P-0-4017, P-0-4016) for synchronous motors
- Inductance characteristic for adjusting the current loop parameters in the case of saturation phenomena
- Precontrol of e.m.f.

### Velocity Loop

The velocity loop is characterized by the following features:

- Standardization of the output value at the velocity loop to Newton (N) or Newton meter (Nm); therefore, depending on the motor type, the following unit results for "S-0-0100, Velocity loop proportional gain":
  - Rotary motor  $\rightarrow$  Nm \* s/rad
  - Linear motor  $\rightarrow$  N \* min/mm
- Extended filter possibilities for filtering resonance frequencies (4 filters of 2nd degree available; setting via P-0-1120, P-0-1121, P-0-1122 and P-0-1123)
- Limiting the acceleration in velocity control by setting in "S-0-0138, Bipolar acceleration limit value"

## Position Loop

The position loop is characterized by the following features:

- Jerk limitation in the operation mode "cyclic position control" in "S-0-0349, Bipolar jerk limit" can be set; filter degree of smoothing filter (moving average) in "P-0-0042, Current position command average value filter order" can be set
- Velocity feedforward (degree of feedforward) can be set in "P-0-0040, Velocity feedforward evaluation" (0% ... 100%)
- Input value for "S-0-0348, Acceleration feedforward gain":
  - Inertia in  $\text{kg}\cdot\text{m}^2$  (for rotary motors)
  - or -
  - Mass in kg (for linear motors)

### 6.1.5 General Notes on Commissioning and Application

#### Additive Command Values and Possibilities of Accessing Outer Control Loops

In closed-loop operation it is possible to add command values in addition to the command values available in the control loop. Depending on the active operation mode, the following parameters are available to do this:

Operation mode	S-0-0081	S-0-0037	P-0-0059	S-0-0048
U/f control (command value processing in velocity control)	--	--	--	--
Torque/force control		--	--	--
Velocity control / velocity synchronization			--	--
Position control				--
Drive-controlled positioning				--
Positioning block mode				--
Phase synchronization			--	
Electronic cam			--	

S-0-0081 Additive torque/force command value

S-0-0037 Additive velocity command value

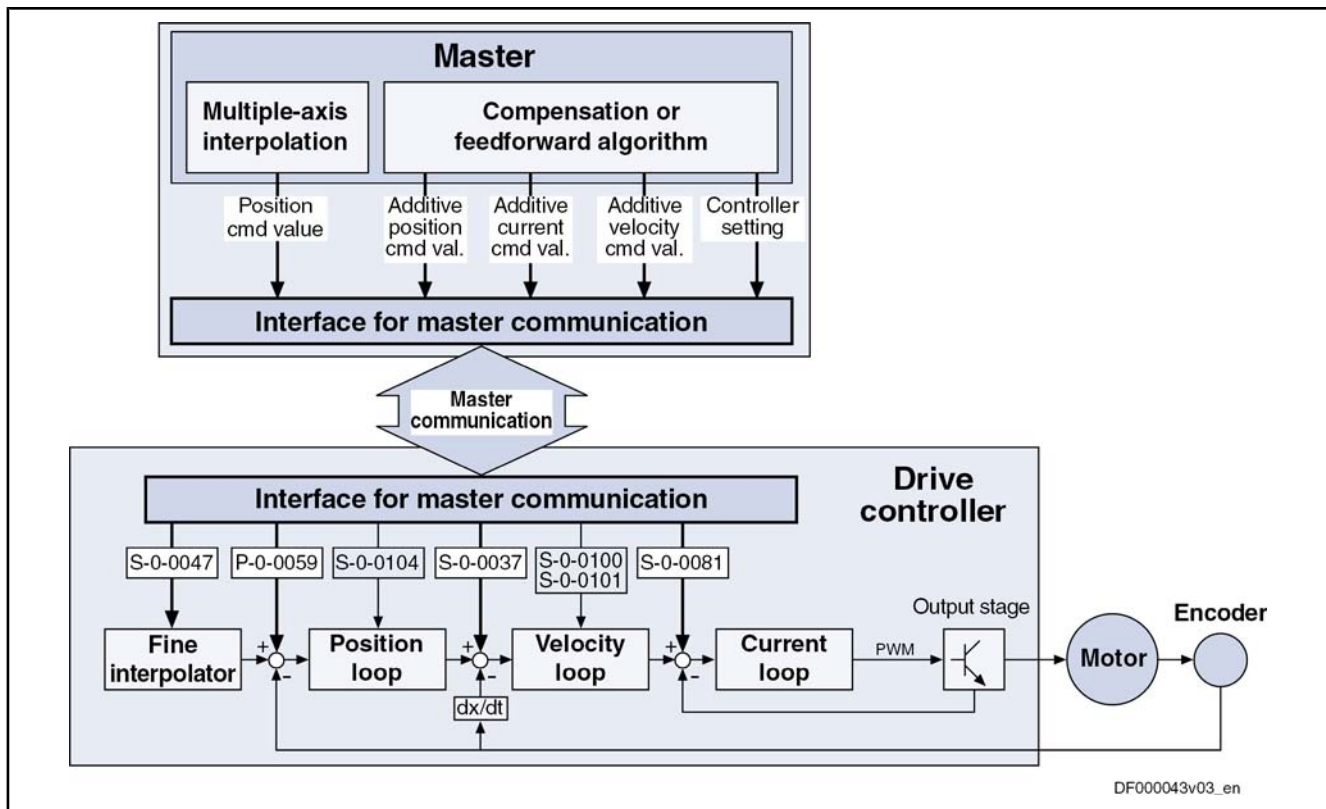
P-0-0059 Additive position command value, controller

S-0-0048 Additive position command value

*Fig. 6-7: Overview of the Additive Command Values Depending on the Operation Mode*

In closed-loop operation, it is possible to access the outer control loops from a higher-level operation mode. The access options to the individual control loops are illustrated in the following example:

Drive Control



- S-0-0037 Additive velocity command value
- S-0-0047 Position command value
- S-0-0081 Additive torque/force command value
- S-0-0100 Velocity loop proportional gain
- S-0-0101 Velocity loop integral action time
- S-0-0104 Position loop Kv-factor
- P-0-0059 Additive position command value, controller

Fig.6-8: Structural Overview Including Access Options (Example for Operation Mode "Position Control With Cyclic Command Value Input")

### Notes on Commissioning of the Control Loop Setting

The control loop settings in a digital drive controller are very important for the features of the servo axis.

To optimize the control loop setting, application-specific controller parameters are available for all digital Rexroth drives.

#### Order of Manual Control Loop Setting

Due to the cascade structure of the control loops it is necessary to parameterize them "from the inside to the outside". The resulting order for setting the control loops is as follows:

##### 1. Current control loop

For **Rexroth motors with motor encoder data memory** (MSK, MHD, MKD and MKE lines), optimizing the current loop is not required because the corresponding parameter values (S-0-0106 and S-0-0107) are read from the motor encoder data memory.

For all **Rexroth Motors without motor encoder data memory** (e.g. linear motors), the parameter settings can be taken from a central motor data base via the "IndraWorks Ds/D/MLD" commissioning tool.

The commissioning of **third-party motors** (incl. control loop setting) is described in the respective sections on third-party motors in this documentation (see "Third-Party Motors at IndraDrive Controllers").



## 2. Velocity control loop

The settings of the velocity loop (S-0-0100 und S-0-0101) with the respective filters (P-0-0004 and P-0-1120, P-0-1121, P-0-1122, P-0-1123) on the one hand depend on the motor parameters (inertia and torque/force constant), on the other hand they strongly depend on the mechanical properties (load inertia/mass, friction, stiffness of the connection, ...). Therefore, manual or automatic optimization is often necessary.

## 3. Position control loop

In general, the position control loop only has to be adjusted to the dynamics of the outer velocity loop, as well as to the kind of preset command values (jerk, acceleration and interpolation procedure).

## Default Settings in the Motor Encoder Data Memory ("Load Defaults Procedure")

### "Load Defaults Procedure" Command

For all Rexroth motors of the lines with motor encoder data memory (e.g. MHD, MKD, MKE, MSK and possibly MAD and MAF), the basic settings for the controllers are stored and can be loaded to the drive by executing the "load defaults procedure" command (S-0-0262).

"There are two ways to activate the S-0-0262, C07\_x Load defaults procedure command":

- Automatically when running up the drive by recognizing that the motor type (cf. S-0-0141) has changed. The display then reads "RL" and the "load defaults procedure" command is internally started by pressing the "Esc" button on the control panel, unless this was deactivated in "P-0-0556, Config word of axis controller".
- Starting the command by writing "11b" to S-0-0262.

See also "Loading, Storing and Saving Parameters"



In order to start the command "load defaults procedure" the value "0" must have been set in "P-0-4090, Configuration for loading default values" (default setting).

During the load defaults procedure, the following control loop parameters are set to their default values optimized for the respective motor:

- S-0-0100, Velocity loop proportional gain
- S-0-0101, Velocity loop integral action time
- S-0-0104, Position loop Kv-factor
- S-0-0106, Current loop proportional gain 1
- S-0-0107, Current loop integral action time 1
- P-0-0004, Velocity loop smoothing time constant



The default settings for the current loop (cf. S-0-0106 and S-0-0107) are automatically adjusted to the currently parameterized PWM frequency (cf. P-0-0001) and performance setting (cf. P-0-0556)!

In addition, during the load defaults procedure, the following control loop parameter is set to its firmware-side default values, although there haven't any default values been stored for them in the motor data memory:

- S-0-0348, Acceleration feedforward gain

## Drive Control



In the majority of cases, the controller settings stored in the motor encoder data memory provide a useful and reliable control loop setting. In exceptional cases, however, it may be necessary to make the settings with regard to the specific application.

## 6.2 Motor Control

### 6.2.1 General Information on Motor Control

#### Overview of Motor Control Methods

##### Classification of Motor Control Methods

There are different methods available to control the motor; the main difference between these methods is the fact whether a motor encoder is required or not.

##### Motor Control With Motor Encoder

Motor control with position feedback via a motor encoder (field-oriented current control → FOC) is the highest-quality method of motor control providing the best control performance. It can be used for synchronous and asynchronous motors and, within the precision and performance of motor and controller determined by the hardware, allows unrestricted motor operation in the following operating modes:

- Position control modes
- Velocity control
- Torque/force control

##### Motor Control Without Motor Encoder

For sensorless motor control, there are different model-based methods available for synchronous and asynchronous motors.

- For asynchronous motors:
  - Voltage-controlled open-loop operation (U/f control)
  - Flux-controlled operation ("FluX Control" → FXC)
- For synchronous motors:
  - Current-controlled closed-loop operation with indirect rotor position detection (field-oriented current control, sensorless → FOCsl)

Regarding the possible operating modes when using these methods, observe the following restrictions:

- Position control modes ("positioning") can only be used with sensorless synchronous motors, or with asynchronous motors only in flux-controlled operation (FXC) and with an external encoder. In these cases, generally take the performance losses into account!
- Velocity control, too, can only be used with performance losses!



Torque/force control cannot be used for motor control without motor encoder!

##### Motor Control Method and Functional Principle of Motor

The motor control method is defined in "P-0-0045, Control word of current controller". Make sure that the requirements regarding functional principle of motor and motor encoder have been fulfilled for specified motor control mode. The table below contains an overview for selecting the method.

Motor encoder?	Functional principle of motor	Motor control method	Specific information for use	Possible operating modes
With Motor encoder	Synchronous motor Asynchronous motor	FOC	Parallel operation of linear motors MLF is possible!	Position control modes Velocity control Torque/force control
Without Motor encoder	Synchronous motor	FOCsl	Difference in inductance between d- and q-axis is required!	Position control modes Velocity control
	Asynchronous motor	FXC	Only single-motor operation!	Velocity control
		U/f Control	Parallel operation of motors is possible!	

Fig. 6-9: Overview of Motor Operation With and Without Motor Encoder  
See also "Overview of Drive Control"

**Pertinent Parameters**

- P-0-0001, Switching frequency of the power output stage
- P-0-0045, Control word of current controller
- P-0-0556, Config word of axis controller

**Field-Oriented Current Control With Motor Encoder (FOC)**

**Features and Use**

Field-oriented current control with position feedback via motor encoder (FOC) is characterized by the following features:

- Highest-quality method of motor control  
→ To be used when there are high demands on the quality of control and the dynamic response!
- Can be used for synchronous and asynchronous motors

**Operating Modes With FOC**

Within the hardware-side precision and performance of motor and controller, field-oriented current control with position feedback via motor encoder allows unrestricted motor operation in the following operating modes:

- Position control modes
- Velocity control
- Torque/force control

See main section "Field-Oriented Current Control (FOC Control)"

**Model-Based Current Control Without Motor Encoder (FXC, FOCsl)**

**Features and Use**

Model-based current control without motor encoder is characterized by the following features:

- Cost-saving motors, compared to the FOC method, can be used, as no motor encoder is required (however, performance losses)
- With asynchronous motors → flux-controlled method (FXC) can be used without motor-specific restrictions
- For synchronous motors → FOCsl method; only applicable with motors that have a difference in inductance between d- and q-axis (few sizes of the MSK motor range)

**Operating Modes With FXC and FOCsl**

Current control without motor encoder allows using the following operating modes:

- Velocity control (only suited for single motors, parallel operation of motors is not possible)

## Drive Control

- Position control modes depending on functional principle of motor
  - With synchronous motors, actual position value detection is possible without encoder
  - With asynchronous motors, actual position value detection via external encoder is required



Torque/force control cannot be used for sensorless (model-based) motor control!

---

See main section "Sensorless Motor Operation, Flux-Controlled (FXC Control)"

### Voltage-Controlled Open-Loop Operation (U/f Control)

#### Features and Use

Voltage-controlled motor operation without motor encoder is characterized by the following features:

- Cost-saving motors, compared to the FOC method, can be used, as no motor encoder is required (however, performance losses)
- Can only be used for asynchronous motors
- Linear or square U/f characteristic can be selected

#### Operating Mode With U/f Control

For voltage-controlled operation without motor encoder, you can only use the "velocity control" mode with the following features:

- Parallel operation of motors is possible
- Adjustment of motor control to velocity-proportional increase in load (e.g. with blowers) by adjusted ("square") U/f characteristic to reduce the motor losses
- Performance losses compared to velocity control with motor encoder



Torque/force control and position control modes cannot be used for voltage-controlled operation without motor encoder!

---

See main section "Voltage-Controlled Open-Loop Operation (U/f Control)"

## Notes on Selection of Motor Control Method

#### Motor Control Performance

The performance of motor control significantly depends on the type of control section including the corresponding firmware, as well as on the PWM frequency of the power output stage which has been set.



An overview of the performance to be achieved and the clock rates depending on control section design and parameter settings is contained in the section "Performance Data" .

---

#### Selecting the Motor Control Method

The motor control method is defined in "P-0-0045, Control word of current controller". By means of a dialog, the commissioning tool "IndraWorks Ds/D/MLD" supports the assignment of the motor control method.

#### Selection Criteria

The following criteria have to be taken into account when selecting the appropriate motor control method:

Motor type	Motor encoder available?	Parallel connection of motors?	Motor control method	Notes on use
Synchronous motor without reluctance torque	Yes	Rotary: no Linear: Yes <sup>1)</sup>	Field-oriented current control	For standard applications with high demands on quality of control and dynamic response
Synchronous motor with reluctance torque	No	No	Field-oriented current control	Only allowed with approval by the drive development department
	Yes	Rotary: no Linear: Yes <sup>1)</sup>		For standard applications with high demands on quality of control and dynamic response
Asynchronous motor	No	No	Flux-controlled current control	For standard applications with medium demands on quality of control and dynamic response
		Yes	U/f Control	For standard applications with low demands on quality of control and dynamic response
	Yes	No	Field-oriented current control	For standard applications with high demands on quality of control and dynamic response

1) observe mechanical setup according to motor data  
 Fig.6-10: Basic Selection Criteria for the Motor Control Method  
 See also "Overview of Drive Control"

**Operating Properties for Control of Synchronous Motors**

Observe the following differences for controlling synchronous motors in operation with and without motor encoder:

Motor characteristic		Control with encoder	Control without encoder
Speed working ranges	Basic speed range	Yes	Yes (with reduced maximum speed)
	Field weakening range	Yes	No (no field weakening range)
Supported operation modes	Torque/force control	Yes	No
	Velocity control (incl. synchronization)	Yes	Yes (with restrictions)
	Position control/positioning (incl. synchronization)	Yes	Yes (with restrictions)
Torque limitation		Yes	Yes
Maximum torque		high	medium
Dynamic response		high	low to medium
Running smoothness/speed quality		high (depending on measuring system, motor type, mechanical system)	medium
Torque ripple		low (< ± 5%)	high
Required precision of the motor parameters		low	high

Drive Control

Motor characteristic	Control with encoder	Control without encoder
Robustness	high	low
Sensitivity against disturbances	low	high
Validity (availability) of the position information	Absolute encoder: in PM + OM	Only when motor supplied with current ("AF" in OM)
	Relative encoder: in OM	

PM Parameter mode  
 OM Operating mode  
 Fig.6-11: Comparison of Motor Control Without Encoder and With Encoder for Synchronous Motors

Operating Properties for Control of Asynchronous Motors

Observe the following differences for controlling asynchronous motors as regards operation with and without encoder:

Motor characteristic	Control with encoder	Control without encoder	U/f Control
Speed working ranges	Basic speed range	Yes	Yes
	Field weakening range	Yes	Yes
Supported operation modes	Torque/force control	Yes	No
	Velocity control (incl. synchronization)	Yes	Yes (with restrictions)
	Position control/positioning (incl. synchronization)	Yes	Only with external position encoder
Torque limitation	Yes	Yes	No (only stall protection loop)
Maximum torque	high	medium	low
Dynamic response	high	medium	low
Running smoothness/speed quality	high (depending on measuring system, motor type, mechanical system)	medium	low
Torque ripple	low (< ± 5%)	high	high
Required Accuracy of the motor parameters	low	low	High, if high performance must be reached
Robustness	high	medium	low
Sensitivity against disturbances	low	high	high
Validity (availability) of the position information	Absolute encoder: in PM + OM	Depending on load-side encoder type used	not available
	Relative encoder: only in OM		

PM Parameter mode  
 OM Operating mode  
 Fig.6-12: Comparison of Motor Control Without Encoder and With Encoder for Asynchronous Motors

## 6.2.2 Motor Control Frequency

### Brief Description

**General Information** The speed of three-phase AC motors depends on the frequency of the voltage applied to the motor. The maximum frequency of the motor voltage provided by the controller depends on the PWM frequency with which the power output stage is controlled (clocked).

The control of the power output stage can be made in different ways. Depending on the relation of the motor control frequency to the output stage frequency, different procedures are possible for IndraDrive controllers:

- "Static PWM" for low and medium output frequency
- "Dynamic PWM" for high output frequency

**Features** Compared to the "static PWM", the maximum motor control frequency - and thus the motor speed - can be significantly increased through the "dynamic PWM" and no-load losses of a dynamic PWM are reduced for high speeds:

PWM frequency in Hz Value in P-0-0001	Max. motor control frequency in Hz	
	Static PWM <sup>1)</sup>	Dynamic PWM
4000	400	--
8000	800	1330
12000	1200	2000
16000	1600	2660

<sup>1)</sup>see also "Supply Units and Power Sections; Project Planning Manual"

Fig. 6-13: PWM Frequency Settings and Maximum Motor Control Frequency for Static and Dynamic PWM

#### Note on Dimensioning



Make sure that the required PWM frequency is observed when selecting the controller as the continuous current of the controller is influenced by the setting of the PWM frequency:

- Set PWM Frequency as low as possible because of continuous current of the controller
- Set PWM frequency as high as necessary because of motor control frequency

#### Advantageous Behaviour

Due to the Reduction of the Continuous Current for PWM Frequencies above 4kHz the Controller can set Automatically the Most Favorable PWM Frequency.

#### Availability

Depending on the control section design and the setting of the PWM frequency, "dynamic PWM" or the "most favorable PWM", depending on the velocity, can be used

Control section	Firmware	Possible PWM frequencies	Programmable PWM or most favorable PWM depending on the speed
CSB	as of MPB06VRS	4000	
CDB	as of MPD06VRS	8000	X
CSH	as of MPH06VRS	4000	
		8000	X
		12000	X
		16000	X

Fig. 6-14: Hardware and Firmware Dependencies

Drive Control

- Pertinent Parameters**
- P-0-0001, Switching frequency of the power output stage
  - P-0-0045, Control word of current controller

**Pertinent Diagnostic Messages** Switching of the PWM frequency is displayed in the respective bit of "P-0-0046, Status word of current controller".


**Functional Description**

**Clocking Method**

In general, IndraDrive controllers can control their power output stage via:

- "Static PWM" due to speed-independent, constant PWM frequency
- "Dynamic PWM" due to variable PWM frequency depending on speed

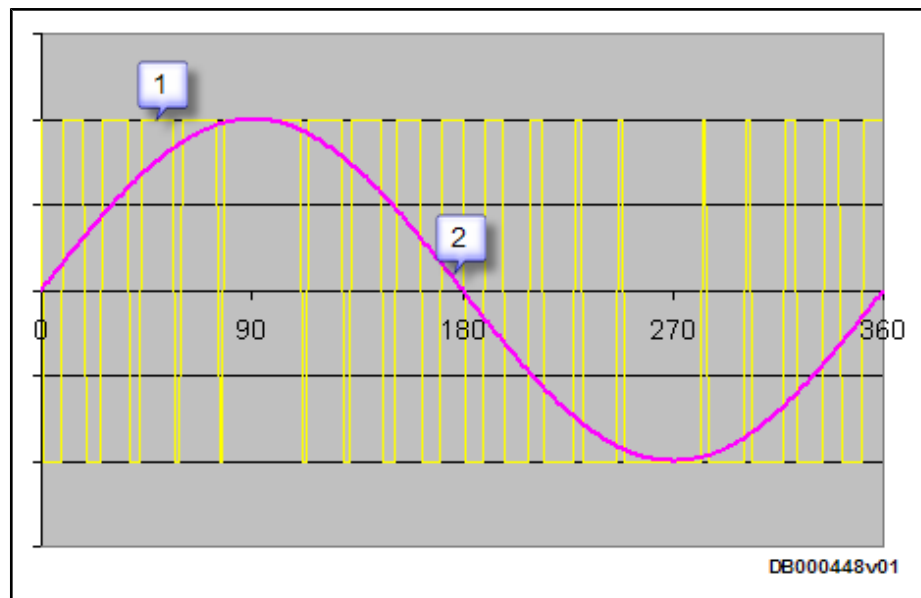
For the mentioned clocking methods the time period and transmission of the "support points" change for a sine wave of the motor voltage.

 A "support point" is a switching action of the power output stage with which the controller can influence the motor current.

The clocking method is selected in "P-0-0045, Control word of current controller".

**Static PWM** "Static PWM" is characterized by a constant number of "support point" within a time interval. For different motor control frequencies the number of support points varies for a periodic time of the motor voltage.

- With increasing motor control frequency the number of support points decreases
- With decreasing motor control frequency the support point number increases



- 1: Motor voltage support points, DC bus voltage is transmitted by the power output stage
- 2: Curve of the effective motor voltage

Fig. 6-15: Control of Power End Stage With "Static PWM", in Principle

**Dynamic PWM** "Dynamic PWM" is characterized by a constant number of "support point" within a sine wave of the motor voltage. In different motor control frequency ranges the number of support points remains constant for a periodic time of the motor voltage.



- The "dynamic PWM" does not take effect until a motor control frequency threshold is exceeded
- The number of "support points" is reduced in stages from 21 to 6 in successive output frequency intervals in ascending order



- 1: Motor voltage support points, DC bus voltage is transmitted by the power output stage
- 2: Curve of the effective motor voltage

Fig. 6-16: Control of Power end Stage With "Dynamic PWM", in Principle

### Automatic PWM Adjustment

#### "Most Favorable PWM Frequency"

As the continuous current of the controller is reduced with increasing PWM frequency due to higher switching losses of the power output stage, the controller selects automatically the most favorable PWM frequency, depending on the actual motor control frequency.

- Dynamic PWM
- PWM switching depending on speed (static PWM)

The "PWM switching depending on speed" as well as the "dynamic PWM" can be set in "P-0-0045, Control word of current controller".

For the two variants the PWM frequency stage required for the maximum motor speed is set in "P-0-0001, Switching frequency of the power output stage". If P-0-0001 was set greater than 4kHz, half the switching frequency will take effect below a motor control frequency threshold:

PWM frequency in Hz		PWM switching for <sup>1)</sup> motor control frequency threshold in Hz	
Set value in P-0-0001/	Effective PWM frequency below <sup>1)</sup> // above <sup>1)</sup>	PWM switching depending on speed:	Dynamic PWM
4000	--	--	--
8000	4000 // 8000	400	190
12000 <sup>*)</sup>	6000 <sup>**) // 12000</sup>	600	285

Drive Control

PWM frequency in Hz		PWM switching for <sup>1)</sup> motor control frequency threshold in Hz	
Set value in P-0-0001/	Effective PWM frequency below <sup>1)</sup> // above <sup>1)</sup>	PWM switching depending on speed:	Dynamic PWM
16000 <sup>*)</sup>	8000 //16000	800	381
<sup>*)</sup> depending on the design of the controller and the performance settings, these PWM frequencies might not be available! <sup>**)</sup> for PWM=6000Hz the controller continuous current data of 8000Hz apply!			

Fig.6-17: PWM Frequency Settings and PWM Switching Thresholds



The continuous current of a controller depends on the effective PWM frequency. Check whether the selected controller provides sufficient continuous current for the motor and/or the application, below and above the motor control frequency threshold for PWM switching.

Notes on Commissioning

Setting the PWM Frequency

The PWM frequency for control of the power output stage is set in "P-0-0001, Switching frequency of the power output stage". Depending on the design of the controller different PWM frequencies are available (see above).

Selection of PWM Adjustment

PWM adjustment is only possible, if a PWM frequency above 4kHz was set. Via the respective bits of P-0-0045 you can choose between:

- Static PWM (default)
- PWM reduction depending on load
- PWM reduction depending on speed
- Dynamic PWM for maximum motor control frequency

IWD Dialogs for the PWM Adjustment

Depending on the selected motor control type different dialogs will appear:

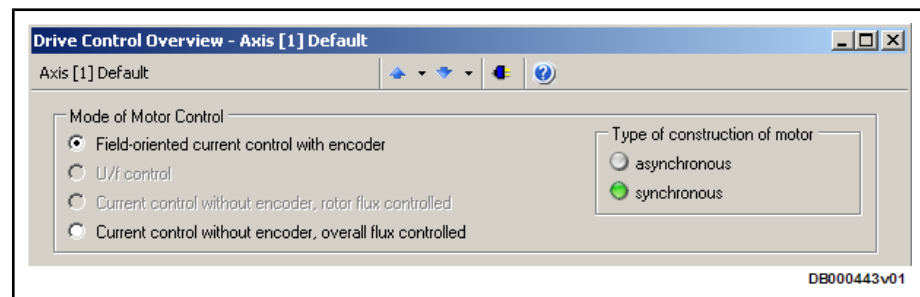


Fig.6-18: IWD Dialog "Motor Control, Setting of FOC"

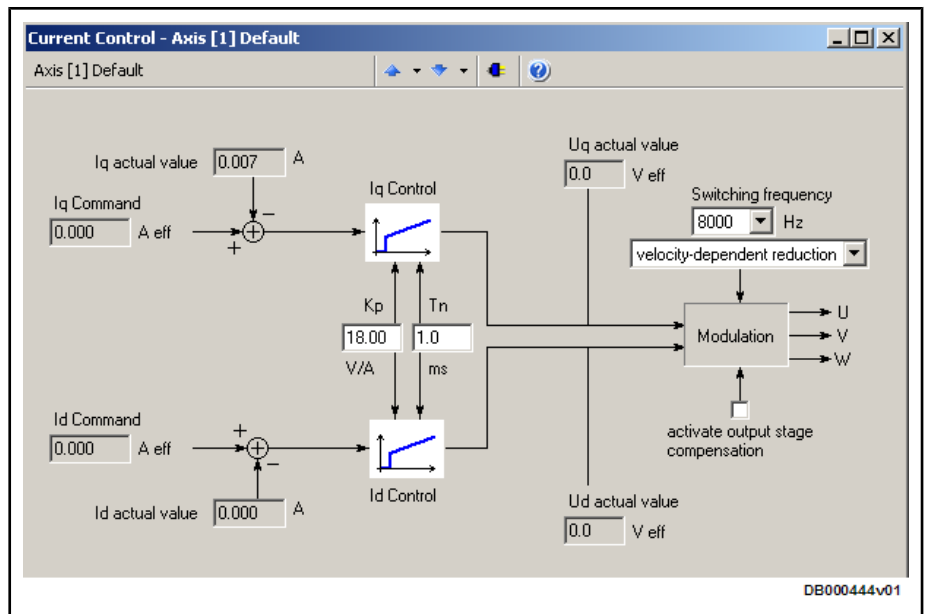


Fig.6-19: IWD Dialog for Setting PWM Adjustment for FOC Operation

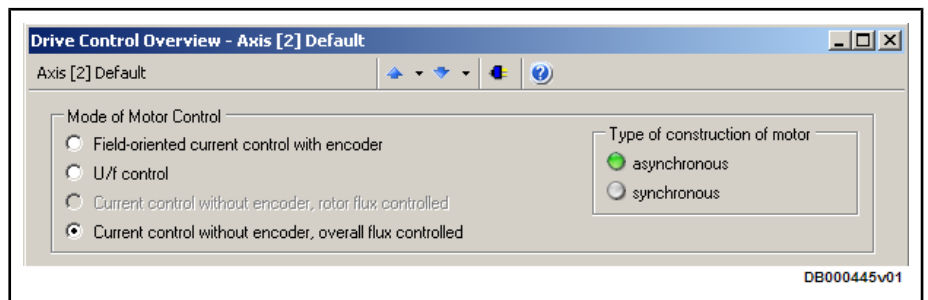


Fig.6-20: IWD Dialog "Motor Control, Setting of FXC"

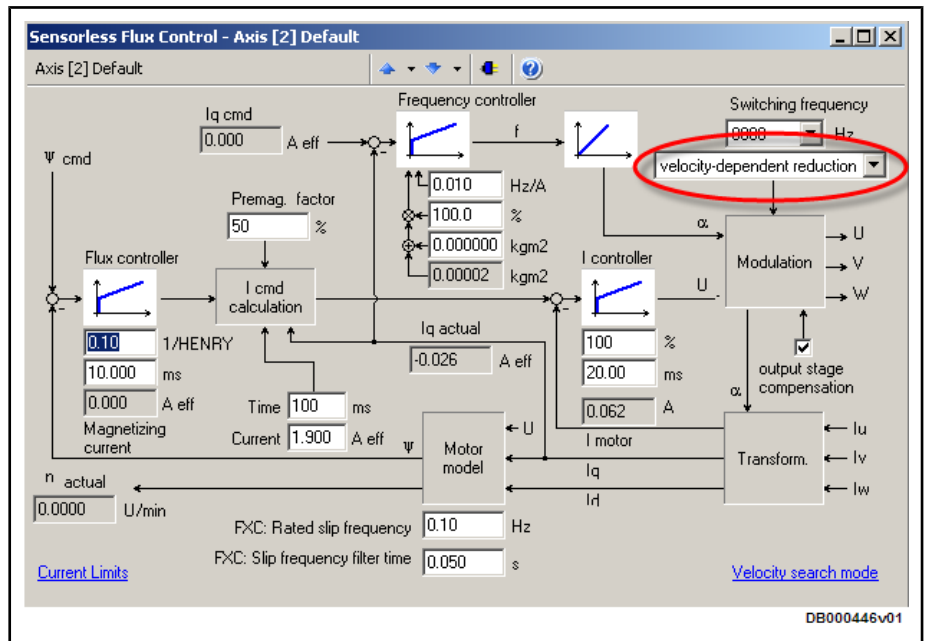


Fig.6-21: IWD Dialog for Setting PWM Adjustment for FXC Operation

Display of PWM Switching

Switching of the PWM frequency to half the value of P-0-0001 is displayed in the respective bit of "P-0-0046, Status word of current controller".

## Drive Control

## 6.2.3 Voltage-Controlled Open-Loop Operation (U/f Control)

## Brief Description

The drive function "voltage-controlled operation of asynchronous motors without encoder in open-loop U/f control" is made available in the base package "open-loop" in the "velocity control" mode. When the expansion package "synchronization" has been enabled, the operation mode "velocity synchronization with real/virtual master axis" is additionally available.

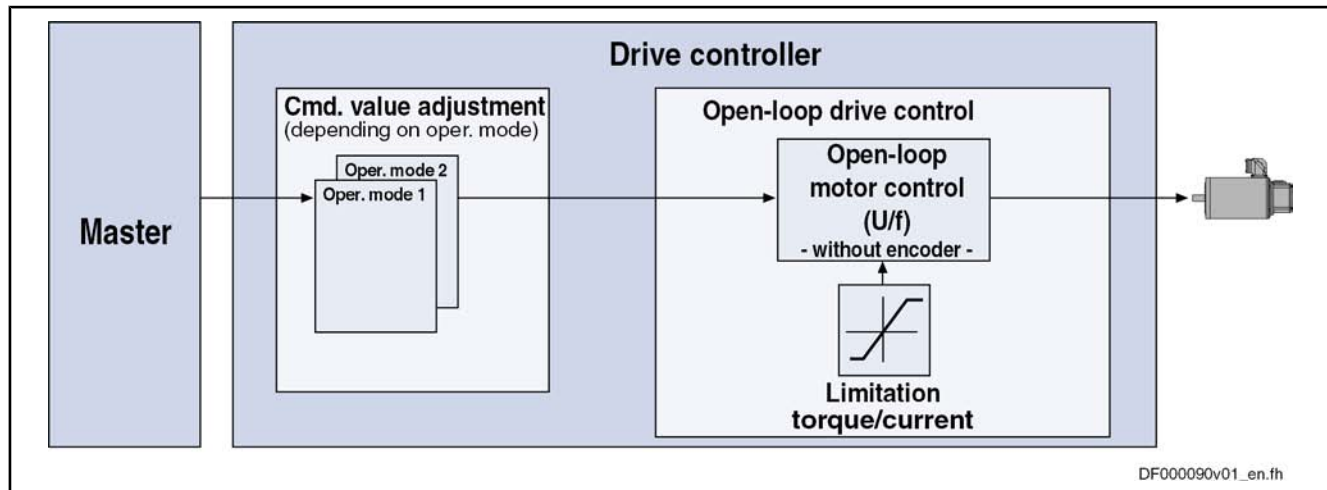


Fig.6-22: Principle of U/f Control

U/f motor control is characterized by the following features or core functions:

- |                             |  |
|-----------------------------|--|
| <b>Features</b>             | <ul style="list-style-type: none"> <li>• Monitoring and <b>limitation</b> of the maximum <b>stator frequency slope</b> that results from the command velocity change</li> <li>• <b>Stall protection loop</b> (PI loop that can be optionally activated to prevent breakdown of the machine when the torque limits are attained)</li> <li>• <b>Slip compensation</b> (feedforward of estimated slip of the machine by means of slip compensation factor)</li> <li>• Calculation of output voltage by means of <b>U/f characteristic</b> based on motor model data</li> <li>• Subsequent trimming of magnetization via premagnetization factor, as well as linear or square characteristic to be selected</li> <li>• <b>IxR boost</b> (adjustable load-dependent feedforward of the output voltage due to the voltage drop on the motor winding resistance)</li> <li>• <b>Oscillation damping</b> (adjustable load-dependent feedforward to prevent velocity oscillations in the partial load and idling ranges)</li> <li>• <b>Current limitation loop</b> to protect the output stage of the drive controller, as well as limitation to the effective peak current</li> <li>• <b>Velocity search mode</b> of a coasting machine after switching drive enable on (can be set for the preset rotational direction or both rotational directions)</li> <li>• <b>D.C. braking</b> to reach standstill more quickly</li> <li>• User-side <b>torque/force limitation</b> via enabled stall protection loop</li> </ul> |
| <b>Pertinent Parameters</b> | <ul style="list-style-type: none"> <li>• S-0-0040, Velocity feedback value</li> <li>• S-0-0106, Current loop proportional gain 1</li> <li>• S-0-0107, Current loop integral action time 1</li> </ul>   |

- P-0-0043, Torque-generating current, actual value
- P-0-0044, Flux-generating current, actual value
- P-0-0045, Control word of current controller
- P-0-0046, Status word of current controller
- P-0-0048, Effective velocity command value
- P-0-0063, Torque-generating voltage, actual value
- P-0-0064, Flux-generating voltage, actual value
- P-0-0065, Absolute voltage value, actual value
- P-0-0440, Actual output current value (absolute value)
- P-0-0442, Actual value torque limit positive (stationary)
- P-0-0443, Actual value torque limit negative (stationary)
- P-0-0532, Premagnetization factor
- P-0-0556, Config word of axis controller
- P-0-0568, Voltage boost
- P-0-0569, Maximum stator frequency slope
- P-0-0570, Stall protection loop proportional gain
- P-0-0571, Stall protection loop integral action time
- P-0-0572, Slip compensation factor
- P-0-0573, IxR boost factor
- P-0-0574, Oscillation damping factor
- P-0-0575, Search mode: search current factor
- P-0-0576, Search mode: finding point slip factor
- P-0-0577, Square characteristic: lowering factor
- P-0-0578, Current for deceleration, absolute value
- P-0-0579, Current for deceleration, time period
- P-0-4036, Rated motor speed
- P-0-4046, Effective peak current

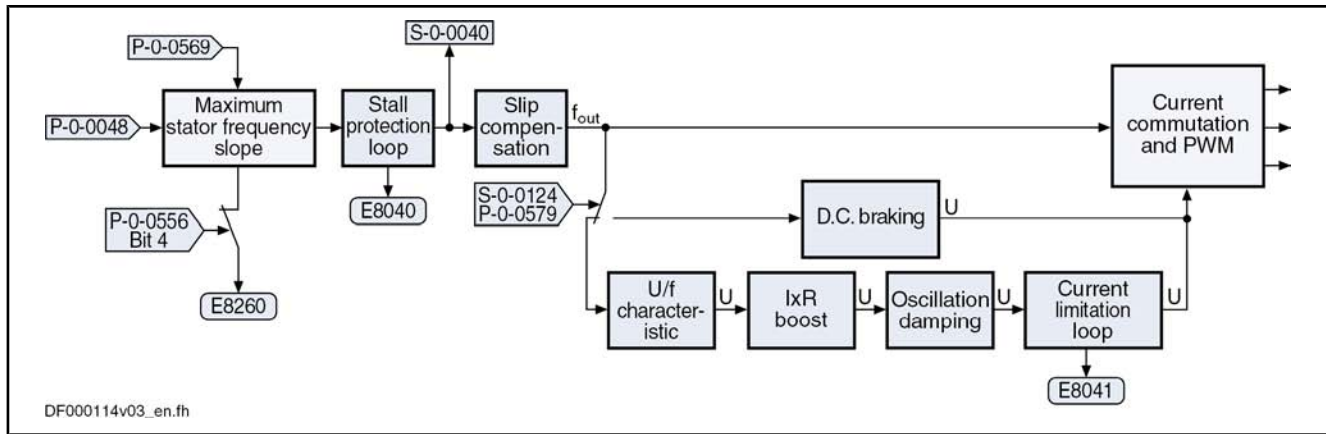
**Pertinent Diagnostic Messages**

- E8040 Torque/force actual value limit active
- E8041 Current limit active
- E8260 Torque/force command value limit active

**Functional Description****Overview of Core Functions**

The figure below illustrates the core functions of U/f control:

Drive Control



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- S-0-0040 Velocity feedback value
- S-0-0124 Standstill window
- P-0-0048 Effective velocity command value
- P-0-0065 Absolute voltage value, actual value
- P-0-0556 Config word of axis controller
- P-0-0569 Maximum stator frequency slope
- P-0-0579 Current for deceleration, time period

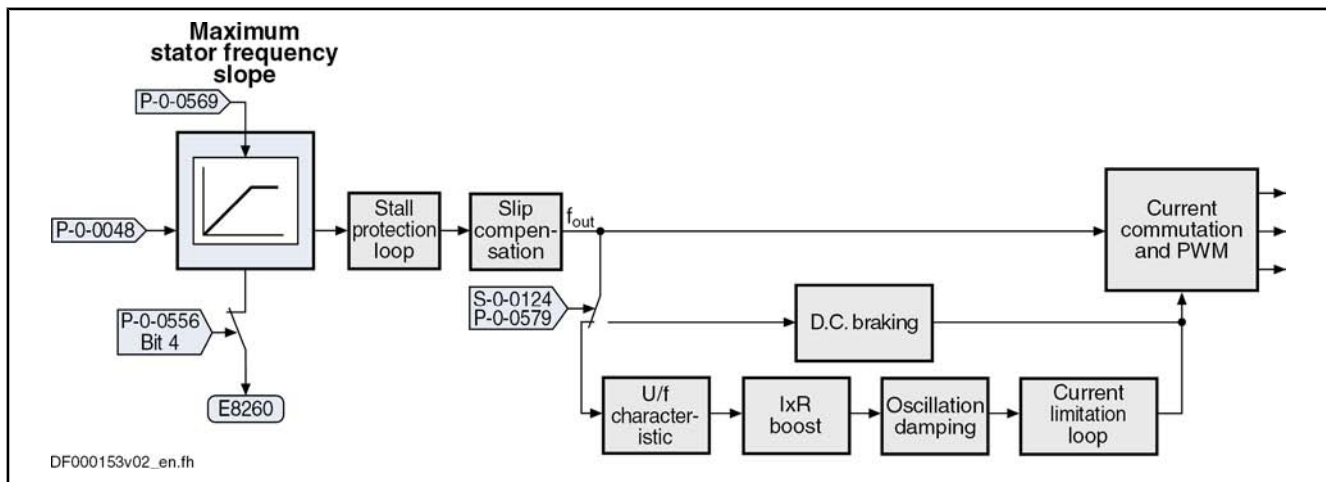
Fig. 6-23: Overview of Functions of U/f Control

Maximum Stator Frequency Slope

The maximum change of velocity with which the drive can follow the command values is determined by the motor and the sampling time of the stall protection loop. The limit value can be set in "P-0-0569, Maximum stator frequency slope". If the acceleration capability was exceeded, the diagnostic message "E8260 Torque/force command value limit active" is output.

This message can be masked via bit 4 of "P-0-0556, Config word of axis controller":

- Bit 4 = 0 → message is displayed
- Bit 4 = 1 → message is not displayed



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- S-0-0124 Standstill window
- P-0-0048 Effective velocity command value
- P-0-0556 Config word of axis controller
- P-0-0569 Maximum stator frequency slope
- P-0-0579 Current for deceleration, time period

Fig. 6-24: Core Function "Maximum Stator Frequency Slope"

## Stall Protection Loop

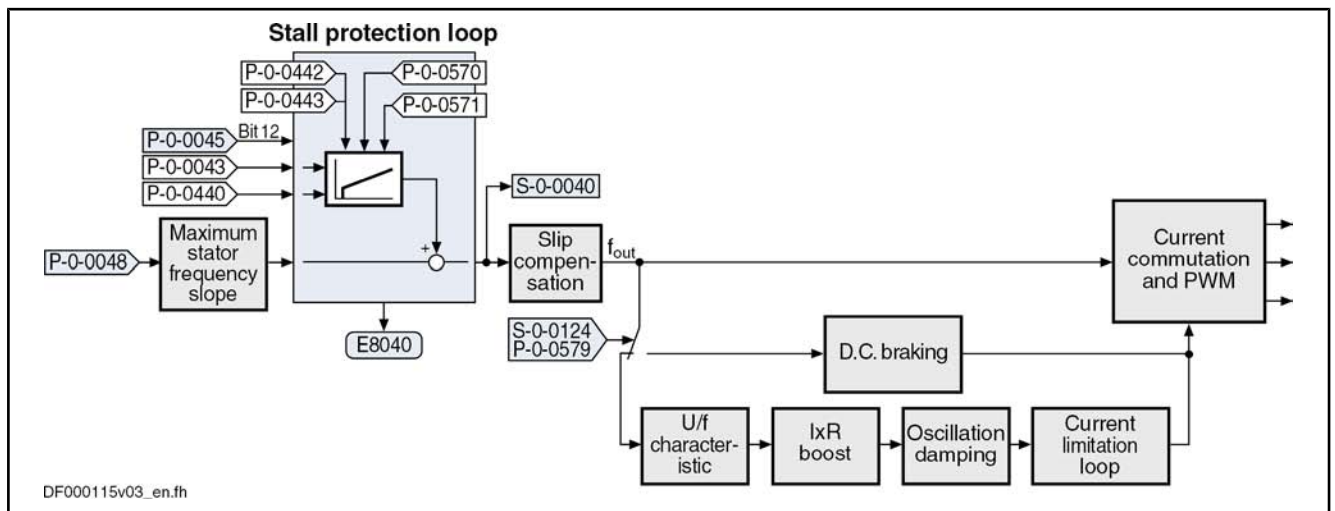
When the torque limits in the case of motive and generating load have been reached, the "breakdown" of the asynchronous motor is prevented by the so-called stall protection loop.

The stall protection loop is enabled via bit 12 of "P-0-0045, Control word of current controller":

- Bit 12 = 1 → stall protection loop enabled
- Bit 12 = 0 → stall protection loop switched off



The default setting in bit 12 of P-0-0045 is "1" (stall protection loop enabled).



S-0-0124	Standstill window
S-0-0040	Velocity feedback value
P-0-0043	Torque-generating current, actual value
P-0-0045	Control word of current controller
P-0-0048	Effective velocity command value
P-0-0440	Actual output current value (absolute value)
P-0-0442	Actual value torque limit positive (stationary)
P-0-0443	Actual value torque limit negative (stationary)
P-0-0570	Stall protection loop proportional gain
P-0-0571	Stall protection loop integral action time
P-0-0579	Current for deceleration, time period

Fig. 6-25: Core Function "Stall Protection Loop"

The input value is the result of the command value adjustment "P-0-0048, Effective velocity command value" as well as the current values in "P-0-0043, Torque-generating current, actual value" and "P-0-0440, Actual output current value (absolute value)".

The controller is set via:

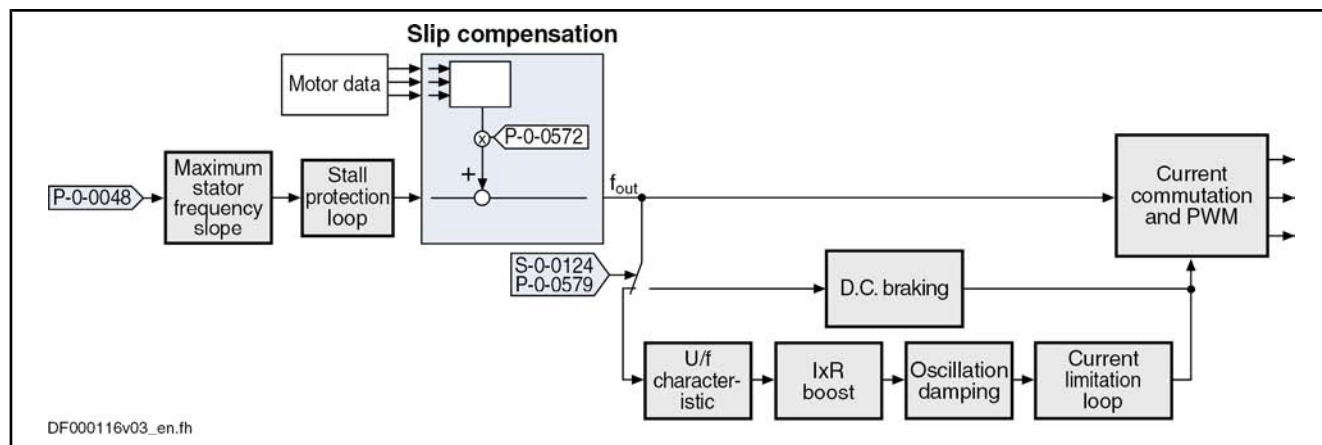
- P-0-0570, Stall protection loop proportional gain
- P-0-0571, Stall protection loop integral action time

The values of "P-0-0442, Actual value torque limit positive (stationary)" and "P-0-0443, Actual value torque limit negative (stationary)" are the torque limits to which the stall protection loop is to limit the values

## Drive Control

## Slip Compensation

With the slip compensation, the motor model data are used for feedforward of the estimated slip of the machine.



S-0-0124	Standstill window
P-0-0048	Effective velocity command value
P-0-0572	Slip compensation factor
P-0-0579	Current for deceleration, time period

Fig. 6-26: Core Function "Slip Compensation"

The output signal of the stall protection loop is used as the input value.

The feedforward can be set via "P-0-0572 , Slip compensation factor".



With a value of "0.00%" in P-0-0572 the slip compensation is switched off.

## U/f Characteristic

In the "U/f characteristic" function the respective voltage for the effective output frequency is calculated from the motor model data.

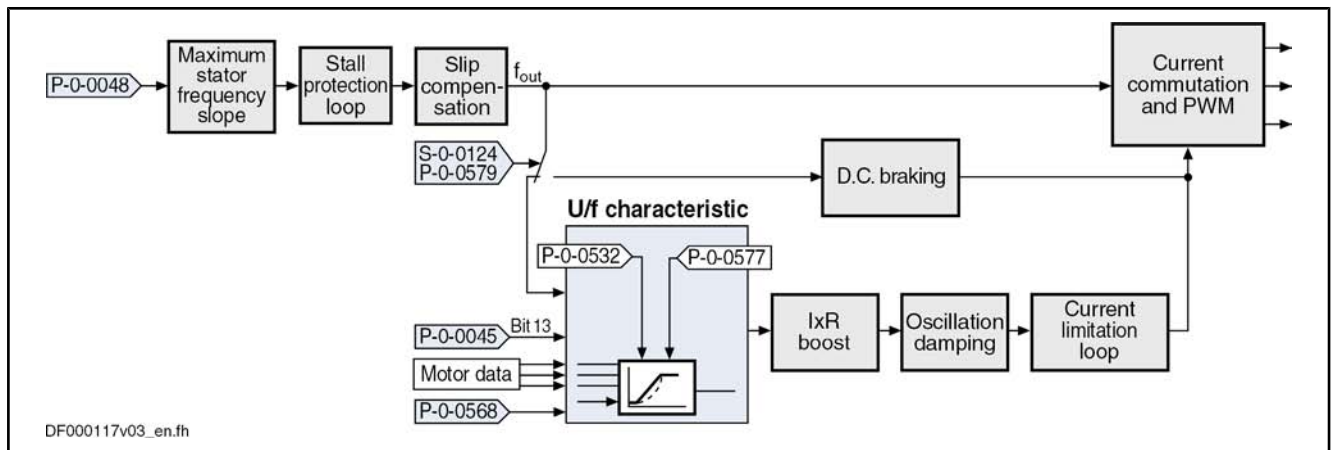
The form of the characteristic in the basic range of setting, i.e. up to "P-0-4036, Rated motor speed" is selected with bit 13 in "P-0-0045, Control word of current controller":

- Bit 13 = 1 → square characteristic
- Bit 13 = 0 → linear characteristic



The default setting in bit 13 of P-0-0045 is "0" (linear characteristic).





S-0-0124	Standstill window
P-0-0045	Control word of current controller
P-0-0048	Effective velocity command value
P-0-0532	Premagnetization factor
P-0-0568	Voltage boost
P-0-0577	Square characteristic lowering factor
P-0-0579	Current for deceleration, time period

Fig. 6-27: Core Function "U/f Characteristic"

The output signal of the slip compensation is used as the input value for the U/f characteristic.

With "P-0-0568, Voltage boost" the voltage at the base point of the U/f characteristic can be increased in addition to the voltage determined by the controller on the basis of the motor data.

Due to long motor lines, for example, starting problems can sometimes occur for motors. In this case, it is possible to improve the starting behavior by means of this parameter by a value higher than 0 V.

With a square characteristic the degree of lowering can be adjusted in the basic range of setting with the value in "P-0-0577, Square characteristic: lowering factor". The value of 100% corresponds to the original square curve. This lowering factor is reduced as the percentage value decreases.



The value "0.00%" in P-0-0577 corresponds to the linear characteristic.

The magnetization of the machine can be trimmed via "P-0-0532, Premagnetization factor". This corresponds to a change in the steepness of the U/F characteristic. P-0-0532 can be configured in MDT. If the premagnetization factor is cyclically transmitted by a higher-level master, it can precontrol the machine's magnetization in an appropriate way in the case of an expected change of load.

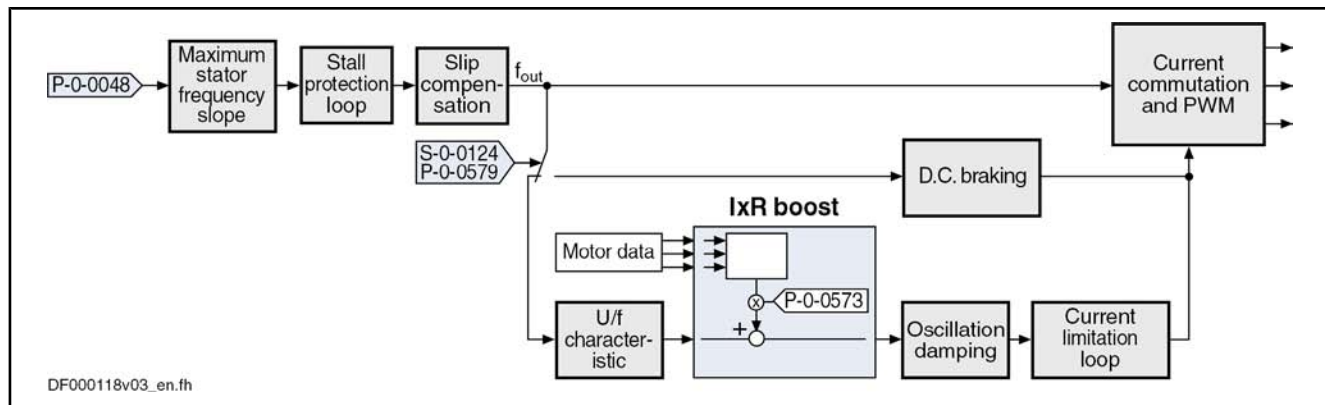
### IxR Boost

By means of "P-0-0573, IxR boost factor" it is possible to influence the feedforward of the output voltage in a load-dependent way. When the motor is under load, the output voltage can be increased by means of P-0-0573 in order to compensate for the enhanced voltage drop inside the motor.



With a value of "0.00%" in P-0-0573 the feedforward is switched off.

Drive Control



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- S-0-0124 Standstill window
- P-0-0048 Effective velocity command value
- P-0-0573 IxR boost factor
- P-0-0579 Current for deceleration, time period

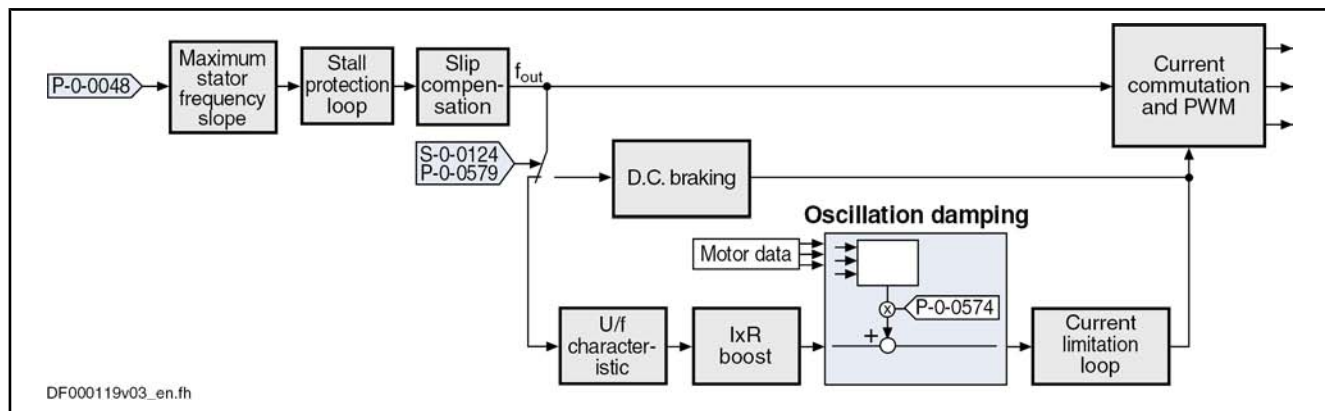
Fig.6-28: Core Function "IxR Boost"

### Oscillation Damping

In open-loop operation, asynchronous machines in the case of low load tend towards speed oscillations. With the oscillation damping it is possible to counteract this behavior. The feedforward can be influenced with "P-0-0574, Oscillation damping factor".



With a value of "0.00%" in P-0-057 the feedforward is switched off.



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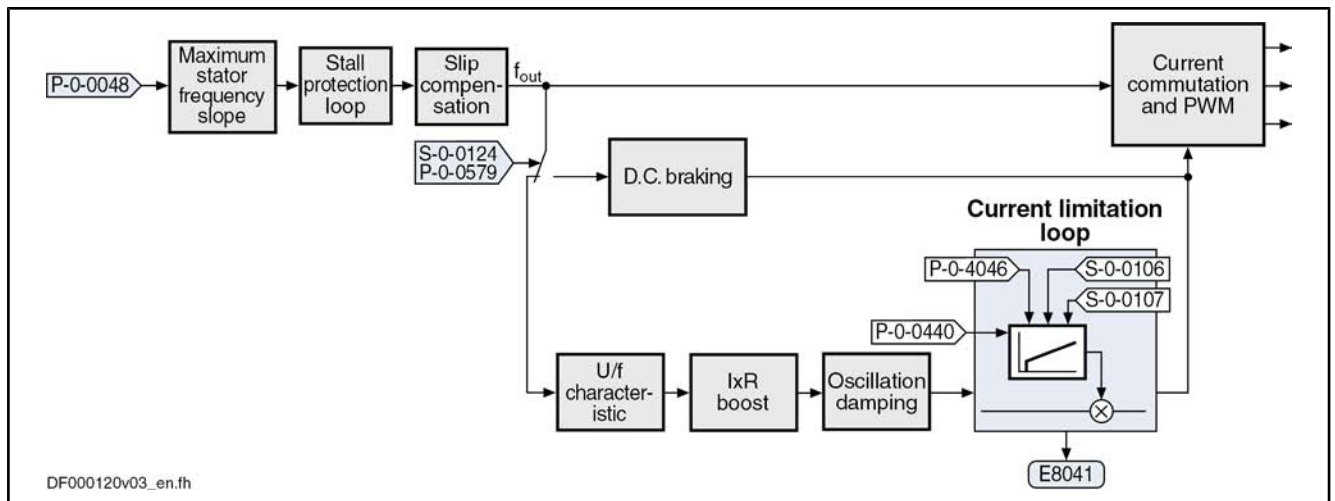
- S-0-0124 Standstill window
- P-0-0048 Effective velocity command value
- P-0-0574 Oscillation damping factor
- P-0-0579 Current for deceleration, time period

Fig.6-29: Core Function "Oscillation Damping"

### Current Limitation Loop

It is the task of the current limitation loop to limit the maximum output current by reducing the output voltage. This normally causes breakdown of the motor. In this case, however, this has to be accepted because the protection of motor and devices has the higher priority.

The current limitation loop is activated if the current in the motor surpasses the maximum current of the motor or of the controller. Before the activation of the current limitation loop, an activated stall protection loop already tried to relieve the motor!



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- S-0-0124 Standstill window
- S-0-0106 Current loop proportional gain 1
- S-0-0107 Current loop integral action time 1
- P-0-0048 Effective velocity command value
- P-0-0440 Actual output current value (absolute value)
- P-0-4046 Effective peak current
- P-0-0579 Current for deceleration, time period

Fig.6-30: Core Function "Current Limitation Loop"

### D.C. Braking

D.C. braking, which can be activated, improves motor deceleration in case the velocity command value equals zero. If the absolute value of the velocity command value and actual value falls below the value in "S-0-0124, Standstill window", switching from open-loop voltage control (U/f operation) to closed-loop current control takes place and the current for deceleration is generated. The degree of current for deceleration is preset in "P-0-0578, Current for deceleration, absolute value".



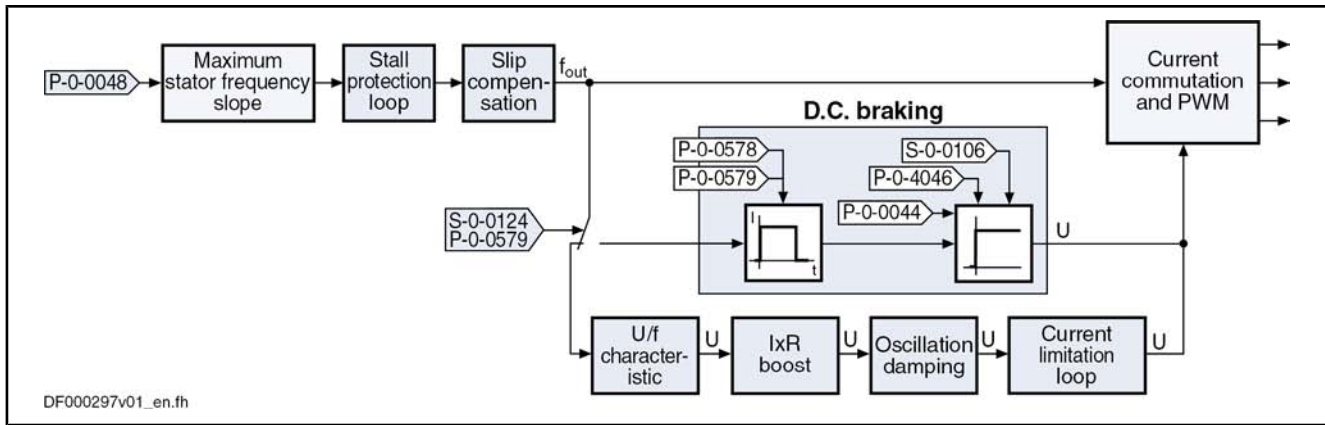
The value of P-0-0578 must at least comply with the value of "P-0-4004, Magnetizing current" and is limited to 90% of the motor peak current (S-0-0109). In addition, the thermal limitations of motor and controller take effect!

Due to sensorless motor operation, motor standstill cannot be definitively ascertained. Therefore, the current for deceleration can be maintained, with the value of "P-0-0579, Current for deceleration, time period", beyond the internally detected motor standstill (velocity command value and actual value equal zero), so that the deceleration of the motor is really completed.



The default value of P-0-0579 is 0.5s. The parameter value must be adapted to the deceleration behavior. Inputting the value "0" deactivates D.C. braking!

Drive Control



- S-0-0106 Current loop proportional gain 1
- S-0-0124 Standstill window
- P-0-0044 Flux-generating current, actual value
- P-0-0578 Current for deceleration, absolute value
- P-0-0579 Current for deceleration, time period
- P-0-4046 Effective peak current

Fig.6-31: Core Function "D.C. Braking"

D.C. braking is terminated when one of the following conditions has been fulfilled:

- During the deceleration process, the time period (P-0-0579) for activation of the current for deceleration has elapsed. Starting point of time is when the actual velocity value enters the standstill window (S-0-0124). After the deceleration time is over, the motor is in U/f control again. In the case of motor standstill "P-0-0568, Voltage boost" determines the current flowing in the motor.
- The absolute value of the velocity command value again exceeds the value of the standstill window (S-0-0124). The motor is accelerated in U/f control.



The value for "S-0-0106, Current loop proportional gain 1" is determined when the command C3200 (calculate motor data) is executed!

**Velocity Search Mode**

The velocity search mode is selected and activated in "P-0-0045, Control word of current controller" (bits 8, 9).

The following modes are distinguished for velocity search:

- **Velocity search after drive enable**  
After the start the search is run up to a speed equal zero with "S-0-0091, Bipolar velocity limit value" in the rotational direction given by "S-0-0036, Velocity command value". At the current speed of the coasting machine, but at the latest at speed = 0, the search mode function is completed and the normal command value processing starts. In normal command value processing, the drive moves to the provided command value with the ramp-function generator.
- **Velocity search after drive enable, bidirectional**  
After the start the search is run up to a speed equal zero with "S-0-0091, Bipolar velocity limit value" in the rotational direction given by "S-0-0036, Velocity command value". If the speed of the machine has not been found up to speed = 0, there is another search with the rotational direction

changed. At the current speed of the coasting machine or at the latest at speed = 0, the search mode function is completed and the normal command value processing starts. In normal command value processing, the drive moves to the provided command value with the ramp-function generator.

During the search process the current given by "P-0-0575, Search mode: search current factor" is generated. It is defined as the percentage value of the magnetizing current (P-0-4004).

As soon as the machine has been found the rated slip is added to the speed at the "finding point". 100% correspond to the rated slip of the machine. This added value is subsequently trimmed with "P-0-0576, Search mode: finding point slip factor".

## Diagnostic and Status Messages

<b>Monitoring the Stator Frequency</b>	<p>The limit value for the maximum change of velocity with which the drive can follow the command values is set in "P-0-0569, Maximum stator frequency slope".</p> <p>When the limitation of the maximum stator frequency change takes effect, "E8260 Torque/force command value limit active" is generated. As soon as the stator can follow the required frequency slope again, the message is reset.</p> <p>This message can be masked via bit 4 of "P-0-0556, Config word of axis controller":</p> <ul style="list-style-type: none"> <li>• Bit 4 = 0 → message is displayed</li> <li>• Bit 4 = 1 → message is not displayed</li> </ul>
<b>Status of Stall Protection Loop</b>	<p>The activation of the stall protection loop is displayed in "P-0-0046, Status word of current controller" (bit 12: stall protection loop):</p> <ul style="list-style-type: none"> <li>• Bit 12 = 1 → stall protection loop active In addition, the diagnostic message "E8040 Torque/force actual value limit active" is generated.</li> <li>• Bit 12 = 0 → stall protection loop not active</li> </ul>
<b>Status of Current Limitation Loop</b>	<p>The activation of the current limitation loop is displayed in "P-0-0046, Status word of current controller" (bit 13: current limitation loop):</p> <ul style="list-style-type: none"> <li>• Bit 13 = 1 → current limitation loop active In Addition, the diagnostic message "E8041 Current limit active" is generated.</li> <li>• Bit 13 = 0 → current limitation loop not active</li> </ul>
<b>Status of Velocity Search Mode</b>	<p>The status of the velocity search mode can be read in "P-0-0046, Status word of current controller" (bit 14: search mode):</p> <ul style="list-style-type: none"> <li>• Bit 14 = 1 → search mode active</li> <li>• Bit 14 = 0 → search mode not active</li> </ul>

## 6.2.4 Field-Oriented Current Control (FOC Control)

### Brief Description



**Base package** of all firmware versions in **closed-loop** characteristic

## Drive Control



The current loop was preset for all motors by Bosch Rexroth and the parameter values have been stored in the motor encoder data memory or in the commissioning tool (IndraWorks Ds/D/MLD, DriveTop).

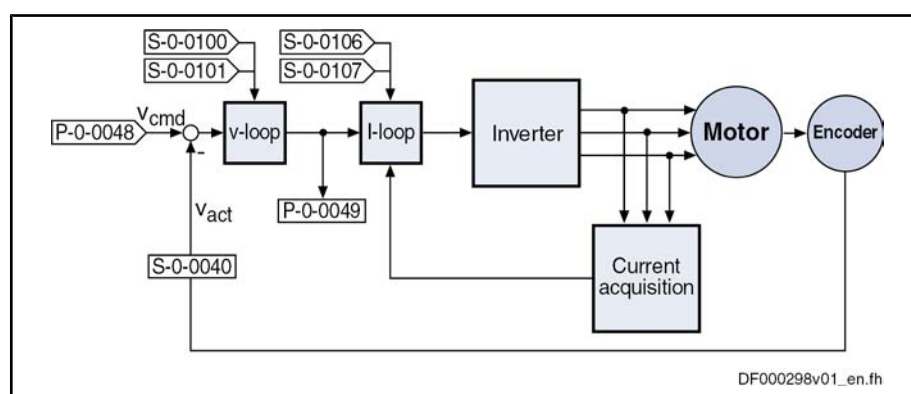
For notes on how to commission the current loop for third-party motors, see "Third-Party Motors at IndraDrive Controllers"!

### Principle of Field-Oriented Current Control

In the case of field-oriented current control, the internal control task consists in generating the transformed currents  $I_d$  and  $I_q$  in controlled form:

- $I_d$  (flux-generating current) → PI loop for  $I_d$
- $I_q$  (torque-generating current) → PI loop for  $I_q$

The figure below illustrates the principle of field-oriented current control for operation with motor encoder:



v-loop            Velocity Loop

I-loop            Current Loop

Fig.6-32: Simplified Schematic Diagram for Field-Oriented Current Control With Higher-Level Velocity Control

### Working Ranges

Field-oriented current control of asynchronous and synchronous motors allows operation in the entire speed range.

The speed range is divided into the following working ranges:

- Basic speed range → **constant torque**
- Field weakening range 1 → **constant power**
- Field weakening range 2 → **power limit range**

### General Features

Field-oriented current control has the following general features:

- Control of the motor current according to the principle of field orientation, i.e. separate control of the torque-generating current and the flux-generating current
- Compensation of the cross coupling of the d and q axes to increase dynamics
- Voltage loop for operation in the field weakening range
- Activation of the optimum current loop proportional gain value, depending on the current PWM frequency during the load defaults procedure

### Features of Synchronous Motor Control

In the case of **synchronous motors**, field-oriented current control additionally has the following features:

- Limitation of the  $I_q$  command value at the voltage limit for protection against too little control margin

- Utilization of the reluctance effect to increase the available torque in the basic speed range
  - Support of synchronous motors with reluctance torque, i.e. motors with significantly different inductances in the d and q axes
- Features of Asynchronous Motor Control**
- In the case of **asynchronous motors**, field-oriented current control has the following features in addition to the general features:
- Optimum torque linearity, even in the field weakening range, by:
    - Permanent correction of the torque constant and the slip factor by means of the currently calculated rotor flux
    - Rotor flux model taking temperature and saturation behavior of the magnetizing inductance into account
  - Improved dynamic behavior by:
    - Voltage- and load-dependent flux feedforward
    - Voltage loop for correcting the flux feedforward
    - Flux loop for dynamically generating the rotor flux
  - Possibility of reducing the magnetizing current for low-loss operation at no load or in partial load range
- Pertinent Parameters**
- Current loop setting:
- S-0-0106, Current loop proportional gain 1
  - S-0-0107, Current loop integral action time 1
  - P-0-0001, Switching frequency of the power output stage
  - P-0-0045, Control word of current controller
  - P-0-4002, Charact. of quadrature-axis induct. of motor, inductances
  - P-0-4003, Charact. of quadrature-axis inductance of motor, currents
- Voltage loop setting:
- P-0-0533, Voltage loop proportional gain
  - P-0-0534, Voltage loop integral action time
  - P-0-0535, Motor voltage at no load
  - P-0-0536, Maximum motor voltage
- Rotor flux control for asynchronous motors:
- P-0-0528, Flux control loop proportional gain
  - P-0-0529, Scaling of stall current limit
  - P-0-0530, Slip increase
  - P-0-0532, Premagnetization factor
- Power monitoring:
- S-0-0158, Power threshold  $P_x$
  - S-0-0337, Status "P  $\geq$   $P_x$ "
  - S-0-0382, DC bus power
- Encoder monitoring (in operation with encoder):
- P-0-0520, Error threshold for encoder monitoring
- Display parameters:
- S-0-0380, DC bus voltage
  - P-0-0046, Status word of current controller
  - P-0-0063, Torque-generating voltage, actual value

Drive Control

- P-0-0064, Flux-generating voltage, actual value
  - P-0-0065, Absolute voltage value, actual value
- Pertinent Diagnostic Messages**
- C0132 Invalid settings for controller cycle times
  - E8025 Overvoltage in power section
  - E8028 Overcurrent in power section
  - F2077 Current measurement trim wrong
  - F8023 Error mechanical link of encoder or motor connection
  - F8060 Overcurrent in power section

**General Function of Field-Oriented Current Control**

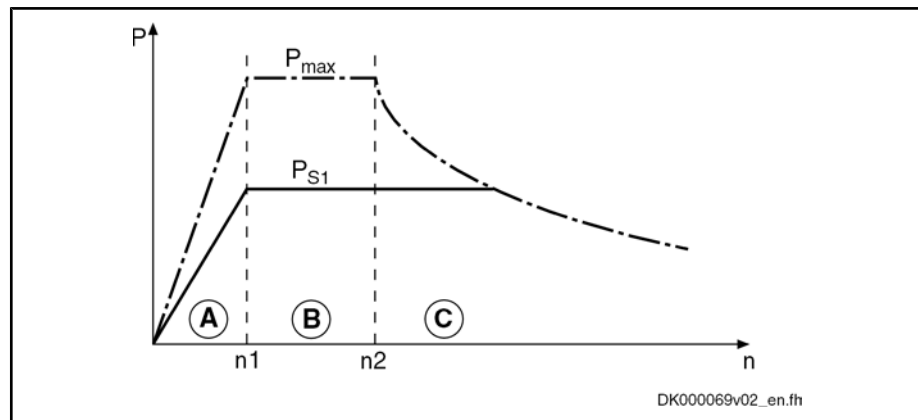
**Torque/Force Control** In contrast to the functional principle used in the "torque/force control" mode, this actually is current control, as the actual current value is measured and not the force or the motor torque. This means that open-loop control of torque/force takes place, the torque or the force being directly connected with the torque-/force-generating current via the torque/force constant.

In the case of asynchronous motors, the torque constant is corrected according to the active rotor flux:

$$M_i = K_M \times I_q$$

**Field Weakening Operation** With the firmware, it is possible to operate asynchronous and synchronous motors in the entire speed range (including field weakening range).

We basically distinguish 3 working ranges that are illustrated in the following figure and described below.



- A Basic Speed Range
- B Field weakening range 1
- C Field Weakening Range 2 (Power Limit Range)

Fig.6-33: Three Working Ranges of the Speed Range

**Basic Speed Range** The base speed range is characterized by constant torque and fixed torque/force constant (P-0-0051).

In the case of asynchronous motors, the programmed, effective magnetizing current flows in no-load operation. The motor voltage is less than the maximum controller output voltage. The corner speed n1 is directly proportional to the DC bus voltage.

**Field Weakening Range 1 (Constant Power)** The field weakening range 1 is characterized by constant power, the motor voltage is kept constant. In the case of asynchronous motors, the no-load current is reduced as the speed increases. This reduces the magnetization and



**Field Weakening Range 2 (Power Limit Range)**

the torque constant, the slip increases accordingly. The adjustment of magnetizing current and slip is automatically carried out by the voltage loop.

The field weakening range 2 is the range of decreasing peak power. An asynchronous motor works at the stall current limit in this range, through vector control, the current is maintained at an efficient and stable level. The peak current is reduced in such a way that the point of maximum power is not exceeded. Further increase in current would only lead to increased power dissipation and less shaft output. The peak power in range 3 is proportional to the square of the DC bus voltage. It is ensured that the maximum possible power is reached for each DC bus voltage without parameter adjustment.



Due to this causal connection, it is clear that the power in range 3 cannot be increased by using a more powerful controller. In this section, performance can only be increased by increasing the voltage of the DC bus!

In the following sections, we distinguish control of synchronous machines (with motor encoder) and asynchronous machines (with and without motor encoder).

**Field-Oriented Current Control of a Synchronous Machine**



For synchronous motors, field-oriented current control is only possible with motor encoder (with closed-loop base package)!

Synchronous motors with a motor encoder in field-oriented current control can be operated in all available operating modes. The figure below illustrates the control loop structure and the points at which the individual parameters take effect for a synchronous machine.

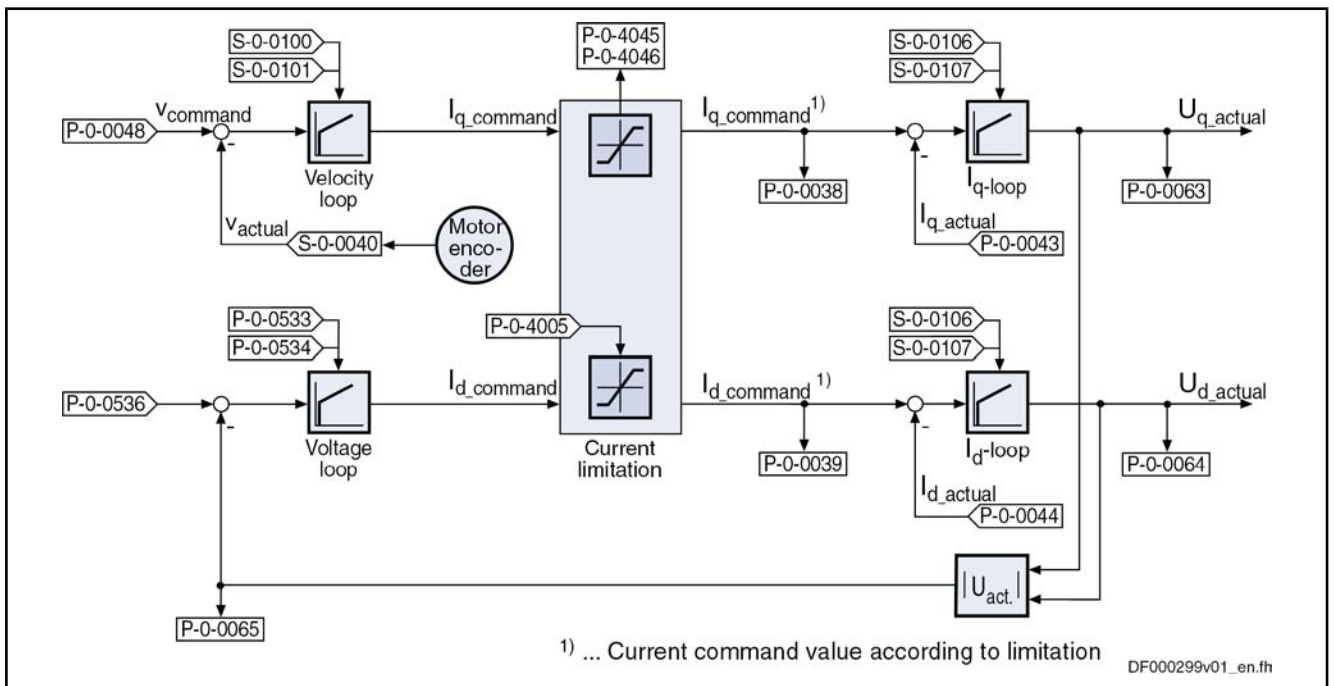


Fig.6-34: Simplified Schematic Diagram of the Current Control Loop for a Synchronous Machine

**Voltage Loop for Synchronous Motors**

For field control (or voltage control), a voltage loop designed as a PI loop is used that can be set via the following parameters:

- P-0-0533, Voltage loop proportional gain

## Drive Control

- P-0-0534, Voltage loop integral action time



The command value of the voltage loop is preset by "P-0-0536, Maximum motor voltage".

The voltage loop becomes active when the current loop output exceeds a defined absolute voltage value (see "P-0-0536, Maximum motor voltage"). By generating a field counteracting the permanent field-linked direct-axis flux ( $\rightarrow$  negative  $I_d$  command value), the reduction of the output voltage can be obtained.



The output value of the voltage loop is the command value for the field-generating component of the subsequent current loop (see figure above).

**Field Weakening of Synchronous Motors**

In the case of synchronous motors with field weakening, a command value of  $I_{d\_cmd} = 0$  is run in the basic speed range, as in the case of synchronous motors without field weakening.

When entering the field weakening,  $I_{d\_cmd}$  is increased towards negative values and therefore allows higher motor velocities.

**Closed-Loop Control of Synchronous Motors With Distinctive Reluctance Torque**

Closed-loop control of synchronous motors with reluctance torque, i.e. motors with significantly different inductances in the d and q axes, requires the separate input of  $L_d$  and  $L_q$  in the respective parameters:

- P-0-4016, Direct-axis inductance of motor ( $L_d$ )
- P-0-4017, Quadrature-axis inductance of motor ( $L_q$ )



Utilization of the reluctance effect allows increasing the available torque in the basic speed range.

**Field-Oriented Current Control of an Asynchronous Machine**

Field-oriented control of the asynchronous machine differs from control of the synchronous machine in the additional function blocks "flux feedforward" and "flux loop incl. field model".

The figure below illustrates the control loop structure of field-oriented current control:

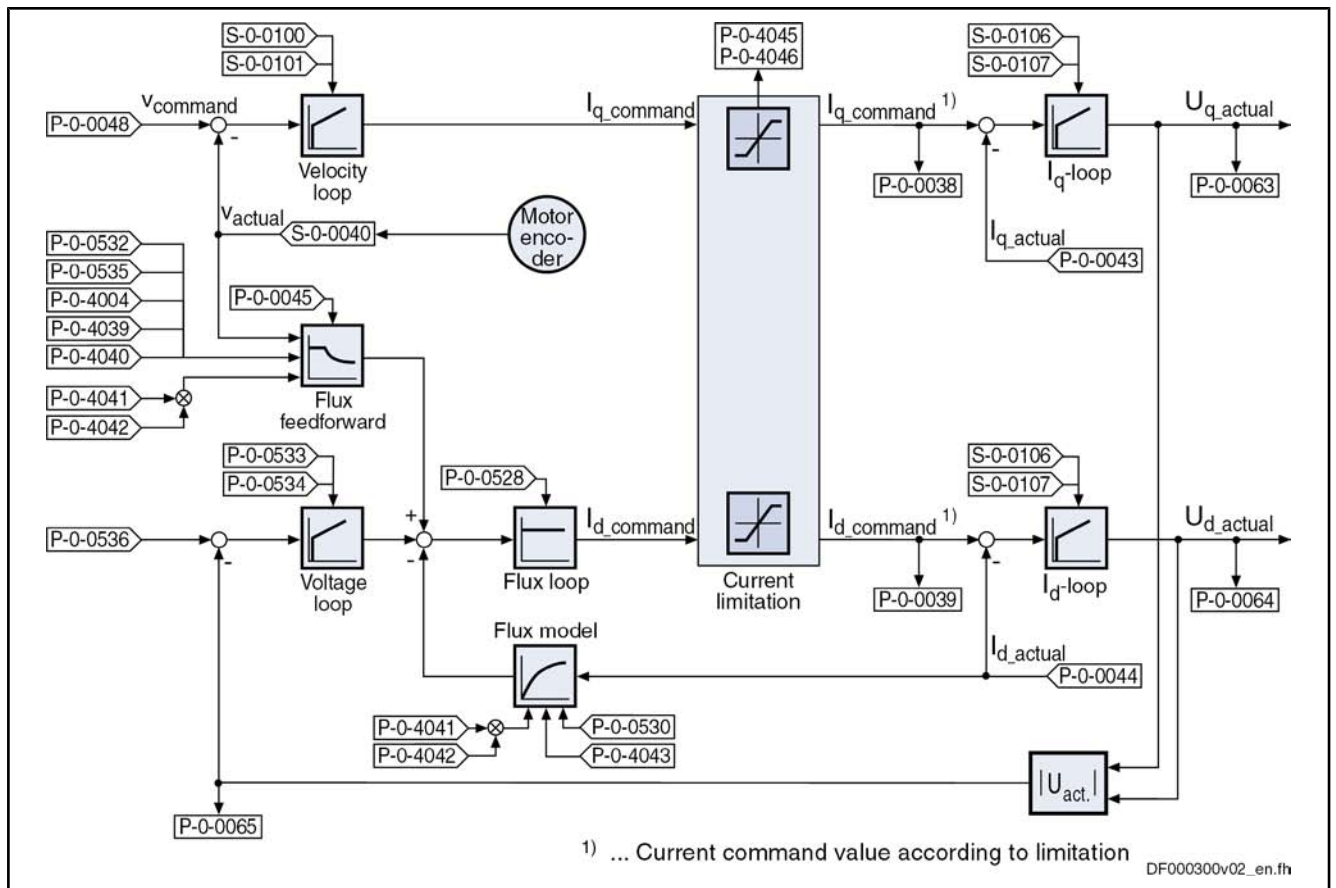


Fig. 6-35: Simplified Schematic Diagram of the Current Control Loop for an Asynchronous Machine

#### Flux Feedforward and Flux Model

The flux feedforward calculates the optimum rotor flux command value for each working point of the machine. The limiting variable is the motor voltage that increases with the speed. As limit value the flux feedforward uses the value in "P-0-0535, Motor voltage at no load".

In addition, the following motor data have an influence on flux feedforward and flux model:

- PP-0-4004, Magnetizing current
- P-0-4039, Stator leakage inductance
- P-0-4040, Rotor leakage inductance
- P-0-4041, Motor magnetizing inductance
- P-0-4042, Characteristic of motor magnetizing inductance
- P-0-4043, Rotor time constant

On the basis of the above motor data and the active value of the flux-generating current  $I_d$ , the flux model calculates the actual value of the rotor flux. This value is used as actual value for the flux loop (see below) and additionally determines the torque constant and the slip frequency of the asynchronous machine required for generating the torque.

#### Voltage Loop

The voltage loop works as a PI loop and in the absolute value limits the voltage output by the current loop to a maximum value. The setting is made via the following parameters:

- P-0-0533, Voltage loop proportional gain

## Drive Control

- P-0-0534, Voltage loop integral action time
- P-0-0536, Maximum motor voltage



When the maximum motor voltage is exceeded, the output of the voltage loop interferes in a corrective way in the output value of the flux feedforward.

**Flux Loop**

The flux loop works as a P-loop with command value feedforward. It compares the actual value from the rotor flux model to the command value from flux feedforward and voltage loop and by the corresponding input of the flux-generating current component  $I_{d-cmd}$  provides for rapid rotor flux generation. This is of importance for applications with dynamic speed response (field weakening range). The amplification can be set in "P-0-0528, Flux control loop proportional gain".



In the case of asynchronous motors, the field or rotor flux control has a decisive influence on the torque generation and dynamic response of the machine, particularly in the field weakening range.



For Rexroth motors the corresponding value is stored in the "DriveBase" database.

**Stall Current Limit**

The stall current limit only takes effect in the power limit range of the field weakening range (C). The maximum allowed torque-generating current is calculated by means of the active rotor flux and the motor data. This absolute limit value can be relatively changed via the setting in "P-0-0529, Scaling of stall current limit" (in percent).



When operating a motor without field weakening it is only the effective magnetizing current that is applied as command value for the field-generating current component.

**Determining the Rotor Flux Angle**

For field-oriented control of an asynchronous motor, the current rotor flux angle is continuously required. This angle is generated from the position information of the motor encoder.

**Notes on Commissioning**

The current loop was preset for all motors by Bosch Rexroth and normally does not have to be adjusted.

**Current Loop**

The current loop for the torque- or force-generating current ( $I_q$ ) designed as a PI loop can be set via the following parameters:

- S-0-0106, Current loop proportional gain 1
- S-0-0107, Current loop integral action time 1

The respective parameter settings depend on the properties of the motor winding (L and R) and on the sampling time of the current loop.

Availability of the parameter settings for the current loop:

- For Rexroth motors with motor encoder data memory, they are stored in this memory.
- For Rexroth motors without motor encoder data memory, they can be taken from the motor data base by means of a commissioning tool.
- For third-party motors, they have to be calculated by means of the data sheet (see "Automatic Setting of Motor Control" and "Third-Party Motors at IndraDrive Controllers").

**Inductance Characteristic for Synchronous Motors**

See also "Commissioning the Motor"

It is possible to store a characteristic of the motor quadrature-axis inductance ( $L_q$ ) in the drive depending on the torque-generating current ( $I_q$ ). If required (e.g. saturation phenomena), it is thereby possible to achieve the reduction of the effective current loop gain for higher currents. This function can be activated by setting bit 12 in "P-0-4014, Type of construction of motor".



For motors with significant saturation phenomena, it is recommended to use the inductance characteristic to achieve adjustment of the effective current loop gain!

The following parameters are used to define the characteristic:

- P-0-4002, Charact. of quadrature-axis induct. of motor, inductances
- P-0-4003, Charact. of quadrature-axis inductance of motor, currents

Both parameters have a list structure; the respective list elements form pairs of values which define the characteristic. The values in P-0-4002 are factors that are referring to the value in "P-0-4017, Quadrature-axis inductance of motor". The inductance values  $L_q$  of the characteristic are resulting by multiplication with this value. The values in P-0-4003 are factors that are referring to the value in "S-0-0111, Motor current at standstill". The current values  $I_q$  of the characteristic are resulting by multiplication with this value.

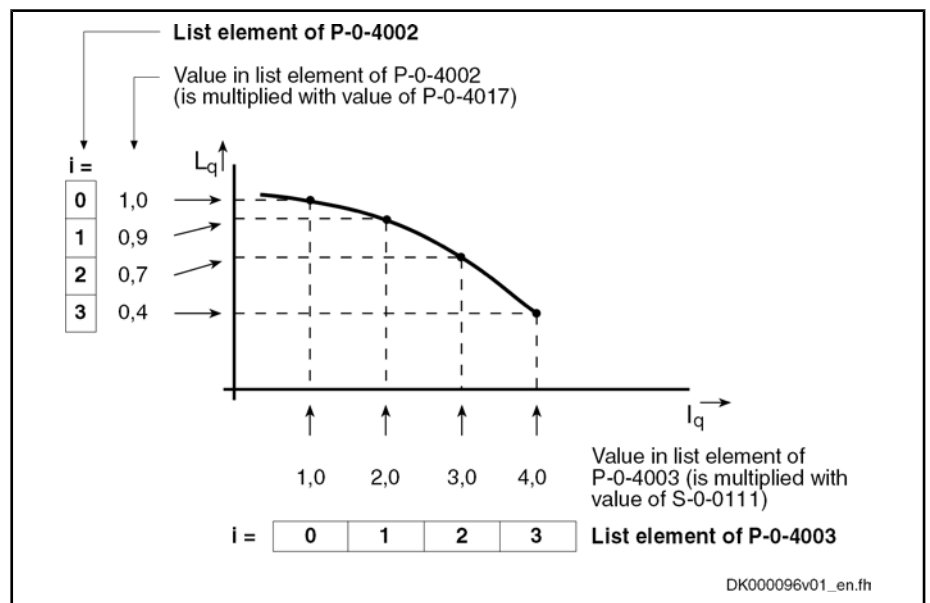


Fig.6-36: Interaction of the Parameters for Defining the Inductance Characteristic (With Exemplary Values)

**Flux Feedforward for Asynchronous Motors**

Due to higher magnetization (rotor flux), the motor produces higher torque. In no-load operation, however, the magnetization produces loss which is the reason why it is useful to reduce magnetization for less dynamic applications.



For reducing magnetization a value between 50% and 100% can be set in "P-0-0532, Premagnetization factor".

In addition, magnetization can be influenced via bit 2 in "P-0-0045, Control word of current controller":

- **Bit 2 = 0** (default setting)

## Drive Control

→ According to required torque, magnetization is increased up to nominal value; 100% are reached at nominal motor torque

- **Bit 2 = 1**

→ Independent of load, magnetization remains at value set in P-0-0532

As limit value for the flux feedforward the value in "P-0-0535, Motor voltage at no load" is used. The motor voltage at no load is specified in a percentage-based way and also refers to the maximum possible output voltage of the inverter.



A **setting of 80%** in P-0-0535 is advisable.

---

### Flux Model for Asynchronous Motors

The slip frequency used in the flux model changes with the temperature of the motor. This is compensated by measuring the motor temperature (S-0-0383) and evaluation with the factor in "P-0-0530, Slip increase".



The factor in P-0-0530 has to be set depending on the motor cooling type!

---

### Voltage Loop (Flux Loop)

The voltage loop designed as a PI loop (flux loop) can be set via the following parameters:

- P-0-0533, Voltage loop proportional gain
- P-0-0534, Voltage loop integral action time



The voltage loop is only active when bit 0 has been set (field weakening operation active) in the current loop control word (P-0-0045)

---

The command value of the voltage loop is defined by "P-0-0536, Maximum motor voltage".

The input in P-0-0536 is made in percent and refers to the maximum possible output voltage of the inverter that is determined by the active DC bus voltage (see "S-0-0380; DC bus voltage"0).



A **setting of 90%** in parameter P-0-0536 is advisable.

---

### Activating Field Weakening and Slip Increase

In addition to the parameterization of the voltage loop, the following settings can be made or changed, if required:

- Via bit 0 in "P-0-0045, Control word of current controller" the field weakening can be activated.
- According to the motor cooling type, a different factor can be set in "P-0-0530, Slip increase" for asynchronous motors.

## Diagnostic and Status Messages

### Status Messages

- S-0-0158, Power threshold Px

This parameter determines the power threshold above which the drive outputs the status message "Power > = Px" in "S-0-0337, Status "P >= Px"".

- S-0-0337, Status "P >= Px"

Only bit 0 of this parameter is used. It is set when the following applies:

"S-0-0382, DC bus power" = "S-0-0158, Power threshold Px"

Simultaneously, bit 7 is set in "S-0-0013, Class 3 diagnostics".

**Display Values and Diagnostic Values**

- The DC bus voltage is measured in the current loop clock and displayed in "S-0-0380, DC bus voltage".
- The effective electric power produced by the controller (taking the inverter losses into account) is displayed in "S-0-0382, DC bus power".

The effective power ( $P_w$ ) is calculated according to the following formula:

$$P_w = (U_d \times I_d + U_q \times I_q) \times 1,5$$

The calculated value is displayed in filtered form ( $T = 8$  ms). When the parameterized threshold value in "S-0-0158, Power threshold Px" is exceeded, bit 0 is set in "S-0-0337, Status "P >= Px"" and bit 7 in class 3 diagnostics.

- The measured value of the torque-generating current ( $I_q$ ) detected in the current loop clock is displayed in "P-0-0043, Torque-generating current, actual value, actual value".
- The measured value of the field-generating current ( $I_d$ ) detected in the current loop clock is displayed in "P-0-0044, Flux-generating current, actual value".
- "P-0-0046, Status word of current controller" displays the status of the current loop.

**Errors, Warnings and Monitoring Functions**

- C0132 Invalid settings for controller cycle times  
→ An error was detected in the parameterization of the controller cycle times and PWM frequency.
- E8025 Overvoltage in power section  
→ This warning is generated when the DC bus voltage exceeds a value of 870.0 V. In this case, the current loop is temporarily switched off to protect the motor.
- E8028 Overcurrent in power section  
→ This warning is generated when the total current  $1.2 \times$  minimum (S-0-0109, motor peak current; S-0-0110, amplifier peak current). In this case, the current loop is temporarily switched off to protect the motor (avoiding demagnetization).
- F2077 Current measurement trim wrong  
→ During zero adjust of the current measurement, a deviation outside of the tolerance range occurred (hardware defect).

## 6.2.5 Sensorless Motor Operation, Flux-Controlled (FXC Control)

### Brief Description



**Base package** of all firmware variants in **open-loop** and **closed-loop** characteristic

For asynchronous and synchronous motors, flux-controlled, sensorless motor operation is available in the base packages "open-loop" and "closed-loop" of all firmware variants and can be used in the "velocity control" mode and in position-controlled operation modes which use position encoder 2 (external encoder).

When using the firmware expansion package "synchronization", you can also run the operation mode "velocity synchronization with real/virtual master axis".

## Drive Control

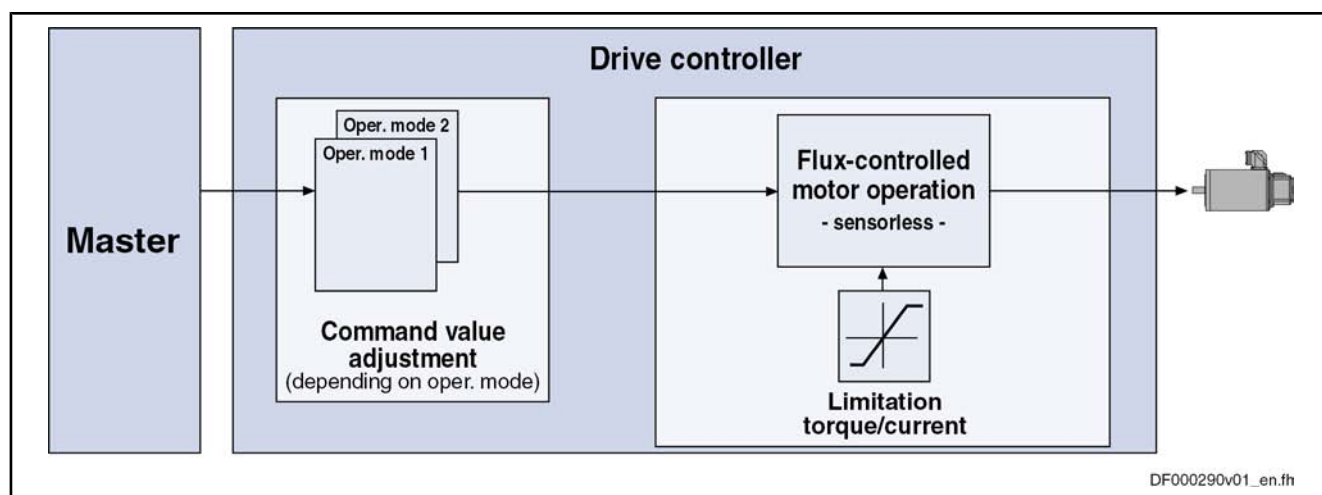


Fig. 6-37: Principle of Sensorless, Flux-Controlled Motor Operation

- Features**
- Limitation of the maximum **stator frequency slope** that results from the command velocity change
  - "Stable" motor operation
    - To maintain the maximum possible torque
  - **Slip compensation** for asynchronous motors (estimated motor slip taken into account for calculating actual velocity value)
    - To minimize the stationary speed deviations, due to slip, from the command value when the asynchronous motor is loaded
  - Motor speed does not tend to oscillation in operation at partial load and no-load operation
  - **Velocity search mode** of a coasting asynchronous motor after switching drive enable on
  - Possibility of taking user-side **torque/force limitation** into account

**Pertinent Parameters** Motor control parameters of sensorless, flux-controlled motor operation:

- P-0-4033, C3200 Command Calculate motor data
- P-0-0532, Premagnetization factor
- P-0-0565, C3600 Command Motor data identification
- P-0-0578, Current for deceleration, absolute value
- P-0-0579, Current for deceleration, time period
- P-0-0580, Motor frequency
- P-0-0593, FXC: Total flux loop proportional gain
- P-0-0594, FXC: Total flux loop integral action time
- P-0-0595, FXC: Frequency loop proportional gain
- P-0-0596, FXC: Frequency loop scaling factor of inertia
- P-0-0597, FXC: Current loop proportional gain
- P-0-0598, FXC: Current loop integral action time
- P-0-0599, FXC: Slip frequency filter time constant
- P-0-0600, FXC: Rated slip frequency
- P-0-0602, FXC: Minimum no-load current

Motor data parameters:

- P-0-0510, Rotor inertia



- P-0-4004, Magnetizing current
- P-0-4032, Motor type plate data

Axis data parameters:

- P-0-4010, Load inertia

Control parameters:

- P-0-0045, Control word of current controller
- P-0-0601, Configuration motor data identification

## Functional Description

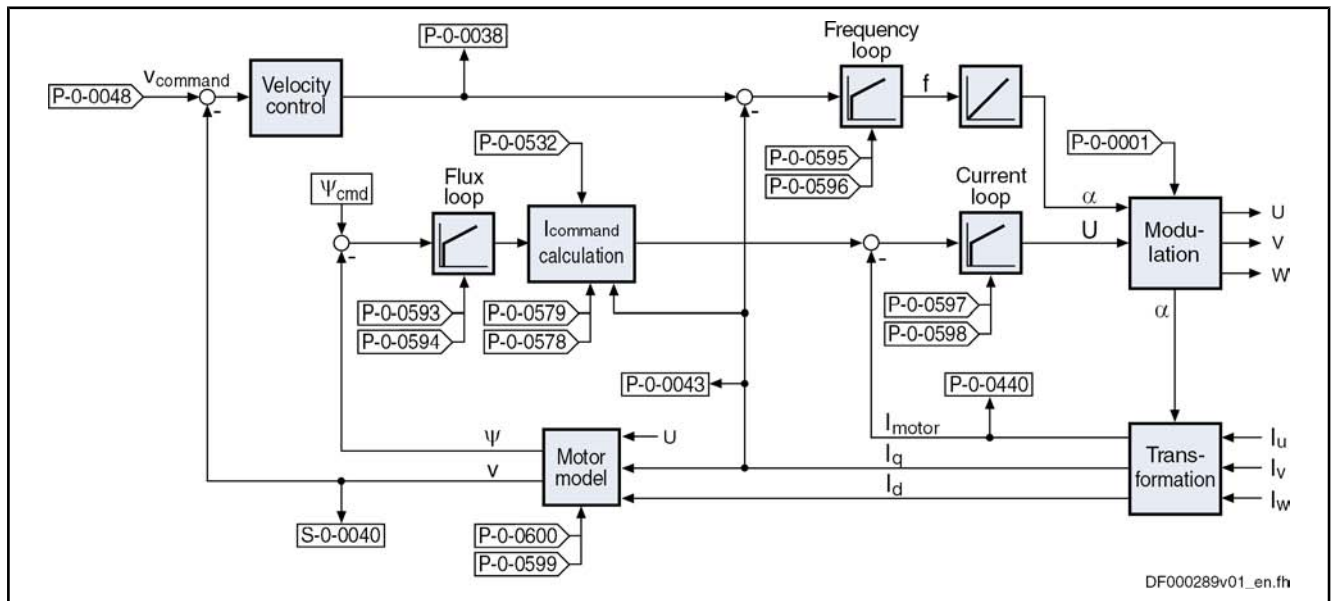


Fig.6-38: Block Diagram of Sensorless, Flux-Controlled Motor Operation

### Control Method

For controlling sensorless synchronous motors (SYM) or asynchronous motors (ASM), the control method generates a three-phase rotary field with variable voltage amplitude and rotary field frequency. The rotary field frequency depends on the velocity command value, the number of pole pairs of the motor and, in the case of ASM, on the motor load. The amplitude of the motor voltage depends on the impedances and on the magnetic flux in the motor.

The frequency of the motor voltage is given by a PI frequency loop, depending on the control difference of the torque-generating command current and actual current. It is the electrical equivalent of the velocity:

- For ASM, torque is generated by "slip" (deviation from velocity command value under load). This "slip" can be compensated for ASM via the calculated actual velocity value (motor model calculation). When the load exceeds the "pull-out slip" of the motor, it stops.
- For SYM, the torque is generated by the "load angle". Its value is proportional to the load; when it remains smaller than  $90^\circ$  el., the actual velocity value follows the velocity command value without deviation. When the load causes a load angle greater than  $90^\circ$  el., the SYM stops abruptly.

The amplitude of the motor voltage is given by a PI current loop, depending on the control difference of the total motor current:

- For ASM, the required magnetic flux must be generated in the air gap. The optimum flux command value for the motor is preset drive-internally. From the current status variables, the motor model calculates the flux existing

## Drive Control

in the motor. By means of the flux deviation, the PI flux loop and a subsequent calculation function generate the command value for the total motor current.

- For SYM, the magnetic flux already exists in the air gap due to the permanent magnets. However, a command value for the total motor current is preset when the motor is in no-load operation. The impulse load stability is improved with increased no-load current, the no-load loss, however, is increased.

**Deceleration, Standstill**

At low speed, the determination of the actual velocity is highly inexact due to motor operation without encoder. At output frequencies below a threshold value, a current for deceleration (P-0-0578, Current for deceleration, absolute value) which can be set is therefore output during deceleration to bring the motor to standstill. During the determination of the motor parameters, the value is automatically set to the rated current of the motor.

As motor standstill cannot be reliably identified, the current for deceleration, after the velocity command value and the actual velocity value have been brought to zero, is maintained for a time which can be set (P-0-0579, Current for deceleration, time period) so that the motor really comes to standstill.

When this time is over, the current is reduced, with the drive having been enabled:

- For asynchronous motors to the magnetizing current (P-0-4004).
- For synchronous motors to the no-load current (P-0-0602).

In both cases, the current flowing in the motor when it is in standstill can be reduced more via a premagnetization factor (P-0-0532). This reduces the temperature rise of the enabled motor which is in standstill and the thermal load of the controller.

**"Coasting" Motor**

By means of the velocity search mode, a coasting asynchronous motor can be brought to deceleration mode and be decelerated, or run to a command value. When this is done, the control of the motor first synchronizes to the current rotational frequency of the motor, before the command value becomes active.



For synchronous motors, this function is not available.

---

**Working Ranges**

The sensorless, flux-controlled synchronous or asynchronous motor works in a velocity-dependent way in the basic speed range (low speed) or in the field weakening range (high speed). For the field weakening range, it is not necessary to make any further settings.

**Determining the Motor and Motor Control Parameters**

On the basis of the type plate parameters, the controller can automatically determine the motor parameters for asynchronous motors by executing commands.



For synchronous motors, this function is not yet available.

---

**Frequency Loop**

See "Automatic Setting of Motor Control"

The frequency loop has been designed as a PI loop. It limits the slope of the frequency change of the motor voltage, when accelerating and decelerating, to the steepest, stable characteristic. The slope is significantly determined by the total inertia of the axis. With the parameter "P-0-0596, FXC: Frequency loop scaling factor of inertia" it can be adjusted to the mechanical transmission performance of the load connection. If necessary, it can compensate lacking accuracy of the motor-shaft-related inertia value.

$$J_{\text{axis\_MW\_FXC}} = \frac{(P-0-0596)}{100\%} \times J_{\text{axis\_MW}} = \frac{(P-0-0596)}{100\%} \times [(P-0-0510) + (P-0-4010)]$$

- $J_{\text{Axis\_MW\_FXC}}$  Effective inertia of the axis (in frequency loop)
- $J_{\text{Axis\_MW}}$  Inertia of the machine axis, motor-shaft-related
- P-0-0596 Frequency loop scaling factor of inertia (FXC)
- P-0-0510 Rotor inertia
- P-0-4010 Load inertia (motor-shaft-related)
- Fig. 6-39: Inertia of the Axis Effective in the Frequency Loop*

The effective slope of the stator frequency can be calculated by means of the following formula:

Asynchronous motor:

$$\frac{\Delta f_{\text{Stator}}}{\Delta t} = \frac{M_{\text{th}}}{J_{\text{Axis\_MW\_FXC}}} = \frac{3 \times (P-0-0018)^2 \times (P-0-0043) \times (P-0-4004) \times (P-0-4041) \times 10^{-3}}{2 \times \pi \times \frac{(P-0-0596)}{100\%} \times [(P-0-0510) + (P-0-4010)]} \text{ [Hz/s]}$$

Synchronous motor:

$$\frac{\Delta f_{\text{Stator}}}{\Delta t} = \frac{M_{\text{th}}}{J_{\text{Axis\_MW\_FXC}}} = \frac{(P-0-0051) \times (P-0-0043)}{2 \times \pi \times \frac{(P-0-0596)}{100\%} \times [(P-0-0510) + (P-0-4010)]} \text{ [Hz/s]}$$

Conversions:

$$\frac{\Delta \omega_{\text{Rotor}}}{\Delta t} = \frac{2 \times \pi}{(P-0-0018)} \times \frac{\Delta f_{\text{Stator}}}{\Delta t} \text{ [rad/s}^2\text{]}; \quad \frac{\Delta n_{\text{Rotor}}}{\Delta t} = \frac{60\text{s/min}}{(P-0-0018)} \times \frac{\Delta f_{\text{Stator}}}{\Delta t} = \frac{60\text{s/min}}{2 \times \pi} \times \frac{\Delta \omega_{\text{Rotor}}}{\Delta t} \text{ [min}^{-1}\text{/s]}$$

- $f_{\text{Stator}}$  Stator frequency
- $M_{\text{th}}$  Theoretical maximum torque of the motor (internally calculated)
- $J_{\text{Axis\_MW\_FXC}}$  Effective inertia of the axis (in frequency loop)
- $\omega_{\text{Rotor}}$  Angular frequency of the rotor (motor shaft)
- $n_{\text{Rotor}}$  Speed of the rotor (motor shaft)
- P-0-0018 Number of pole pairs/pole pair distance
- P-0-0043 Torque-generating current, actual value
- P-0-4004 Magnetizing current
- P-0-4041 Motor magnetizing inductance
- P-0-0596 Frequency loop scaling factor of inertia (FXC)
- P-0-0510 Rotor inertia
- P-0-4010 Load inertia
- P-0-0051 Torque/force constant
- Fig. 6-40: Calculating the Stator Frequency Slope*

Enter the motor inertia in the parameter "P-0-0510, Rotor inertia" and the axis inertia (motor-shaft-related) in the parameter "P-0-4010, Load inertia".

If the motor-shaft-related axis inertia is unknown, it can be determined by an acceleration test:

Drive Control

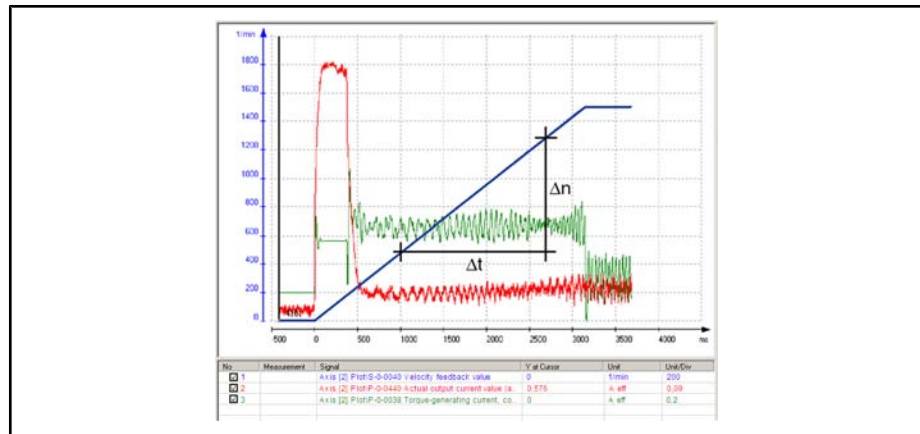


Fig.6-41: Acceleration Curve of the Axis With the Required Status Variables



Select the acceleration ramp such that the actual value of the torque-generating current (P-0-0043) is constant over the biggest possible velocity range. If applicable, a smaller ramp acceleration is to be selected!

Asynchronous motor:

$$J_{\text{Axis\_MW}} = \frac{3 \times (P-0-0018) \times (P-0-4041) \times (P-0-4004) \times (P-0-0043) \times 60\text{s}}{2 \times \pi \times 10^3 \text{min}} \times \frac{\Delta t}{\Delta n}$$

Synchronous motor:

$$J_{\text{Axis\_MW}} = \frac{(P-0-0051) \times (P-0-0043) \times 60\text{s}}{2 \times \pi \times (P-0-0018)} \times \frac{\Delta t}{\Delta n}$$

- $J_{\text{Axis\_MW}}$  Inertia of the machine axis, motor-shaft-related
- P-0-4041 Motor magnetizing inductance (in mH)
- P-0-4004 Magnetizing current (in A)
- P-0-0043 Torque-generating current, actual value (average value during the linear acceleration in A)
- P-0-0018 Number of pole pairs/pole pair distance
- P-0-0051 Torque/force constant
- $\Delta t$  Run-up time in the range of the linear speed increase (in s)
- $\Delta n$  Speed change during the run-up time (in min<sup>-1</sup>)

Fig.6-42: Calculating the Motor-Shaft-Related Total Inertia of the Machine Axis

Enter the calculated value of the motor-shaft-related total inertia of the axis, less the rotor inertia (P-0-0510), in parameter "P-0-4010, Load inertia".



If the rotor inertia is unknown, you can enter the total inertia in parameter P-0-0510 or P-0-4010.

Only in particular cases is it necessary to change the value of parameter "P-0-0595, FXC: Frequency loop proportional gain".

**Flux Loop**

The flux loop, too, has been designed as a PI loop. It is one of the input values for calculating the current command value. The values for the parameters "P-0-0593, FXC: Total flux loop proportional gain" and "P-0-0594, FXC: Total flux loop integral action time" remain at default. By means of run-up measurement with little acceleration, check the values and adjust them, if necessary (see below "Notes on Commissioning").



Only in particular cases is it necessary to change the value of parameter "P-0-0593, FXC: Total flux loop proportional gain".

### Speed Slip Compensation (Only for Asynchronous Motors)

For speed slip compensation, the slip of the asynchronous motor to be expected under load is taken into account in the motor model for the determined current velocity. By velocity control (PI loop), the slip in comparison to the velocity command value is compensated.

Speed slip compensation is only required for drives with high demands as regards the maintaining of the velocity command value under load. It does not need to be used for standard requirements!

In the default status, speed slip compensation is inactive. It can be activated by means of the motor-specific value in parameter "P-0-0600, FXC: Rated slip frequency". The theoretical value is calculated according to the formula below:

$$P-0-0600 = f_{\text{nominal}} - \frac{n_{\text{nominal}} \times (P-0-0018) \times \text{min}}{60\text{s}}$$

P-0-0600	Rated slip frequency (FXC)
$f_{\text{Nominal}}$	Rated frequency acc. to motor type plate (in Hz)
$n_{\text{Nominal}}$	Rated speed acc. to motor type plate (in 1/min)
P-0-0018	Number of pole pairs/pole pair distance
<i>Fig. 6-43:</i>	<i>Calculating the Value for the Slip Frequency</i>

As it is not really possible to check the velocity of sensorless motors, it is only due to subjective assessment that you can deduce whether the command velocity has been maintained under load.

The value of parameter "P-0-0599, FXC: Slip frequency filter time constant" influences the reaction time of slip compensation at load impulse. Only in particular cases is it necessary to adjust the value in motor-specific form!

### Current Loop

The current loop for sensorless, flux-controlled motor operation outputs the amplitude of the motor terminal voltage. It differs from the current loop of the methods for field-oriented motor control with motor encoder. The preset values of the parameters "P-0-0597, FXC: Current loop proportional gain" and "P-0-0598, FXC: Current loop integral action time" only have to be adjusted in particular cases.

## Notes on Commissioning

### Establishing the Basic State

To establish a neutral state of the drive parameters, it is recommended that you execute the command "load basic parameters".

Sensorless, flux-controlled motor operation (FXC) is only possible when the motor encoder input (if available) has been deactivated.

Drive Control

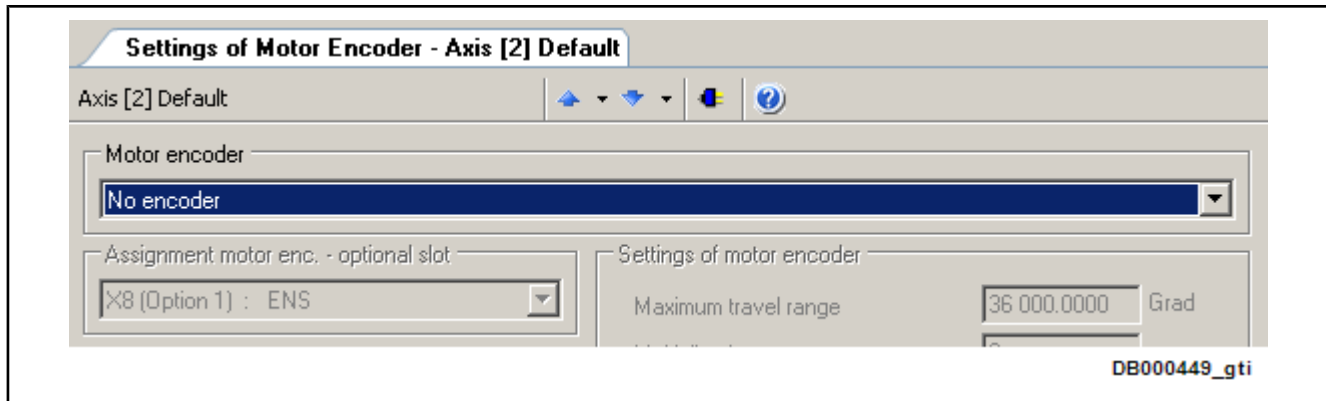


Fig.6-44: "IndraWorks Ds/D/MLD" Dialog "Motor Encoder", Deactivation

**Activating FXC Operation**

When you set the type of construction of motor to "synchronous", sensorless, flux-controlled motor operation is automatically activated; with the type of construction of motor "asynchronous", you can choose between FXC operation and U/f operation.



You can make the settings via dialogs in "IndraWorks Ds/D/MLD", or set the corresponding bits in the control word of the current controller (P-0-0045).

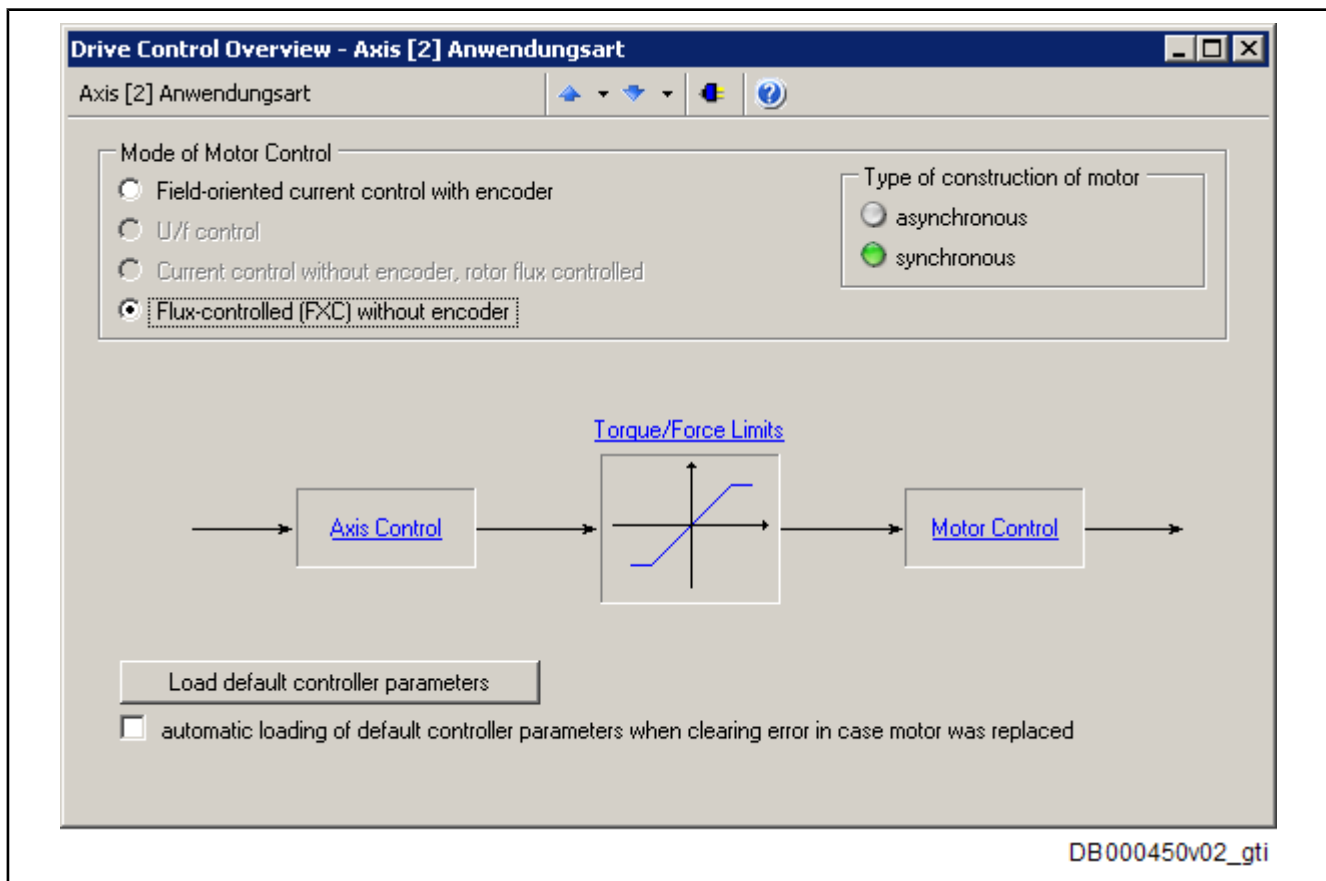


Fig.6-45: "IndraWorks Ds/D/MLD" Dialog for Setting the Mode of Motor Control

**Determining the Motor Parameters for Asynchronous Motors**

For asynchronous motors, it is recommended that you have the motor parameters determined by the controller on the basis of the type plate data. For this purpose, enter the type plate data in the parameter "P-0-4032, Motor type plate

data" and afterwards execute the commands "C3200 Command Calculate motor data" (P-0-4033) and "C3600 Command Motor data identification" (P-0-0565).

See also "Automatic Setting of Motor Control"



When reading the type plate data, make sure the data correlate. Only enter data with the same frequency reference (in the case of data for 50Hz and 60Hz) or data with reference to the same winding connection (in the case of data for Y and  $\Delta$ )!

Before you start "C3600 Command Motor data identification" (P-0-0565), check whether it is allowed to put the motor shaft into rotation. Enter the result in the parameter "P-0-0601, Configuration motor data identification". When the motor is turning, the magnetizing inductance can be determined more precisely; therefore, the motor shaft, if allowed, is brought to approx. 50% of the nominal speed by C3600.



The default setting of parameter P-0-0601 is "Motor shaft **cannot** move freely".

**Motor - Axis [2] Default**

Axis [2] Default

Motor category: Asynchronous third-party motor

Date of motor database: 1/1/1601

Motor type: ASM030B-0900

Rotary  Linear

Type plate  Equivalent circuit diagram

Rated current: 4.000 A eff

Rated voltage: 380.000 V eff

Rated frequency: 50.000 Hz

Rated speed: 925.000 1/min

Power factor cos Phi: 0.760

Rated power: 1.500 kW

Determining magnetiz. inductance:

Motor shaft cannot move freely

Motor shaft can move freely

Default!

Calculate Motor Data

Motor Data Identification

DB000451\_gti

Fig. 6-46: "IndraWorks Ds/D/MLD" Dialog "Motor", Setting Type of Construction of Motor, Entering Type Plate Data of ASM, Starting Command "Calculate Motor Data" and "Motor Data Identification" With Exemplary Values

#### Determining the Motor Parameters for Synchronous Motors

Enter the motor data of the synchronous motor in the "IndraWorks Ds/D/MLD" dialog "Motor", otherwise in the following parameters:

- P-0-0018, Number of pole pairs/pole pair distance
- S-0-0113, Maximum motor speed
- S-0-0111, Motor current at standstill
- S-0-0109, Motor peak current
- P-0-0051, Torque/force constant
- P-0-4005, Flux-generating current, limit value

## Drive Control

- P-0-4016, Direct-axis inductance of motor
- P-0-4017, Quadrature-axis inductance of motor
- P-0-4048, Stator resistance
- P-0-0510, Rotor inertia



The command "C4600 Command Calculate motor control parameters" is irrelevant for FXC operation of synchronous motors!

**Motor - Axis [1] Default**

Axis [1] Default

Motor category: Synchronous third-party motor

Date of motor database: 3/23/2009

Motor type:

Rotary  Linear

Number of pole pairs	<input type="text" value="3"/>	Pole pairs	Torque/force constant	<input type="text" value="1.00"/>	Nm/A eff
Maximum motor velocity	<input type="text" value="3000.0000"/>	Rpm	Direct-axis induct. of motor	<input type="text" value="1.000"/>	mH
Motor peak current	<input type="text" value="5.000"/>	A eff	Quadrature-axis induct. of motor	<input type="text" value="1.000"/>	mH
Motor current at standstill	<input type="text" value="1.000"/>	A eff	Stator resistance	<input type="text" value="0.000"/>	Ohm
Nominal motor torque/force	<input type="text" value="0.000"/>	Nm	Rotor inertia	<input type="text" value="0.00000"/>	kgm2
Motor peak torque/force	<input type="text" value="0.000"/>	Nm			
Limit value of flux-generating current	<input type="text" value="0.000"/>	A eff			
FXC: minimum no-load current	<input type="text" value="0.100"/>	A eff			

DB000455\_gti

Fig.6-47: "IndraWorks Ds/D/MLD" -Dialog "Motor", Setting Type of Construction of Motor, Entering Motor Data of SM With Exemplary Values

### Determining the Inertia

The frequency loop can only work correctly, if the inertia of the machine axis (motor-shaft-related) has been entered in the following parameters:

- P-0-0510, Rotor inertia
- P-0-4010, Load inertia

If the total inertia of the axis, which relates to the motor shaft, is unknown, it can be determined by means of an acceleration test. For this purpose, it is advisable to accelerate the motor with a flat ramp to approx. 75% of the nominal speed.

Recommendation for setting the appropriate velocity ramp with velocity control:



$$P-0-1201 = P-0-1211 = \frac{\pi}{30\text{s/min}} \times \frac{\Delta n}{\Delta t} \approx 0,1 \times \frac{0,75 * n_{\text{nominal}}}{2\text{s}} \times \frac{\text{min}}{\text{s}}$$

$$P-0-1202 \geq n_{\text{nominal}}$$

- P-0-1201 Ramp 1 pitch (in rad/s<sup>2</sup>)
- P-0-1211 Deceleration ramp 1 (in rad/s<sup>2</sup>)
- Δt Run-up time in the range of the linear speed increase (in s)
- Δn Speed change during the run-up time (in min<sup>-1</sup>)
- P-0-1202 Final speed ramp 1
- n<sub>Nominal</sub> Rated speed acc. to type plate

Fig. 6-48: Velocity Ramp to Determine the Total Inertia of the Axis

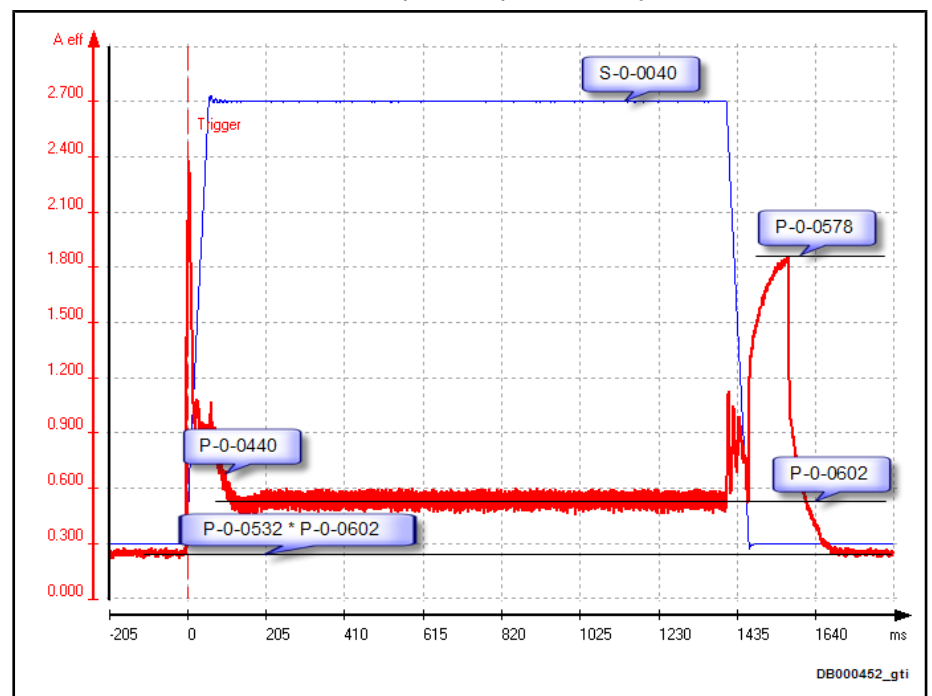
As regards data for calculating the total inertia of the axis, see above "Functional Description".

**Setting the Acceleration/Deceleration Ramp**

As a matter of principle, the acceleration and deceleration ramp (P-0-1201 et seq.) should be used for velocity-controlled FXC operation. It is recommended that you only use approx. 90% of the maximum possible acceleration. This results in steadier acceleration and deceleration behavior than is the case at the current limit (determining the acceleration/deceleration values "Calculating the Stator Frequency Slope, page 393").

**Entering the No-Load Current**

The no-load current which can be set influences the impulse load stability of the motor. The value of "P-0-0602, FXC: Minimum no-load current" can be set to values between 0.1....0.75\*nominal current; via the sign, the no-load current behavior can be influenced in a speed-dependent way:



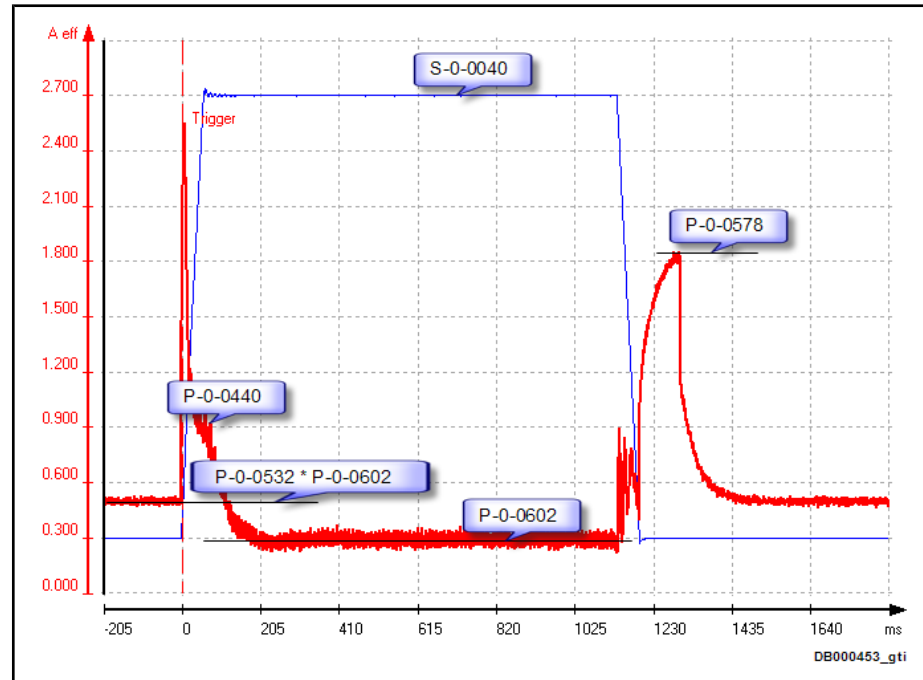
- P-0-0602 FXC: Minimum no-load current
- P-0-0532 Premagnetization factor
- P-0-0578 Current for deceleration, absolute value
- P-0-0440 Actual output current value (absolute value)
- S-0-0040 Velocity feedback value

Fig. 6-49: No-Load Current With Positive Sign of P-0-0602, P-0-0532 = 50%

Drive Control



With positive sign of P-0-0602, the no-load current of the motor is at least as high as the value of P-0-0602. In the case of motor standstill the no-load current can be decreased via factor P-0-0532.



- P-0-0602 FXC: Minimum no-load current
- P-0-0532 Premagnetization factor
- P-0-0578 Current for deceleration, absolute value
- P-0-0440 Actual output current value (absolute value)
- S-0-0040 Velocity feedback value

Fig.6-50: No-Load Current With Negative Sign of P-0-0602, P-0-0532 = 100%



With negative value of P-0-0602, the no-load current of the motor can be reduced to a minimum of 0.1\* nominal current (S-0-0111) when the motor is turning; when the motor is in standstill, control takes place with regard to the absolute value of P-0-0602 \* P0-0532. This improves the acceleration behavior and minimizes the no-load loss of the turning motor.

Checking Relevant Parameters

The parameters relevant to FXC operation are shown in a block diagram in "IndraWorks Ds/D/MLD".

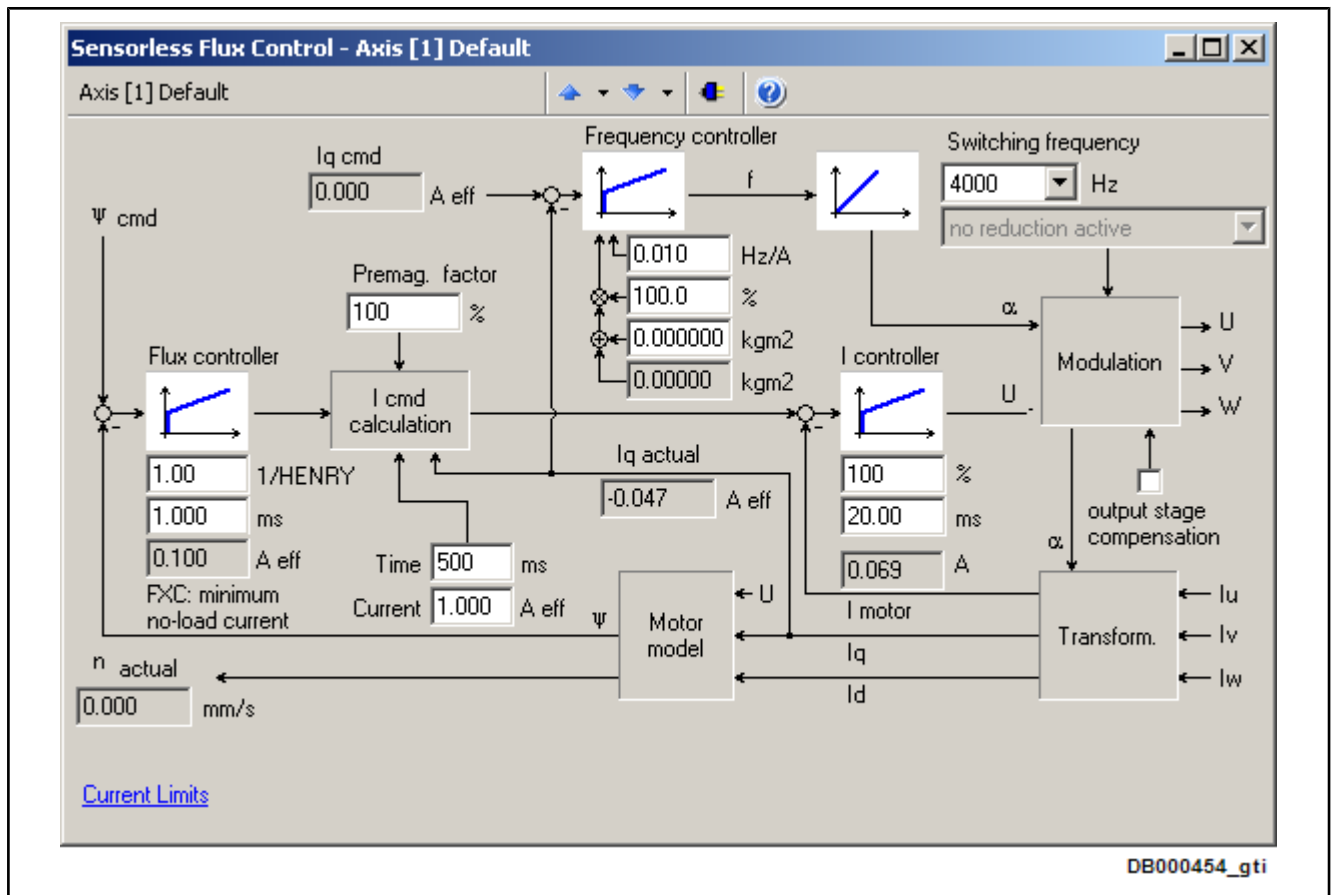


Fig. 6-51: "IndraWorks Ds/D/MLD" Dialog for FXC Operation, With Exemplary Values

#### Setting the Frequency Loop

With the value of the parameter "P-0-0596, FXC: Frequency loop scaling factor of inertia", you can influence the pitch of the frequency ramp of the frequency loop. The optimum value has been reached at maximum acceleration of the motor. If you continue modifying the value, this will only cause the motor temperature to rise due to increased motor currents!

Leave the value of parameter "P-0-0595, FXC: Frequency loop proportional gain" unchanged!

#### Checking the Flux Loop

For the flux loop, you should check and, if necessary, adjust the value of the parameter "P-0-0594, FXC: Total flux loop integral action time". For this purpose, carry out an acceleration test with ramp-like velocity command value, for example to 75% of the rated speed in approx. 2 s (see above). After the flux loop has been activated, the total current (P-0-0440) should quickly fall to a stationary value (see above "Functional Description"). In order for the total current to fall more quickly, reduce the value of parameter P-0-0594.

Drive Control

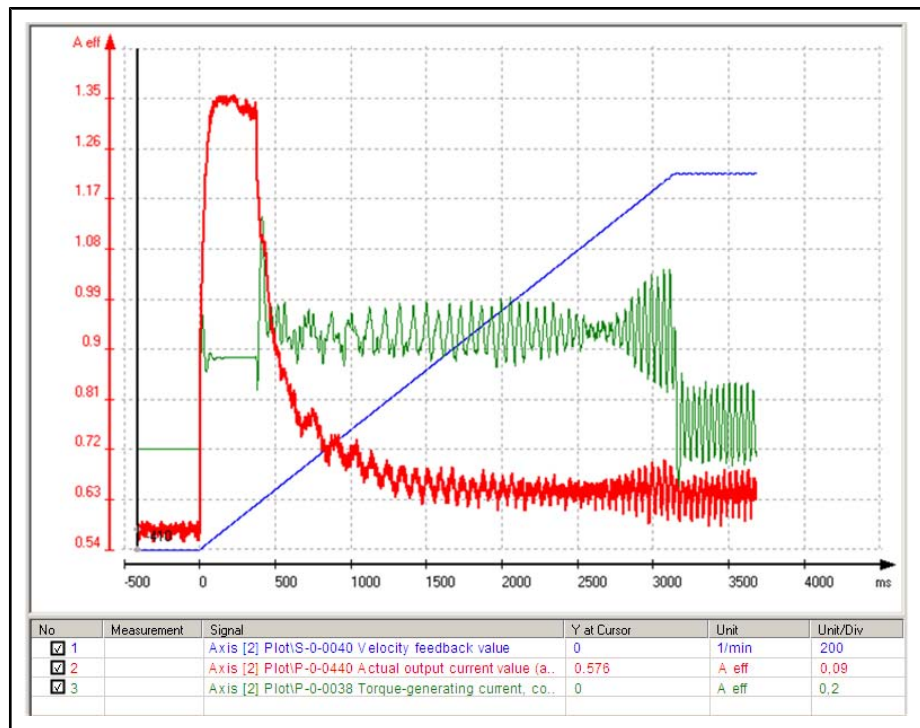


Fig.6-52: Result of P-0-0594 Check → Value too High

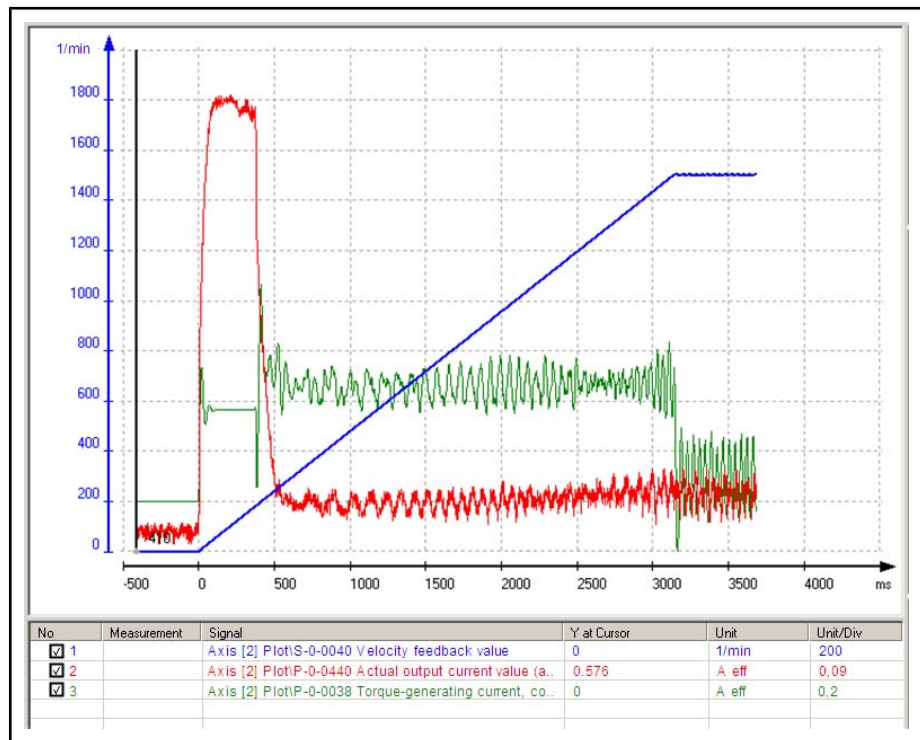


Fig.6-53: Result of P-0-0594 Check → Value Correct



The appropriate value for parameter "P-0-0594, FXC: Total flux loop integral action time" quickly causes the total current (P-0-0440) to fall to a horizontal current profile.

In most of the cases, the value of parameter "P-0-0593, FXC: Total flux loop proportional gain" can remain unchanged!

**Current Loop** Only in particular cases does the current loop require motor-specific settings. Leave the values of the parameters "P-0-0597, FXC: Current loop proportional gain" and "P-0-0598, FXC: Current loop integral action time" unchanged!

When the current oscillates under load, you should first try to attenuate the oscillation by increasing the value of P-0-0598.



For motors with low ohmic resistance, unstable motor movement can be improved with higher values of P-0-0597 (compared to default value)!

When overcurrent occurs during acceleration from standstill (message "F8060 Overcurrent in power section"), you should reduce the value of the parameter P-0-0597.

**Speed Slip Compensation (Only for Asynchronous Motors)**

For the parameter "P-0-0600, FXC: Rated slip frequency", calculate the value (see above "Functional Description") and enter it.

Judge the slip compensation of the motor at constant speed under load:

- Motor speed audibly reduced → increase value in P-0-0600
- Motor speed audibly increased → reduce value in P-0-0600

Only in particular cases is it necessary to change the default setting of parameter "P-0-0599, FXC: Slip frequency filter time constant". You should increase the value when the motor, at load impulse, is "out-of-step" and possibly stops because the current limit of the device has been reached. The reaction time of speed slip compensation is slowed down as the values increase; this causes the current to rise less at load impulse (Requirement: The continuous current of the device must be sufficient for stationary load!).



Using speed slip compensation is mainly advantageous in the "velocity control" mode!

**Settings for Deceleration**

The deceleration behavior of the drive is decisively influenced by the parameters "P-0-0578, Current for deceleration, absolute value" and "P-0-0579, Current for deceleration, time period".

When the velocity value falls below a firmware-internal threshold, the motor is taken to velocity value "zero" with the current amplitude from parameter P-0-0578. By entering a time period for the current for deceleration (P-0-0579) unequal zero, the current for deceleration is maintained for this time, after velocity command value and actual velocity value have reached "zero".

If the drive does not come to standstill, increase:

- Deceleration time (P-0-0579)  
- and/or -
- Current for deceleration (P-0-0578)



When acceleration takes place out of standstill, the value of P-0-0578 takes effect, too, below the mentioned velocity threshold!

**Using the Motor Search Mode (Only for Asynchronous Motors)**

If a motor could already be in motion without control, you should activate the motor search mode in the control word of the current controller (P-0-0045). This leads the motor from uncontrolled motion to the preset command value.



**CAUTION**

**Acceleration of the motor shafts of motors in standstill with activated motor search mode after drive enable!**

⇒ Only activate the motor search mode when arbitrary rotation of the motor shaft is safely possible!

## Drive Control

## Notes on Error Diagnosis

Sensorless, flux-controlled motor operation does not require any specific diagnosis!

Problems in the operating behavior can have the following causes:

- **Difference between actual value of no-load current and entered magnetizing current for asynchronous motors**

Read the value of parameter "P-0-0440, Actual output current value (absolute value)" in no-load motor operation (without connected load) at 50% of the rated speed. This value must correspond to the value of the magnetizing current (P-0-4004).

→ The value of P-0-0440 can be proportionally adjusted to the value of P-0-4004 by the setting in parameter "P-0-4041, Motor magnetizing inductance".

**Note:** Make sure that parameter P-0-4004 contains the **correct magnetization current** of the asynchronous motor!

- **Current limitation at motor standstill**

If the warning "E8260 Torque/force command value limit active" appears in standstill with the drive having been enabled, the controller cannot continuously supply the required current at standstill of the motor.

→ Reduce current at standstill by smaller value in parameter "P-0-0532, Premagnetization factor".

→ Use controller with higher continuous current (type current).

## 6.2.6 Automatic Setting of Motor Control

### Brief Description



**Base package** of all firmware variants in **open-loop and closed-loop** characteristic

For operating motors, it is necessary to collect the values for motor parameters (resistance values, inductances, ...), in order to determine the motor control parameters (flux loop, voltage loop, current loop, ...) with these values.

Depending on the manufacturer and type of the motor to be controlled, the values for motor parameters and motor control parameters are made available to the controller in different ways.

#### Motors by Bosch Rexroth

For Rexroth motors, the values for the motor and motor control parameters are optimized and made available by the manufacturer. The automatic setting of the motor control parameters by the drive firmware is not required and not allowed for Rexroth motors!

- For motors **with motor encoder data memory**:
  - Parameters Loaded Automatically When Drive is Switched on (see "Default Settings in the Motor Encoder Data Memory ("Load Defaults Procedure"))
- For motors **without motor encoder data memory**:
  - Loading the parameters via the commissioning tool "IndraWorks D" from the motor data base (DriveBase)
  - or -
  - Individual parameters manually written via the serial interface or the master communication interface by means of a motor parameter list

**Third-Party Motors** For third-party motors, the drive firmware possesses commands by means of which the values for the motor and motor control parameters are generated depending on the available output data and the functional principle of the motor. The following commands are available for calculating values for the motor and motor control parameters:

- C3200Command Calculate motor data
  - 1.1 Calculating the motor parameter values for asynchronous motors from the **data on the type plate**
  - 1.2 Calculating the values to be set for the motor control parameters
- C3600Command Motor data identification
  - 2.1 Identifying (or optimizing) the motor parameter values for asynchronous motors  
**Note:** Appropriate start values already have to be available!
  - 2.2 Calculating the values of the motor control parameters
- C4600 Command Calculate motor control parameters  
Calculating the values of the motor control parameters from the motor parameters for synchronous motors and, if necessary, for asynchronous motors (after manual input of motor data in motor parameters)

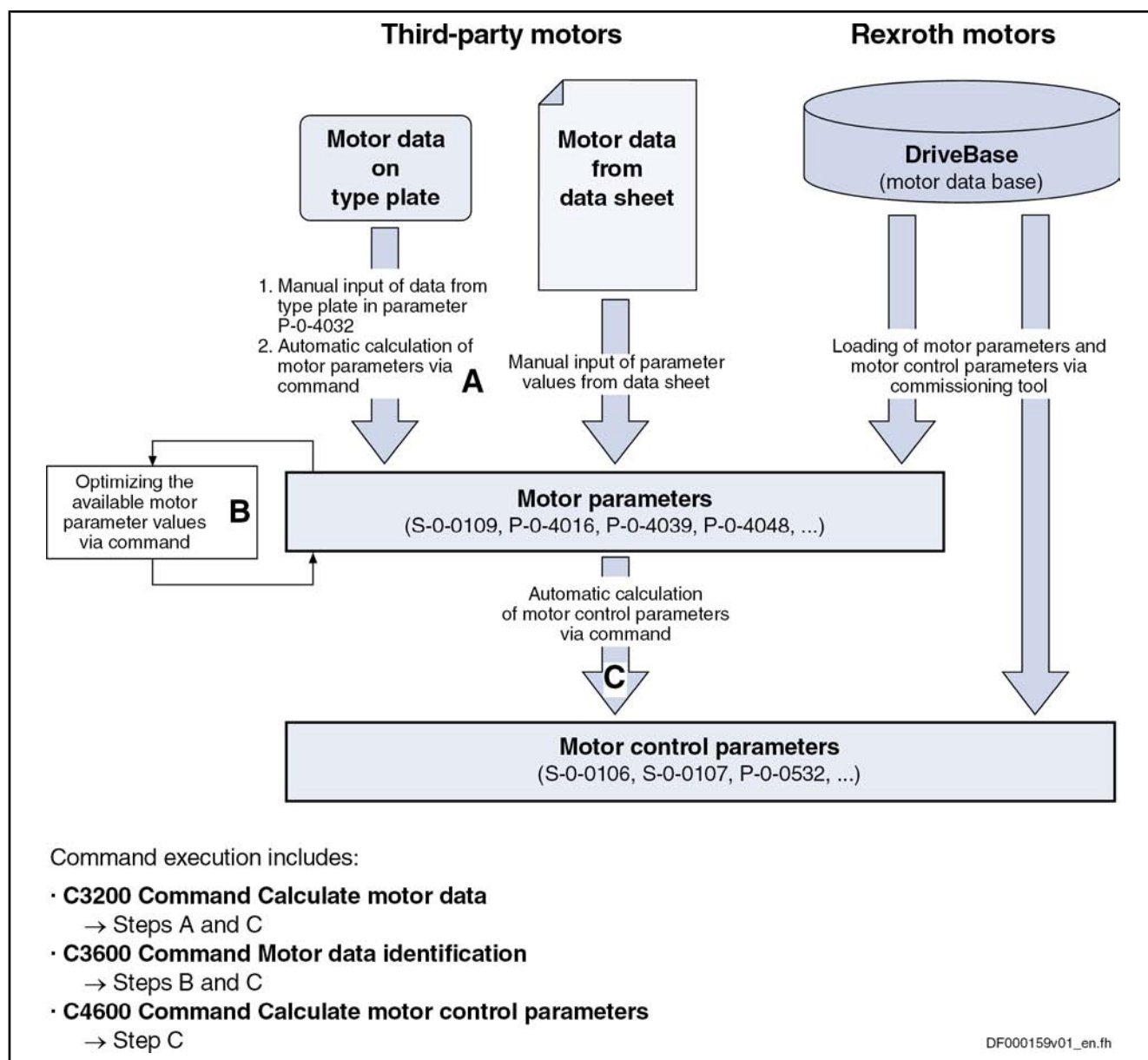


Basically, the prerequisite is the form "Manufacturer-Side Data of Synchronous Motors" or "Manufacturer-Side Data of Asynchronous Motors" in the section "Third-Party Motors at IndraDrive Controllers", to be completed by the motor manufacturer!

---

**Overview** The figure below illustrates an overview of the possibilities of determining the motor and motor control parameters for motors without motor encoder data memory:

Drive Control



P-0-4032 Motor type plate data  
 Fig. 6-54: Determining Motor and Motor Control Parameters for Motors Without Motor Encoder Data Memory



In addition to collecting or determining the motor and motor control parameters, further data on measuring system, temperature sensor, motor temperature model, motor holding brake and, if necessary, position and velocity loop are required.

See "Closed-Loop Axis Control (Closed-Loop Operation)"

See "Notes on Commissioning" in section "Third-Party Motors at IndraDrive Controllers"

**Pertinent Parameters**

- P-0-0565, C3600 Command Motor data identification
- P-0-0566, C4600 Command Calculate motor control parameters
- P-0-4032, Motor type plate data



- Pertinent Diagnostic Messages**
- P-0-4033, C3200 Command Calculate motor data
  - C3200Command Calculate motor data
  - C3201Incorrect input for current
  - C3202Incorrect input for voltage
  - C3203Incorrect input for frequency
  - C3204Incorrect input for speed
  - C3205Incorrect input for power factor
  - C3206Incorrect input for power
  - C3207Type plate list incomplete
  - C3208 Error when writing parameters (->S-0-0423)
  - C3600 Command Motor data identification
  - C3601 Motor not or not correctly connected
  - C3602 Determined values invalid
  - C3603 Device current limit too low
  - C3604 Error when writing parameters (->S-0-0423)
  - C3605 Motor turning
  - C3606 Type of construction of motor not allowed
  - C4600 Command Calculate motor control parameters
  - C4601 Error when writing parameters (->S-0-0423)

### Overview of Motor and Motor Control Parameters

**Motor Parameters** The table below contains an overview of the motor parameters for synchronous and asynchronous motors:

Motor parameters	
Synchronous motor	Asynchronous motor
P-0-4014, Type of construction of motor	P-0-4014, Type of construction of motor
S-0-0109, Motor peak current	S-0-0109, Motor peak current
S-0-0111, Motor current at standstill	S-0-0111, Motor current at standstill
S-0-0113, Maximum motor speed	S-0-0113, Maximum motor speed
P-0-0018, Number of pole pairs/pole pair distance	P-0-0018, Number of pole pairs/pole pair distance
P-0-0051, Torque/force constant	P-0-0051, Torque/force constant
P-0-0510, Rotor inertia	P-0-0510, Rotor inertia
P-0-4048, Stator resistance	P-0-4048, Stator resistance
P-0-4013, Current limit value of demagnetization	P-0-0530, Slip increase
P-0-4016, Direct-axis inductance of motor	P-0-4004, Magnetizing current
P-0-4017, Quadrature-axis inductance of motor	P-0-4036, Rated motor speed
P-0-4002, Charact. of quadrature-axis induct. of motor, inductances	P-0-4039, Stator leakage inductance
P-0-4003, Charact. of quadrature-axis inductance of motor, currents	P-0-4040, Rotor leakage inductance
P-0-4005, Flux-generating current, limit value	P-0-4041, Motor magnetizing inductance

Drive Control

Motor parameters	
Synchronous motor	Asynchronous motor
	P-0-4042, Characteristic of motor magnetizing inductance
	P-0-4043, Rotor time constant

Fig. 6-55: Overview of Motor Parameters for Synchronous and Asynchronous Motors

**Motor Control Parameters** The following tables contain an overview of the motor control parameters for synchronous and asynchronous motors that are used for field-oriented current control (with and without encoder) and voltage-controlled operation:

Motor control parameters for voltage-controlled operation (U/f)	
Synchronous motor	Asynchronous motor
	S-0-0106, Current loop proportional gain 1
	S-0-0107, Current loop integral action time 1
	P-0-0532, Premagnetization factor
	P-0-0568, Voltage boost
	P-0-0569, Maximum stator frequency slope
	P-0-0570, Stall protection loop proportional gain
	P-0-0571, Stall protection loop integral action time
	P-0-0572, Slip compensation factor
	P-0-0573, IxR boost factor
	P-0-0574, Oscillation damping factor
	P-0-0575, Search mode: search current factor
	P-0-0576, Search mode: finding point slip factor
	P-0-0577, Square characteristic: lowering factor

Fig. 6-56: Overview of Motor Control Parameters for Synchronous and Asynchronous Motors and Voltage-Controlled Operation (U/f)

Motor control parameters for field-oriented current control (FOC)	
Synchronous motor	Asynchronous motor
S-0-0106, Current loop proportional gain 1	S-0-0106, Current loop proportional gain 1
S-0-0107, Current loop integral action time 1	S-0-0107, Current loop integral action time 1
P-0-0533, Voltage loop proportional gain	P-0-0533, Voltage loop proportional gain
P-0-0534, Voltage loop integral action time	P-0-0534, Voltage loop integral action time
P-0-0535, Motor voltage at no load	P-0-0535, Motor voltage at no load
P-0-0536, Maximum motor voltage	P-0-0536, Maximum motor voltage
	P-0-0528, Flux control loop proportional gain
	P-0-0529, Scaling of stall current limit
	P-0-0532, Premagnetization factor

Fig. 6-57: Overview of Motor Control Parameters for Synchronous and Asynchronous Motors and Field-Oriented Current Control (FOC)

Motor control parameters for sensorless motor operation, flux-controlled (FXC)	
Synchronous motor	Asynchronous motor
	P-0-0532, Premagnetization factor
	P-0-0578, Current for deceleration, absolute value
	P-0-0579, Current for deceleration, time period
	P-0-0593, FXC: Total flux loop proportional gain
	P-0-0594, FXC: Total flux loop integral action time
	P-0-0595, FXC: Frequency loop proportional gain
	P-0-0596, FXC: Frequency loop scaling factor of inertia
	P-0-0597, FXC: Current loop proportional gain
	P-0-0598, FXC: Current loop integral action time
	P-0-0599, FXC: Slip frequency filter time constant
	P-0-0600, FXC: Rated slip frequency

Fig. 6-58: Overview of Motor Control Parameters for Synchronous and Asynchronous Motors and Sensorless, Flux-Controlled Motor Operation (FXC)

## Determining the Parameter Values by Means of Type Plate Data

### Command "Calculate Motor Data" (C3200)

For asynchronous motors it is possible via "C3200 Command Calculate motor data" to calculate the values for motor parameters from the type plate data and then the values of the motor control parameters. The activation of C3200 first requires manual input of the motor data from the type plate of the asynchronous motor in "P-0-4032, Motor type plate data".



See description of "P-0-4032, Motor type plate data"



The command C3200 can only be used for asynchronous motors and can only be activated in communication phases "P2" or "P3"!

The figure below illustrates the scope of functions of the command C3200:

## Drive Control

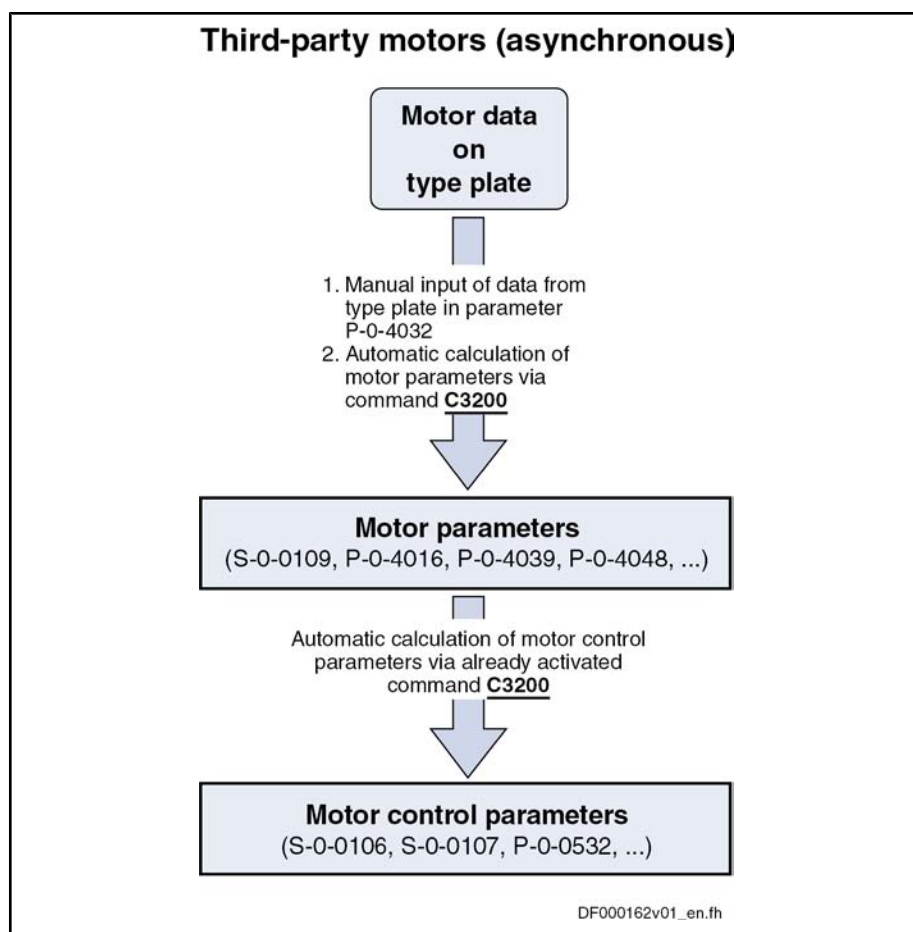


Fig. 6-59: Functions of "C3200 Command Calculate Motor Data"



The type plate does not contain the complete information required for safe operation of the third-party motor!

All required data are part of the form of manufacturer-side motor data which has to be available in completed form. The additional data, however, are not required for executing the command C3200.

#### Internally Calculated Parameter Values

By activating the command C3200 (P-0-4033), the following parameter values are calculated from the data of the asynchronous motor entered in list parameter P-0-4032:

- Motor parameters
  - Motor parameters, general
  - Specific motor parameters for asynchronous motors
- Motor control parameters
  - Motor control parameters for voltage-controlled operation (U/f) of sensorless asynchronous motors
  - Motor control parameters for field-oriented current control (FOC) of asynchronous motors
  - Motor control parameters for flux-controlled operation (FXC) of asynchronous motors without encoder

#### Notes on Operating Principle

As regards the operating principle of the command C3200, observe the following points:

- The input in P-0-4032 is irrelevant unless the command C3200 has been started.
- When the command was processed without error, the calculated values of motor and motor control parameters are operational.

## Identifying and Optimizing the Motor Parameter Values

### "Command Motor Data Identification" (C3600)

For asynchronous motors it is possible via "C3600 Command Motor data identification" to automatically identify and optimize the optimum motor and motor control parameters on the basis of appropriate start values.



The command C3600 can only be used for asynchronous motors and can only be activated in the operating mode (communication phase "P4")!

The figure below illustrates the scope of functions of the command C3600:

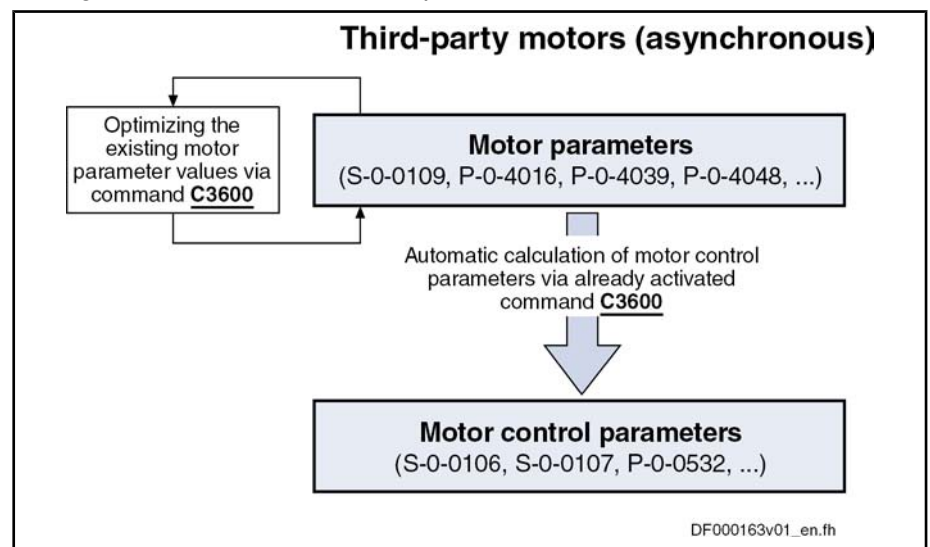


Fig. 6-60: Functions of "C3600 Command Motor Data Identification"

**Requirements** To execute the command C3600, the following requirements must have been fulfilled:

- Manual input of motor data from type plate in "P-0-4032, Motor type plate data" and then execution of "C3200 Command Calculate motor data"
- or -
- Manual input of all motor data in the motor parameters according to manufacturer's specification in completed motor data form

**Procedure** In status "ready for power output" ("Ab"), current and voltage test signals are transmitted to the motor with the execution of command C3600. In this way, the motor parameters for asynchronous motors (see above) are checked and, if necessary, optimized.

A possibly available holding brake continues remaining in the status of control as existing in the operating status "Ab".

After having successfully completed the command execution, the motor and motor control parameters have been optimized and stored.

The following parameters have been recalculated:

- Motor control parameters for voltage-controlled operation (U/f) of sensorless asynchronous motors

## Drive Control

- Motor control parameters for field-oriented current control (FOC) of asynchronous motors
  - Motor control parameters for flux-controlled operation (FXC) of asynchronous motors without encoder
- Notes on Operating Principle** As regards the operating principle of the command C3600, observe the following points:
- Motor motion is not required; the motor holding brake possibly applied at "Ab" remains applied. The motor does not generate torque. With little friction and inertial mass, little motion can however occur!
  - When the command was processed without error, the calculated values of motor and motor control parameters are operational. If the command execution is aborted during the measurement, all motor and motor control parameters remain unchanged.

### Calculating the Motor Control Parameters From the Motor Parameters

#### Command "Calculate Motor Control Parameters" (C4600)

For synchronous motors and in special cases (see Requirements) for asynchronous motors it is possible via "C4600 Command Calculate motor control parameters" to calculate the motor control parameters from the motor parameters.



The command C4600 can only be activated in the operating mode (OM)!

→ Communication phase P4 ("bb" or "Ab")

The figure below illustrates the scope of functions of the command C4600:

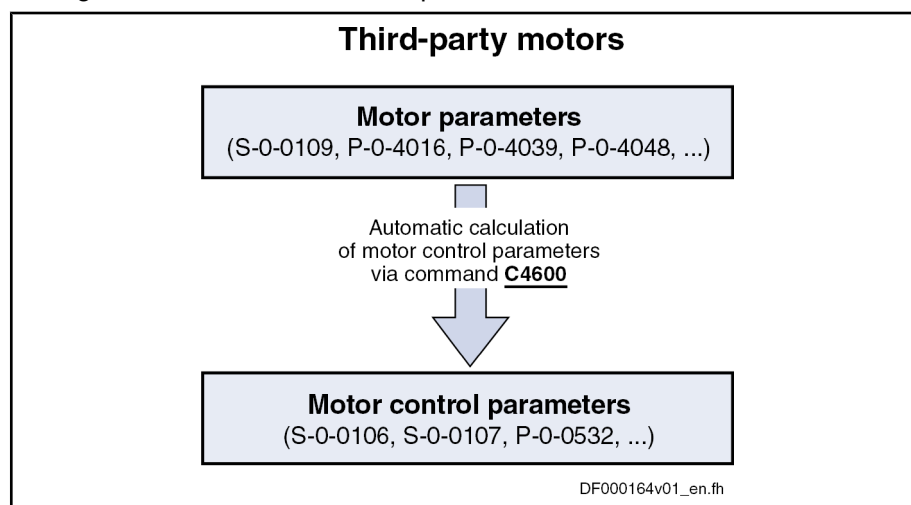


Fig. 6-61: Function of "C4600 Command Calculate Motor Control Parameters"

#### Requirements

To execute the command C4600, the following requirements must have been fulfilled:

- **Synchronous third-party motors** require manual input of the motor data in the motor parameters (see "Third-Party Motors at IndraDrive Controllers").
- For **asynchronous third-party motors** the command C4600 is only useful, if the motor control parameters are to be generated from specific, manually input motor parameters (e.g. from equivalent circuit diagram data, see "Third-Party Motors at IndraDrive Controllers"). The calculated values for the motor control parameters thereby might possibly be more exact! It is easier, however, to use the commands C3200 and C3600 (see above) for asynchronous motors.

**Notes on Operating Principle** As regards the operating principle of the command C4600, observe the following points:

- When the command was processed without error, the calculated values of motor and motor control parameters are operational.

### Notes on Commissioning

Motor connected to controller				Parameter values made available	
Motor manufacturer	Motor design	Motor type	Encoder data memory	Motor parameters	Motor control parameters
Bosch Rexroth	Housing	MHD, MKD, MKE, MSK, SF, MAD, MAF	Yes	A	A
		MSD	No	M/D	M/D
	Kit	1MB, MBS, MBT, MBW, MLF, MBSxx2 (high speed)	No	M/D	M/D
Third-party motor	Housing or kit	Synchronous third-party motor	No	M	C
	Housing or kit	Asynchronous third-party motor	No	M/C	C

- A Automatically after drive switched on
- D Download via commissioning tool
- M Manual input via control master
- C Automatic determination via drive command

*Fig. 6-62: Making Available Values for Motor Parameters and Motor Control Parameters*

**Rexroth Motors** For Rexroth motors, both the motor and motor control parameters are optimized by the manufacturer via the encoder data memory of the motor encoder or, for motors without encoder memory, via the commissioning tool.



For Rexroth motors it is not required to determine the motor or motor control parameters! The commands C3200, C3600 and C4600 mustn't be started for drives with Rexroth motors, because otherwise the values of motor and motor control parameters optimized by the manufacturer are overwritten with the values calculated by means of command. This can modify the drive characteristics in a disadvantageous way!

**Third-Party Motors** The commissioning of a third-party motor is similar to the commissioning of a Rexroth motor without motor encoder data memory. The basic difference is the fact that the motor and motor control parameters cannot be loaded from the motor parameter database of the commissioning tool, but are determined via command by the controller after manual input of the type plate data and motor parameter values (see "Third-Party Motors at IndraDrive Controllers").

### Diagnostic and Status Messages

If the command execution cannot be carried out successfully, diagnostic messages will be signaling the respective errors. The description of the respective command error contains information on the causes and suggests measures for remedy. If necessary, the manufacturer-side motor data have to be questioned and the motor and motor control parameters determined again!

## Drive Control



See description of diagnostic messages in the separate documentation "Description of Diagnostic Messages"

## 6.3 Open-Loop Axis Control (Open-Loop Operation)

### 6.3.1 Brief Description

In operation without encoder (open-loop operation) the velocity control loop is not closed in the drive, but the drive is operated in a velocity-controlled way (without feedback) via open-loop U/f control.



The method of open-loop/closed-loop motor control can be selected via bit 14 of "P-0-0045, Control word of current controller".

See also section "Motor Control"

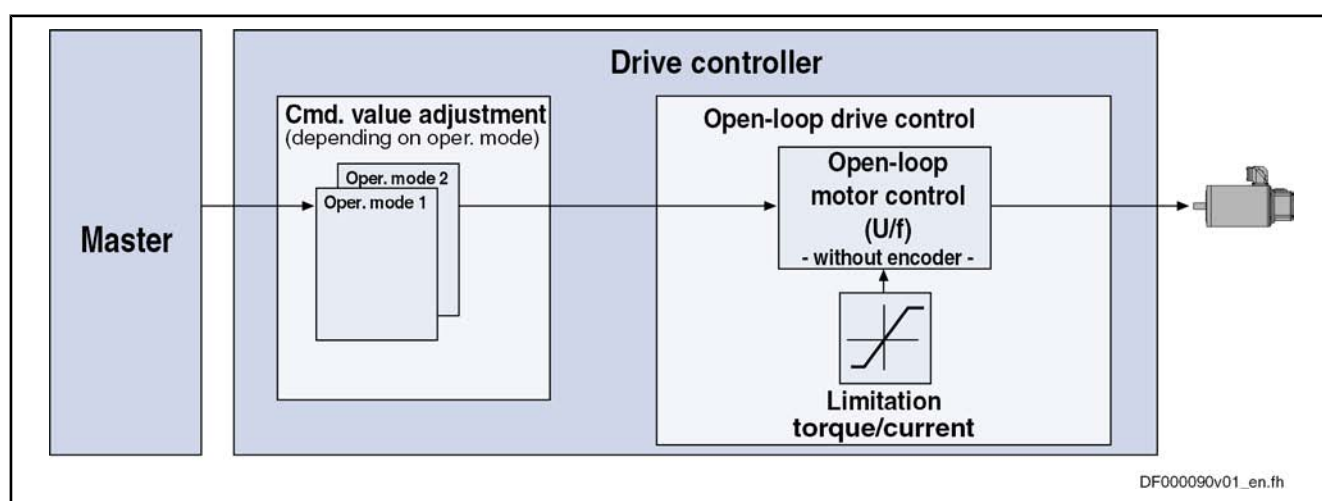


Fig.6-63: Principle of Drive Control in Open-Loop Operation

**Features** The velocity control has the following features:

- Fine interpolation of the velocity command value (can be switched off)
- Monitoring of the velocity control loop is possible (can be switched off via P-0-0556; bit 1)
- Parameterizable filtering of the actual velocity value
- Additive velocity command value (S-0-0037)
- Display of the resulting command value (in P-0-0048)
- Monitoring and **limitation** of the maximum stator frequency slope that results from the command velocity change
- **Stall protection loop** (PI loop that can be optionally activated to prevent breakdown of the machine when the torque limits are attained)
- **Slip compensation** (feedforward of estimated slip of the machine by means of rotor time constant and slip compensation factor)
- Calculation of output voltage by means of **U/f characteristic** based on motor model data
- Subsequent trimming of magnetization via premagnetization factor (linear or square characteristic to be selected)
- **IxR Boost** (adjustable load-dependent feedforward of the output voltage due to the voltage drop on the motor winding resistance)



- **Oscillation damping** (adjustable load-dependent feedforward to prevent velocity oscillations in the partial load and idling ranges)
- **Current limitation loop** to protect the output stage
- **Velocity search mode** of a coasting machine after switching drive enable on (can be set for one or both rotational directions)

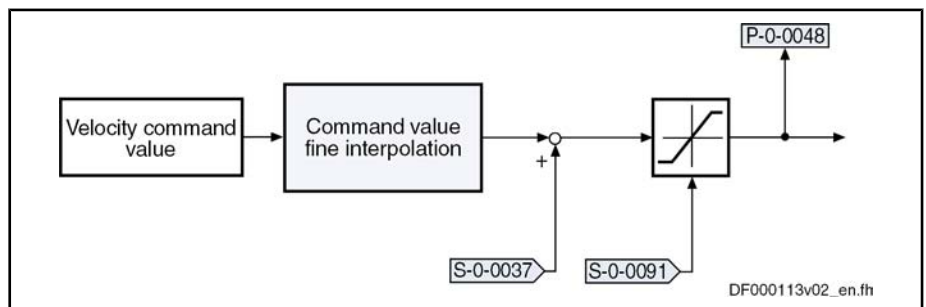
**Pertinent Parameters**

- S-0-0037, Additive velocity command value
- S-0-0040, Velocity feedback value
- S-0-0091, Bipolar velocity limit value
- P-0-0048, Effective velocity command value
- P-0-0049, Effective torque/force command value
- P-0-0555, Status word of axis controller
- P-0-0556, Config word of axis controller

**Pertinent Diagnostic Messages**  
S-0-0091 Exceeded

- F8079 Velocity limit value exceeded (S-0-0091)

## 6.3.2 Functional Description

**Fine Interpolator**

- S-0-0037 Additive velocity command value  
 S-0-0091 Bipolar velocity limit value  
 P-0-0048 Effective velocity command value

*Fig. 6-64: Fine Interpolation of the Velocity Command Value***Units of the Processed Data**

The physical data for velocity control have the following units:

- Velocity data → rpm or mm/min
- Acceleration data → (rpm)/controller clock or (mm/min)/controller clock
- Torque data → Nm or N

**U/f Control**

The output value of the fine interpolator (P-0-0048) is used as the input value for the subsequent U/f control (open-loop operation) which is described in the section "Voltage-Controlled Operation" .

## 6.3.3 Diagnostic and Status Messages

**Monitoring the Velocity Limit Value**

The actual velocity value, internally generated via the stall protection loop, is monitored for the limit value of  $1.125 \cdot S-0-0091$  (bipolar velocity limit value) as soon as it is outside the standstill window S-0-0124. When this value is exceeded, the following error message is generated:

- F8079 Velocity limit value exceeded

## Drive Control

## 6.4 Closed-Loop Axis Control (Closed-Loop Operation)

### 6.4.1 General Information on Closed-Loop Axis Control

#### Control Loop Structure

The drive controller has a so-called cascade structure, i.e. the individual loops (position, velocity and current) are interconnected. Depending on the operating mode there are different control loop structures with different points of input and paths of the command values. Depending on the active mode of operation, only the torque control loop, the torque control loop and the velocity control loop or, in addition to these two control loops the position control loop can be closed in the drive.

The structure and the interaction of the control loops are illustrated in the two graphics in the section "Overview of Drive Control" (see "Control Loop Structure with Setting Parameters" or "Control Loop Structure with Display Parameters").

#### Features of the Control Loops

For the simplification of the parameterization of the control loops and for an increase in performance, a number of standardizations and structural changes have been carried out.

##### Performance (Controller Cycle Times)

The internal controller cycle times (current, velocity and position) depend on the following conditions and parameters:

- Control section design (CSH, CSB or CDB)
- Activation of the functional packages
- P-0-0001, Switching frequency of the power output stage
- P-0-0556, Config word of axis controller (bits 2 and 5)

Depending on these factors, the following cycle and switching times can be achieved:

	ADVANCED control sections	BASIC control sections
PWM switching frequency	max. 16 kHz	max. 8 kHz
Current loop clock ( $T_{A\_current}$ )	62.5 $\mu$ s	125 $\mu$ s
Velocity loop clock ( $T_{A\_velocity}$ )	125 $\mu$ s	250 $\mu$ s
Position loop clock ( $T_{A\_position}$ )	250 $\mu$ s	500 $\mu$ s

Fig.6-65: Cycle and Switching Times to be Achieved With IndraDrive



All data about performance are summarized in the section "Performance Data".

##### Position Loop

- Jerk limitation in operation mode "cyclic position control" by introduction of "S-0-0349, Bipolar jerk limit". The filtering degree of the smoothing filter (moving average value) can be set in "P-0-0042, Current position command average value filter order".
- Velocity feedforward, i.e. degree of feedforward, to be set via "P-0-0040, Velocity feedforward evaluation" (0% ... 100%)
- Input value for "S-0-0348, Acceleration feedforward gain" can be the respective inertia in  $\text{kg}\cdot\text{m}^2$  (for rotary motor) or the mass in kg (for linear motor).

- Velocity Loop**
- Standardization of the output value at the velocity loop to Newton (N) or Newton meter (Nm). Therefore, depending on the motor type, the following unit is obtained for S-0-0100 in IndraDrive:
  - Rotary motor → Nm \* s/rad
  - Linear motor → N \* min/mm
  - Possibility of extending the filter options for filtering the resonance frequencies. There are 4 filters of 2nd degree available that can be set via P-0-1120, P-0-1121, P-0-1122 and P-0-1123.
  - Limiting the acceleration in velocity control by setting in "S-0-0138, Bipolar acceleration limit value"

### Possibilities of Access to Outer Control Loops

For operation in a higher-level mode of operation, it is possible to access an outer control loop. Depending on the basic mode of operation, the following parameters are available:

In position control:

- P-0-0059, Additive position command value, controller
- S-0-0037, Additive velocity command value
- S-0-0081, Additive torque/force command value

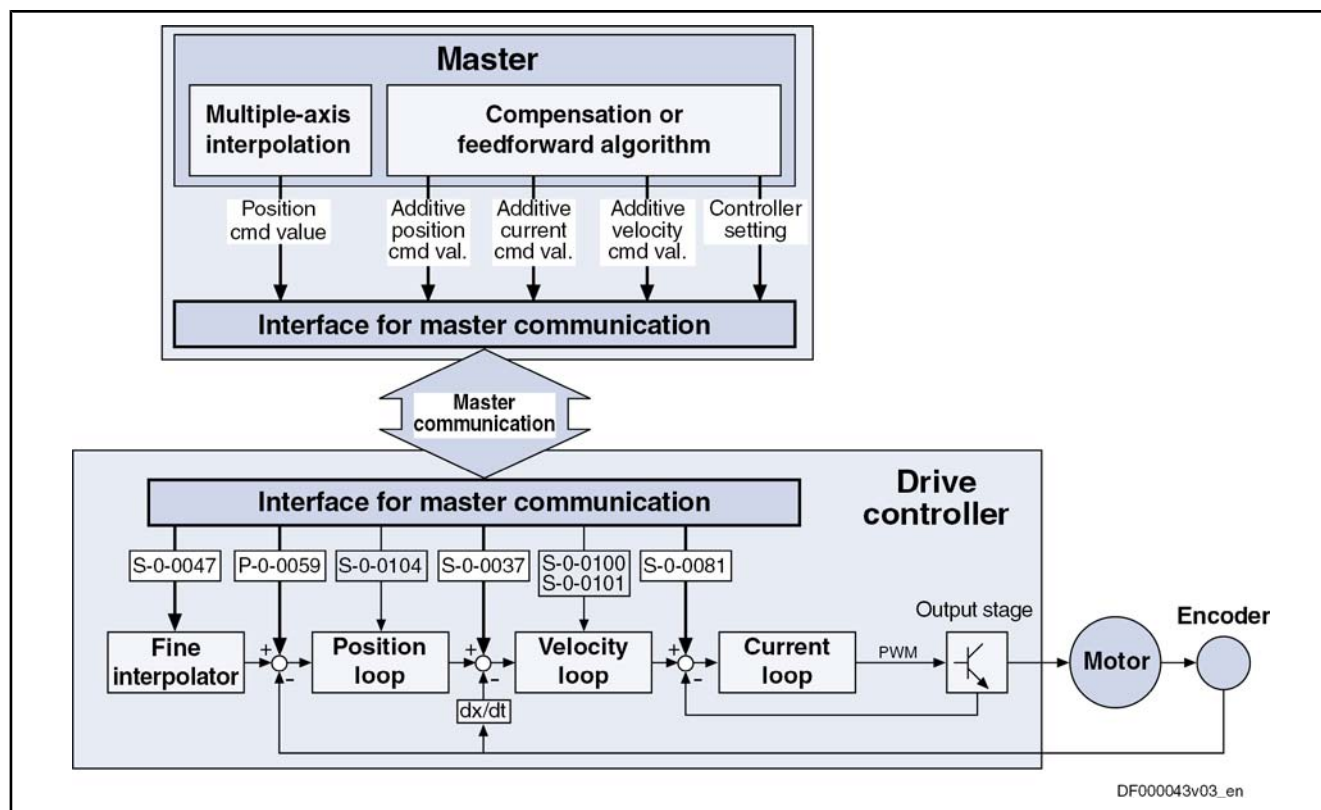
In velocity control:

- S-0-0037, Additive velocity command value
- S-0-0081, Additive torque/force command value

In current control:

- S-0-0081, Additive torque/force command value

Drive Control



DF000043v03\_en

- S-0-0037 Additive velocity command value
- S-0-0047 Position command value
- S-0-0081 Additive torque/force command value
- S-0-0100 Velocity loop proportional gain
- S-0-0101 Velocity loop integral action time
- S-0-0104 Position loop Kv-factor
- P-0-0059 Additive position command value, controller

Fig.6-66: Structural Overview With Access Options

### Command Value Processing Depending on Operating Mode

**Position Control** For the following modes of operation, the position control loop is closed internally (in the drive) in addition to the velocity and the current control loops:

- Position Control With Cyclic Command Value Input
- Drive-Internal Interpolation
- Drive-Controlled Positioning

See also description of the respective mode of operation

**Velocity Control** In the "velocity control" mode, the velocity control loop, apart from the current control loop, is closed in the drive, too.

See also "Velocity Control"

**Torque/Force Control** The "torque/force control" mode actually is not torque or force control but current control. Therefore, only the current control loop is closed in the drive.

See also "Torque/Force Control"

### Notes on Commissioning for Control Loop Setting

The control loop settings in a digital drive controller are very important for the features of the servo axis.

To optimize the control loop setting, application-specific controller parameters are available for all digital Rexroth drives.

**Order of Manual Control Loop Setting**

Due to the cascade structure of the control loops it is necessary to parameterize them "from the inside to the outside". The resulting order for setting the control loops is as follows:

**1. Current control loop**

For **Rexroth motors with motor encoder data memory** (for the ranges MHD, MKD and MKE) the optimization of the current loop is not required, as the respective parameter values (S-0-0106 and S-0-0107) are read from the motor encoder data memory.

For all **Rexroth motors without motor encoder data memory** (e.g. linear motors), the parameter settings can be taken from a central motor data base via the "IndraWorks D" commissioning tool.

The commissioning of **third-party motor** (incl. control loop setting) is described in the respective sections on third-party motors in this documentation (see "Third-Party Motors at IndraDrive Controllers").

**2. Velocity control loop**

The settings of the velocity loop (S-0-0100 and S-0-0101) with the respective filters (P-0-0004 and P-0-1120, P-0-1121, P-0-1122, P-0-1123) on the one hand depend on the motor parameters (inertia and torque/force constant), on the other hand they strongly depend on the mechanical properties (load inertia/mass, friction, stiffness of the connection, ...). Therefore, manual or automatic optimization is often necessary.

**3. Position control loop**

In general, the position control loop only has to be adjusted to the dynamics of the outer velocity loop, as well as to the kind of preset command values (jerk, acceleration and interpolation procedure).

**Default Settings in the Motor Encoder Data Memory ("Load Defaults Procedure")****Load "Defaults Procedure"**

For all Rexroth motors of the lines with motor encoder data memory (e.g. MHD, MKD, MKE, MSK and possibly MAD and MAF), the basic settings for the controllers are stored and can be loaded to the drive by executing the "load defaults procedure" command (S-0-0262).

"There are two ways to activate the S-0-0262, C07\_x Load defaults procedure command":

- Automatically when running up the drive by recognizing that the motor type (cf. s-0-0141) has changed. The display then reads "RL" and the "load defaults procedure" command is internally started by pressing the "Esc" button on the control panel, unless this was deactivated in "P-0-0556, Config word of axis controller".
- Starting the command by writing "11b" to S-0-0262.

See also "Loading, Storing and Saving Parameters"



In order to start the command "load defaults procedure" the value "0" must have been set in "P-0-4090, Configuration for loading default values" (default setting).

During the load defaults procedure, the following control loop parameters are set to their default values optimized for the respective motor:

- S-0-0100, Velocity loop proportional gain
- S-0-0101, Velocity loop integral action time
- S-0-0104, Position loop Kv-factor
- S-0-0106, Current loop proportional gain 1

## Drive Control

- S-0-0107, Current loop integral action time 1
- P-0-0004, Velocity loop smoothing time constant



The default settings for the current loop (cf. S-0-0106 and S-0-0107) are automatically adjusted to the currently parameterized PWM frequency (cf. P-0-0001) and performance setting (cf. P-0-0556)!

In addition, during the load defaults procedure, the following control loop parameter is set to its firmware-side default values, although there haven't any default values been stored for them in the motor data memory:

- S-0-0348, Acceleration feedforward gain



In the majority of cases, the controller settings stored in the motor encoder data memory provide a useful and reliable control loop setting. In exceptional cases, however, it may be necessary to make the settings with regard to the specific application.

## 6.4.2 Automatic Setting of Closed-Loop Axis Control

### Brief Description

To facilitate drive parameterization, the IndraDrive firmware provides automatic control loop setting in closed-loop operation. "P-0-0163, Damping factor for autom. controller setting" and "P-0-0164, Application for autom. controller setting" can be used to influence the result of the control loop setting (obtained control loop dynamics).



To carry out the automatic control loop setting, it is necessary to move the drive. The velocity and position control loops are optimized.

- |                             |   |
|-----------------------------|---|
| <b>Features</b>             | <ul style="list-style-type: none"> <li>• Definition of a travel range for movement control for the automatic control loop setting by             <ul style="list-style-type: none"> <li>– Absolute position limits for the travel range</li> <li>- or -</li> <li>– Entering a travel distance based on the current actual position</li> </ul> </li> <li>• Use of drive-internal interpolation and its parameters</li> <li>• Possible settings in "P-0-0165, Drive optimization, control word" can be used for:             <ul style="list-style-type: none"> <li>– Velocity Loop</li> <li>– Position loop</li> <li>– acceleration feedforward</li> <li>– Determination of the load inertia</li> <li>– Determination of the maximum acceleration</li> <li>– Oscillation movement / unipolar movement</li> <li>– Absolute travel limits / relative movement around start position</li> </ul> </li> </ul> |
| <b>Pertinent Parameters</b> | <ul style="list-style-type: none"> <li>• P-0-0162, C1800 Command Drive optimization / command value box</li> <li>• P-0-0163, Damping factor for autom. controller setting</li> <li>• P-0-0164, Application for autom. controller setting</li> <li>• P-0-0165, Drive optimization, control word</li> </ul>   |

- Pertinent Diagnostic Messages**
- P-0-0166, Drive optimization, end position negative
  - P-0-0167, Drive optimization, end position positive
  - P-0-0168, Maximum acceleration to be parameterized
  - P-0-0169, Drive optimization, travel distance
  - C1800 Command Drive optimization / command value box
  - C1801 Start requires drive enable
  - C1802 Motor feedback data not valid
  - C1803 Inertia detection failed
  - C1804 Automatic controller setting failed
  - C1805 Travel range invalid
  - C1806 Travel range exceeded
  - C1807 Determining travel range only via travel distance
  - E2049 Positioning velocity  $\geq$  limit value (S-0-0091)
  - E2055 Feedrate override S-0-0108 = 0
  - F2039 Maximum acceleration exceeded

### Prerequisites for Starting the Automatic Control Loop Setting



**CAUTION**

#### Property damage and/or personal injury caused by drive motion!

During the execution of "C1800 Command Drive optimization / command value box", the drive moves automatically, i. e. without external command values.

→ Check and make sure that the E-Stop circuit and the travel range limit switches are working.

#### Defining the Travel Range

As the axis is moved for identifying and setting the control loop, it is necessary to define an allowed travel range. There are basically two possibilities for defining the range within which the axis may move during the automatic control loop setting:

- Definition of a travel range by entering end positions in the parameters P-0-0166 and P-0-0167
- or -
- Definition of a travel range through parameterization of "P-0-0169, Drive optimization, travel distance" (required for modulo axes)

The minimum values required for the travel range are:

- for rotary motors  $> 2$  motor revolutions
- for linear motors  $> 100$  mm

If the travel range set by the user falls below the minimum value, the automatic control loop setting cannot be started. The controller signals "C1805 Travel range invalid".

For a successful automatic control loop setting the path or the angle range of the minimum travel range must be run through approximately ten times. The required movement range of the axis depends on the selected type of movement:

- Oscillating operation
  - Through the reversing procedure the movement range can be restricted to the minimum travel range.
- Stepper mode

## Drive Control

→ Through the stepwise travelling of the travel range in the same direction, ten times the minimum travel range must be calculated for the movement range of the axis.



The mode for travel range definition is selected in "P-0-0165, Drive optimization, control word" (bit 15).

## Determining Travel Range Limits

For the determination of absolute position limits in "P-0-0165, Drive optimization, control word" the limit values are entered into the following parameters:

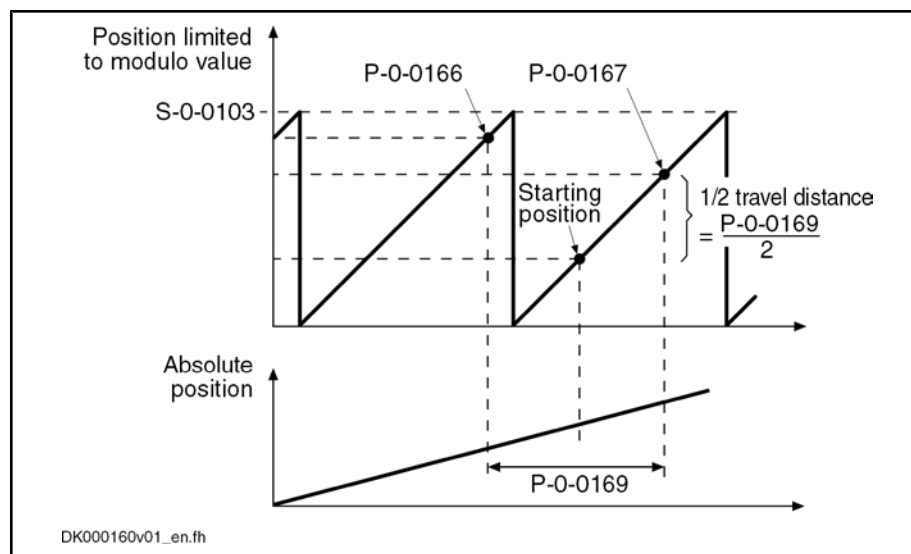
- P-0-0166, Drive optimization, end position negative  
- and -
- P-0-0167, Drive optimization, end position positive

The value for "P-0-0169, Drive optimization, travel distance" results from the two end positions.

## Input of the Travel Distance

For determination of a relative travel distance in the parameter P-0-0165, the value of the travel distance must be entered into in "P-0-0169, Drive optimization, travel distance". The following applies:

- If in P-0-0165 the type of motion "oscillating movement" has been determined, the axis will travel between the current starting position +/- half the value of P-0-0169.
- If in P-0-0165 the Type of motion "stepper mode" has been determined, the axis will only travel in the direction that has been set by the bit for travel direction.



S-0-0103	Modulo value
P-0-0166	Drive optimization, negative end position
P-0-0167	Drive optimization, positive end position
P-0-0169	Drive optimization, travel distance

Fig. 6-67: Travel Range for Automatic Control Loop Setting With Modulo Scaling



The travel range defined is only monitored during the execution of the command "automatic Control loop setting".

## Loading the Default Controller Parameters

Before starting the command "automatic control loop setting", the default controller parameters stored in the motor encoder data memory should be loaded



or the data of the motor data sheet should be entered in the respective parameters.

#### Drive Enable and "Drive Start"

An oscillation for automatic control loop setting is only carried out when the following requirements have been fulfilled:

- **Drive enable** is present
- **"Drive start"** has been set

#### Parameter Settings

All parameters used for the command "automatic control loop setting" must be determined before command start so that they take effect for the automatic control loop setting.

- P-0-0163, Damping factor for autom. controller setting  
→ Selection of the desired control loop dynamics
- P-0-0164, Application for autom. controller setting  
→ Consideration of the mechanical properties for the controller optimization
- P-0-0165, Drive optimization, control word  
→ Selection of the functionality (modes) of the automatic control loop setting and determination of requirements

### Time Flow of Automatic Control Loop Setting

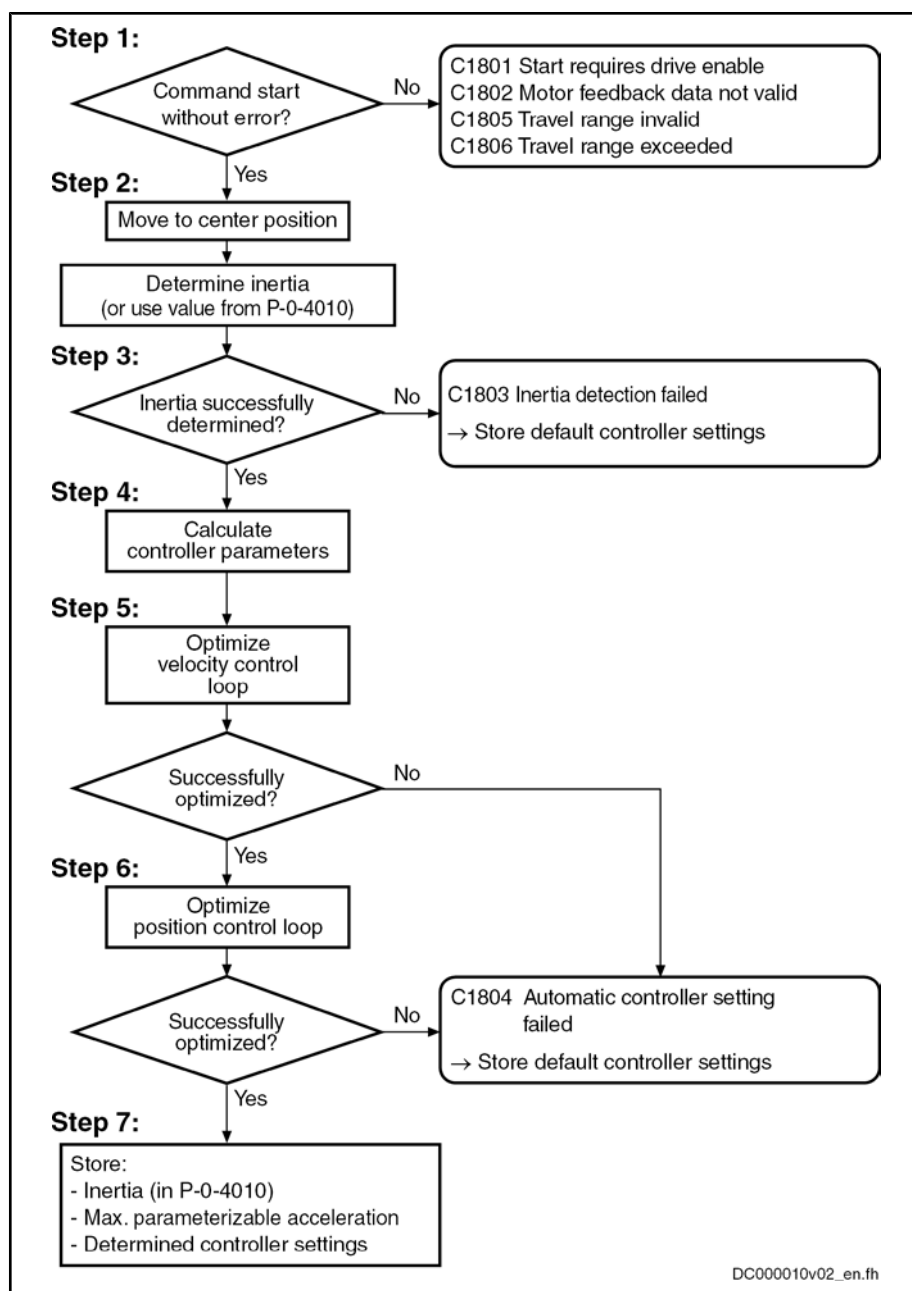
#### Steps of Automatic Control Loop Setting

The automatic control loop setting is carried out in the following steps:

1. Start command and make check for possible command errors
2. Determine total and extrinsic inertia by evaluating acceleration and deceleration processes
3. Calculate and activate controller parameters in the drive in consideration of "P-0-0163, Damping factor for autom. controller setting" and "P-0-0164, Application for autom. controller setting".
4. Check velocity control loop and correct controller parameters, if need be, until desired behavior occurs (depends on dynamics programmed)
5. Check position control loop and correct controller parameters, if need be, until desired aperiodic behavior in position control loop occurs
6. Wait for possible restart or end of command

During this step the drive is idle (velocity = 0) and the display reads "C1800".

Drive Control



P-0-4010 Load inertia  
Fig.6-68: Steps of Automatic Control Loop Setting

### Result of Automatic Control Loop Setting



The current control loop is not affected during the automatic control loop setting, as its setting is load-independent and optimum current controller parameters were already stored in the motor encoder data memory at the factory.

See also "Default Settings in the Motor Encoder Data Memory ("Load Defaults Procedure")"

#### Selection Parameter for Automatic Control Loop Setting

Via "P-0-0165, Drive optimization, control word" it is possible, by selecting the corresponding bit, to activate (bit = 1) or deactivate (bit = 0) the respective

function of the automatic control loop setting. The result of the automatic control loop setting depends on the selection made in P-0-0165.



See Parameter Description "P-0-0165, Drive optimization, control word"

Possible results of the automatic control loop setting (with respective bit set in P-0-0165):

- **Bit 1** → Setting of velocity control loop (cf. S-0-0100, S-0-0101, P-0-0004, P-0-1120 ...)
- **Bit 2** → Setting of position control loop (cf. S-0-0104)
- **Bit 4** → Setting of load inertia (reduced to motor shaft) and input in P-0-4010
- **Bit 6** → Determination of maximum drive acceleration and input in P-0-0168
- **Bit 3** → Determination of acceleration feedforward

As the result of the automatic control loop setting, the value for acceleration feedforward is calculated according to the formula below and entered in S-0-0348:

$$S-0-0348 = (P-0-4010) + (P-0-0510)$$

Fig. 6-69: Calculating the Acceleration Feedforward

## Notes on Commissioning



**CAUTION**

**The execution of the automatic control loop setting is connected with a drive motion!**

⇒ Select the travel range defined with P-0-0166 and P-0-0167 or P-0-0169 such that danger to man and machine resulting from drive motion is excluded.



The parameter settings required to execute the command "automatic control loop setting" must be made prior to command start.

### Starting the Automatic Control Loop Setting

The automatic control loop setting is started by writing the binary numeric value "3" (11b) to "P-0-0162, C1800 Command Drive optimization / command value box" (command start).

### Triggering a Motion

An axis motion and thus the execution of the automatic control loop setting is only possible if the "Drive HALT" signal has not been set. If the "Drive HALT" signal has been set, the drive will acknowledge the start of "C1800 command automatic control loop setting", but the axis will not move.

Drive Control

Triggering the Motion by Starting the Command C1800

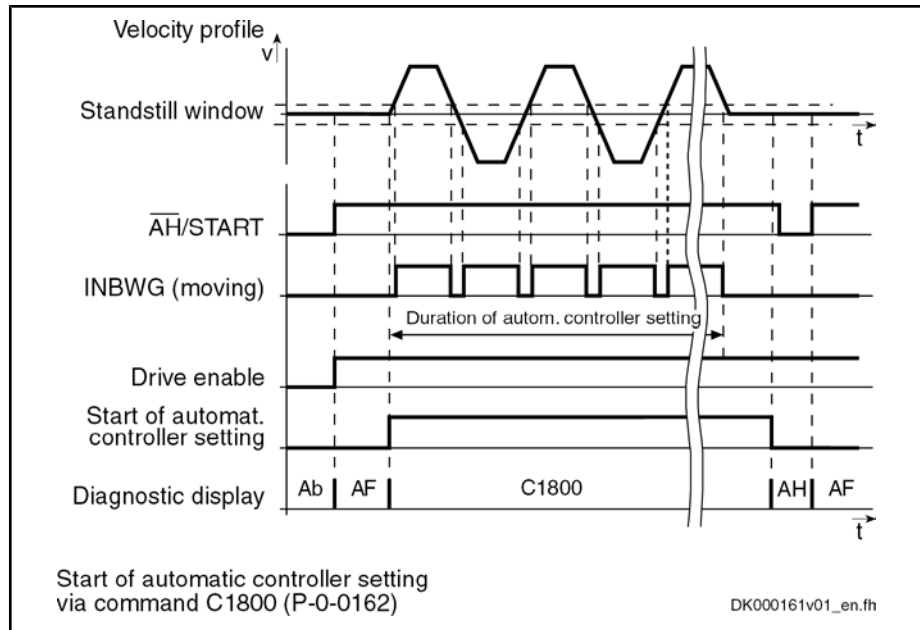


Fig.6-70: Signal Flow Chart for Motion by Command Start

Triggering the Motion by "Drive Start"

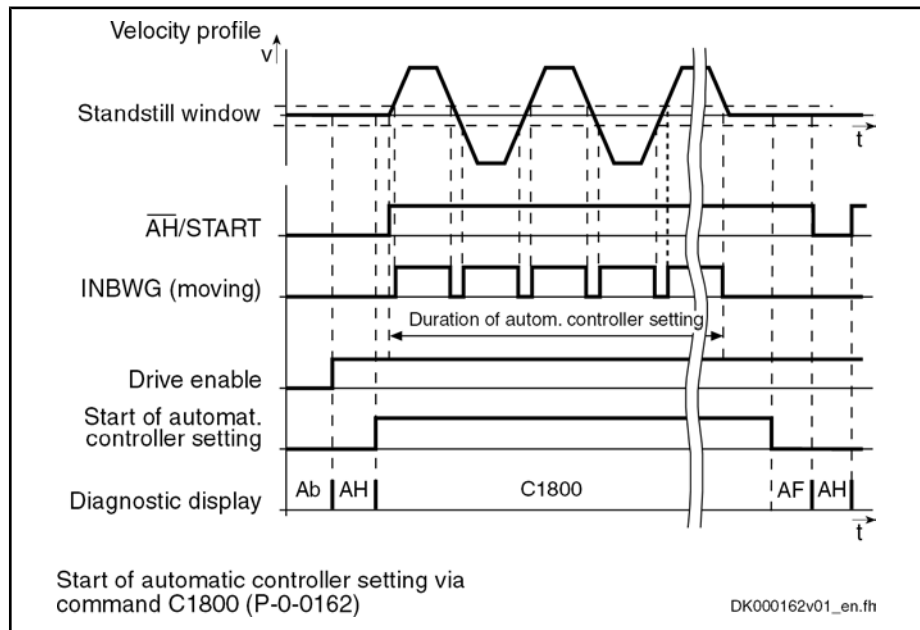


Fig.6-71: Signal Flow Chart for Motion by "Drive Start"

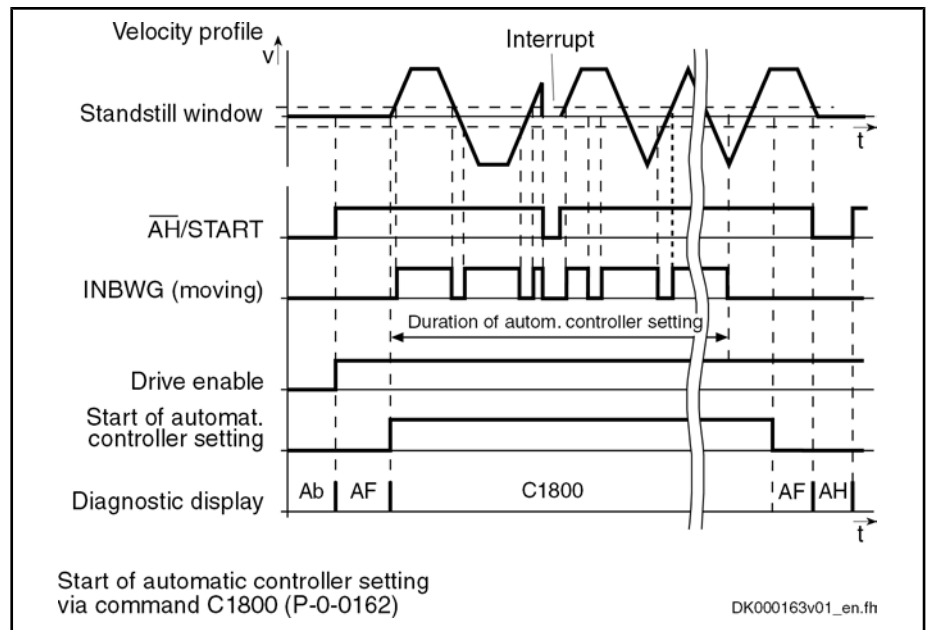
Interrupting the Command with  
"Drive Halt"

Fig.6-72: Signal Flow Chart for Interruption by "Drive HALT"



A repeated run with possibly changed settings can be carried out in two ways:

- By removing and then re-applying drive enable or the start signal ("drive start")
- By completing and then restarting command C1800

## Diagnostic Messages and Monitoring Functions

Checking the Defined Travel  
Range

When the travel range is defined, it is checked for useful values. In the case of error, the following command error messages can be generated:

- If the defined travel range is less than 2 motor revolutions for rotary motors or less than 100mm for linear motors, the error message "C1805 Travel range invalid" will be displayed, as a minimum travel distance is required for the correct execution of the command.
- If the axis is not within the defined travel range at command start, the error message "C1806 Travel range exceeded" will be displayed.

## Drive Enable Missing

If at command start drive enable is not available, the error message "C1801 Start requires drive enable" will be displayed.

## Monitoring of Mass Inertia Determination

In order to ensure correct setting of the controller parameters, the required determination of the mass inertia is monitored. Incorrect detection of the inertia would cause incorrect controller settings and therefore is signaled by the error message "C1803 Inertia detection failed". This error message is generated when the values set in the following parameters are too low:

- S-0-0092, Bipolar torque/force limit value
  - The maximum motor torque effective during the automatic control loop setting can be influenced via S-0-0092. It is thereby possible to limit the torque to prevent wear of the mechanical system.
- S-0-0108, Feedrate override
  - By means of the feedrate override the velocity can be influenced via the analog channel (potentiometer) during the automatic control loop setting.

## Drive Control

- P-0-0170, Drive optimization, acceleration  
→ This parameter defines the acceleration effective during the automatic control loop setting.
- P-0-0171, Drive optimization, velocity  
→ In this parameter you have to set the velocity effective during the automatic control loop setting.



The command error C1803 can occur due to the above-mentioned points, but also due to a too high degree of inertia. In this case, the entire drive dimensioning has to be checked, if necessary.

## 6.4.3 Velocity Loop (Including the Respective Filters)

### Brief Description

In closed-loop operation, in addition to the field-oriented current controller, the velocity control loop is also closed in the drive by means of the drive software (PI cascade structure).

The controlled-loop operation (current and velocity) can be carried with encoder for all types of motors and for asynchronous motors also without encoders.



The selection of the type of motor control is carried out by means of "P-0-0048, Control word of current controller" (bits 14, 15)

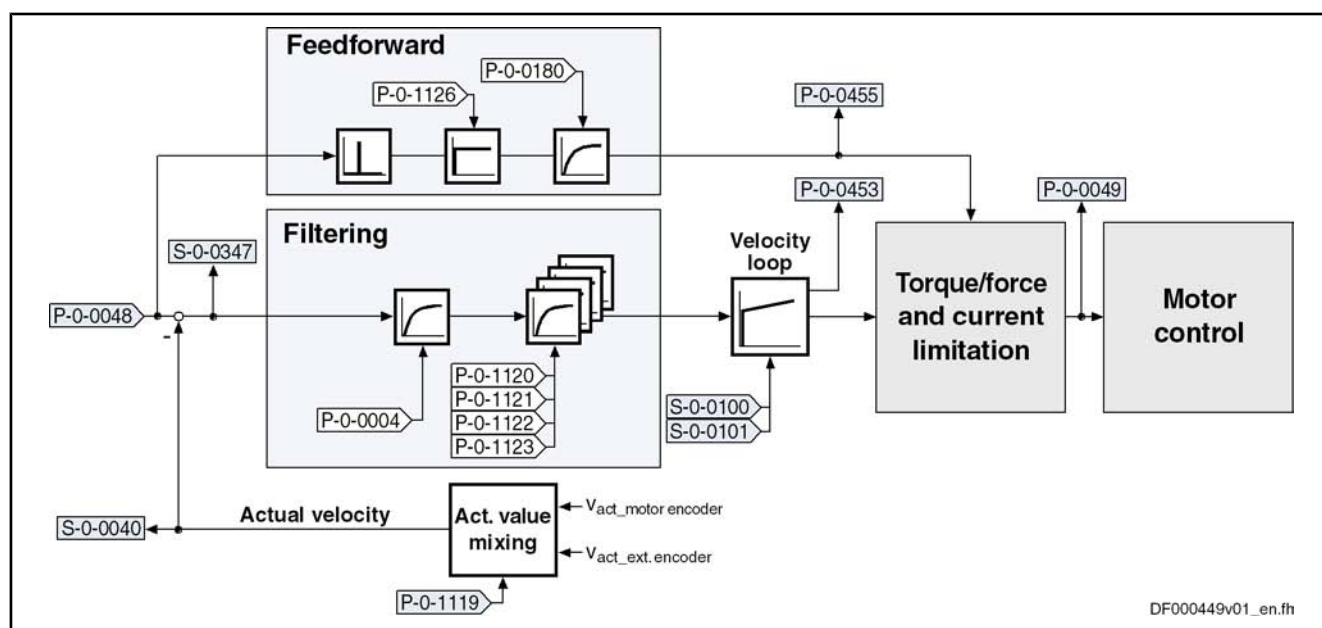


Fig.6-73: Structure of the Velocity Loop



The following description is restricted to the velocity loop including the respective options of filtration and feedforward. The processing of the velocity command value is described within the operation mode "Velocity control" .

- Features**
- Digital PI controller with anti-windup function, can be set by means of the following parameters:
    - S-0-0100, Velocity loop proportional gain

- S-0-0101, Velocity loop integral action time
- Setting can be carried out by
  - Executing the "load defaults procedure" function once
  - or -
  - Manual optimization (see description below)
  - or -
  - Automatic parameterization of the axis controller (see "Automatic Setting of Axis Control").
- Depending on the control performance which has been set, the cycle time  $T_{A\_velocity}$  is used for velocity loop calculations (see "Performance Data").
- Possibility of mixing the velocities of motor encoder and optional encoder
- 4 freely configurable filters of 2nd order (e.g. band-stop filters) for filtering resonance frequencies
- Moving average filter of the control loop deviation for a maximum of 16 controller clocks (as "feedback filter", in the case of low-resolution motor measuring systems)
- Low-pass filter to attenuate interference frequencies, to be set via P-0-0004 (VZ1)
- Fine interpolation of the command values of the position loop (can be switched on by P-0-0556, Bit 0)
- Monitoring of the velocity control loop (can be switched off by P-0-0556; Bit 1)
- Optional acceleration feedforward from the torque command value (with filtering option)

**Pertinent Parameters**

- S-0-0037, Additive velocity command value
- S-0-0040, Velocity feedback value
- S-0-0081, Additive torque/force command value
- S-0-0084, Torque/force feedback value
- S-0-0091, Bipolar velocity limit value
- S-0-0100, Velocity loop proportional gain
- S-0-0101, Velocity loop integral action time
- S-0-0149, C1300 Positive stop drive procedure command
- S-0-0155, Friction compensation
- S-0-0164, Acceleration feedback value 1
- S-0-0347, Velocity error
- P-0-0004, Velocity loop smoothing time constant
- P-0-0048, Effective velocity command value
- P-0-0049, Effective torque/force command value
- P-0-0180, Acceleration feedforward smoothing time constant
- P-0-0451, Actual acceleration torque/force value
- P-0-0452, Actual process torque/force value
- P-0-0555, Status word of axis controller
- P-0-0556, Config word of axis controller
- P-0-1119, Velocity mix factor feedback 1 & 2

## Drive Control

- P-0-1120, Velocity control loop filter: filter type
- P-0-1121, Velocity control loop filter: limit frequency of low pass
- P-0-1122, Velocity control loop filter: bandwidth of band-stop filter
- P-0-1123, Vel. cont. loop filter: center frequency of band-stop filter
- P-0-1126, Velocity control loop: acceleration feedforward
- P-0-2100, Velocity loop proportional gain, encoder memory
- P-0-2101, Velocity loop integral-action time, encoder memory
- P-0-3004, Speed loop smoothing time constant, encoder memory

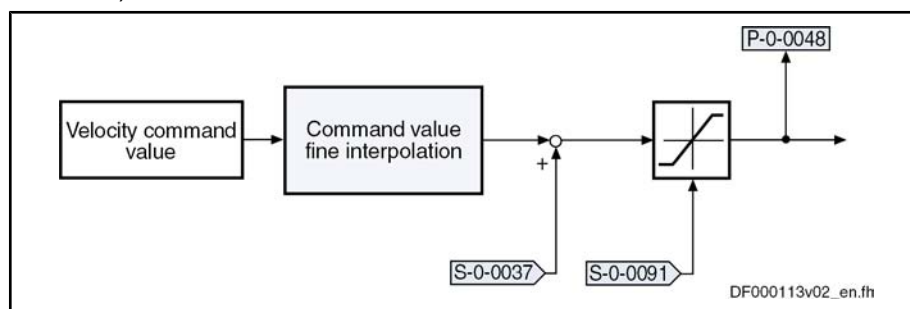
## Pertinent Diagnostic Messages

- E2059 Velocity command value limit active
- E8260 Torque/force command value limit active
- F8078 Speed loop error

## Functional Description

## Fine Interpolator

The preset velocity command value can be smoothed through a fine interpolator via 2 steps. This is reasonable e.g. for cyclic position control with especially large position command value jumps (great cycle times, comp. S-0-0001 and S-0-0002).



S-0-0037 Additive velocity command value

S-0-0091 Bipolar velocity limit value

P-0-0048 Effective velocity command value

Fig.6-74: Fine Interpolation of the Velocity Command Value

## Units of the Processed Data

The physical data for the velocity control loop have the following units:

- Velocity data → rpm or mm/min
- Acceleration data → (rpm)/controller clock or (mm/min)/controller clock
- Torque data → Nm or N

## Velocity Loop

The velocity loop designed as a PI loop can be set via the following parameters:

- S-0-0100, Velocity loop proportional gain
- S-0-0101, Velocity loop integral action time

The respective parameter settings depend on the mechanical properties (mass inertia, stiffness,...) of the motors and the connected mechanical system.

- For Rexroth motors with motor data memory (e.g. the motor range Indra-Dyn S) a default controller setting that is suitable for the most standard applications is stored in this memory.
- For Rexroth motors without motor data memory and for third-party motors, the controller settings must be determined at the commissioning, as they are strongly dependent on loads, especially for kit motors.

See also "Velocity Controller: Notes on Commissioning"



**Velocity Mix Factor**

In the velocity control loop, for the utilization of a load-side encoder, there is the possibility of calculating the velocity value utilized for the control from a "mix factor" (see description of the parameter P-0-1119) that consists of the velocity values of the motor encoder and of the load-side encoder (see also Figure "Structure of the Velocity Loop").

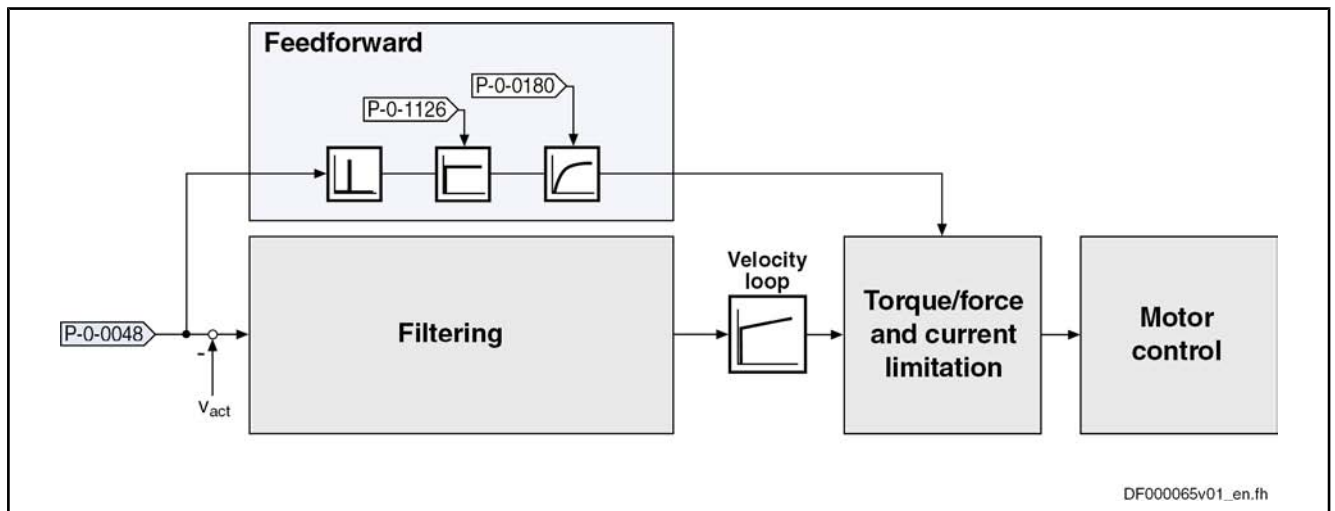


Combining the actual values of motor encoder and load-side encoder via a mix factor can be very advantageous for controlling systems with a low degree of stiffness in the case of connected load.

**Acceleration Feedforward**

In the velocity control loop there is the additional possibility of configuring the velocity loop in the control performance more dynamically through utilization of the so-named acceleration feedforward. The command value for the current controller then, to the greatest possible extent, is directly derived from the velocity command value. The velocity loop will then only be required for correcting disturbances.

The following graphic illustrates the feedforward of the controller:



P-0-0048	Effective velocity command value
P-0-0180	Acceleration feedforward smoothing time constant
P-0-1126	Velocity control loop: acceleration feedforward
Fig. 6-75:	Acceleration Feedforward in the Velocity Control Loop



This type of feedforward can be advantageous for very large mass inertia and/or low encoder resolution.

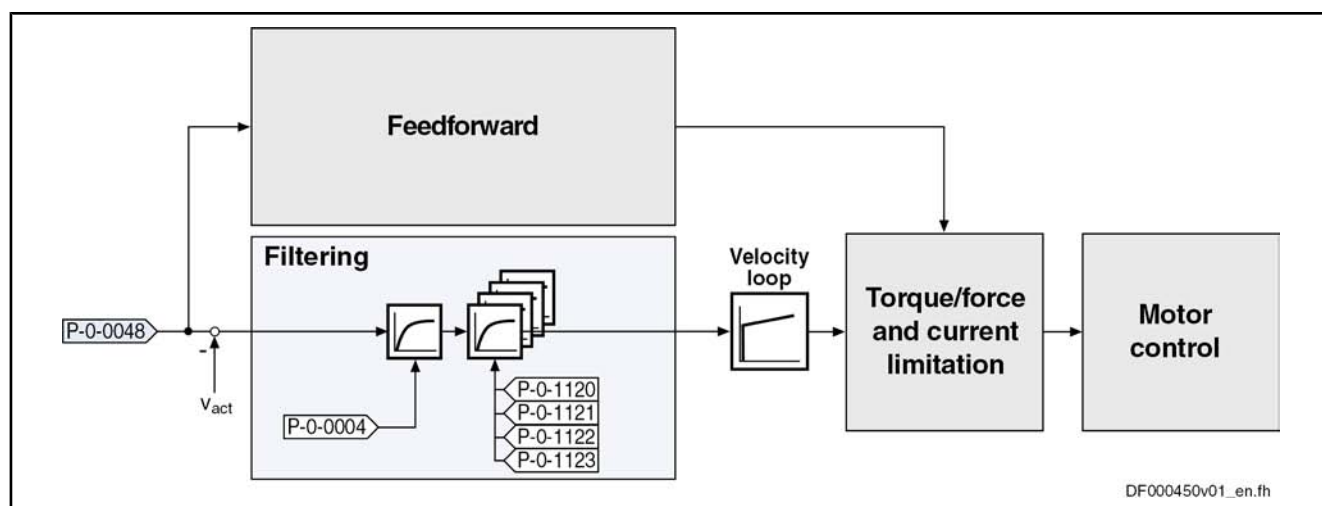
**Filter Options**

The following filters are available in the velocity control loop:

- Four individually configurable filters of 2nd order (low pass, band-stop filter...)
- One low pass of 1st order (PT1-element)
- One average value filter

The graphic below illustrates the position of the filter in the overall control loop:

## Drive Control



P-0-0004	Speed loop smoothing time constant
P-0-0048	Effective velocity command value
P-0-1120	Velocity control loop filter: filter type
P-0-1121	Velocity control loop filter: limit frequency of low pass
P-0-1122	Velocity control loop filter: bandwidth of band-stop filter
P-0-1123	Velocity control loop filter: center frequency of band-stop filter

Fig. 6-76: Filtering Options in the Velocity Control Loop

In practical application there often occur resonant oscillations that mostly result from deficiencies or restrictions of the mechanical system:

- Limits the rigid connection of the mechanical system to the motor shaft  
→ Resonances in the range of 100 Hz ... 1000 Hz are possible (according to rigidity of the connection and to the mass ratio)
- Gear backlash
- Faulty connection of the load-side encoder  
→ Resonances in the range of 1 kHz ... 2 kHz are possible (according to connection of the encoder)

This "two-mass oscillation" (or multiple-mass oscillation) mostly has one (or several) distinctive resonance frequency/frequencies that can be selectively suppressed by the rejection filters integrated in the drive. By means of the implemented filter cascade it is possible to selectively suppress up to 4 different resonance frequencies.



The implemented band-stop filters enable a suppression of resonance frequencies in the **frequency range from 100 Hz up to max. 4000 Hz** (advanced performance).

The upper limit depends on the velocity loop cycle time  $T_{An}$  (sampling theorem).

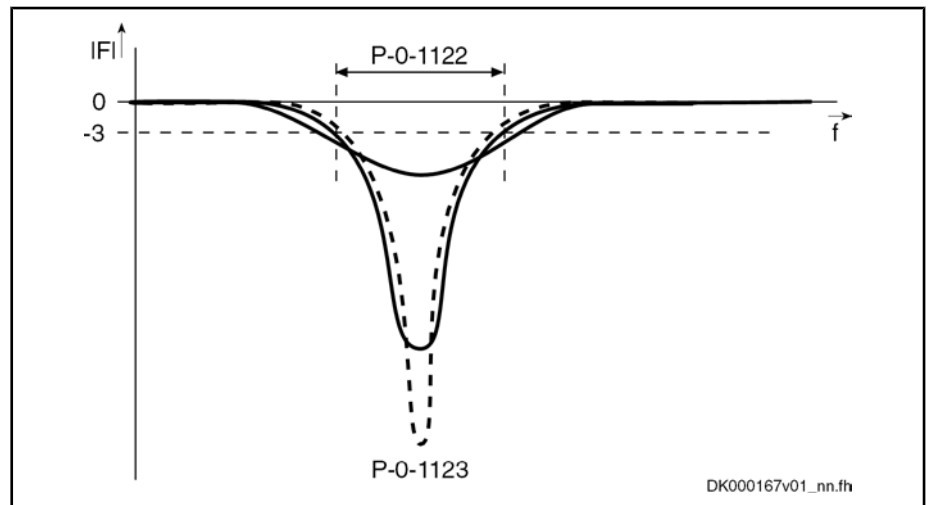
With the suppression of the mechanical resonance frequencies both the dynamics of the torque control loop and the dynamics of the position control loop can be improved by far more than with the control without the application of the rejection filters. This leads to improved movement according to contour and smaller cycle times for positioning processes with sufficient distance to the stability limit.

#### Explanation of the Filter Function

Both center frequency and band width can be set for the filters. The attenuation of the rejection frequency is the strongest; the bandwidth determines the frequency range in which the attenuation is smaller than  $-3$  dB.



Due to the filter structure, greater bandwidth results in lower attenuation of the rejection frequency!



|F| Value of the transmission function (in dB)

P-0-1122 Velocity control loop filter: bandwidth of band-stop filter

P-0-1123 Velocity control loop filter: center frequency of band-stop filter

Fig. 6-77: *Amplitude Characteristic of a Band-Stop Filter Depending on the Bandwidth (Qualitative)*

#### Filtering by Means of a Multiple Smoothing Filter

The optimization of the control loop by means of a rejection filter does not always lead to a sufficient improvement of the control quality. This is the case, for example, when the closed control loop has no distinctive resonance frequencies or when there are more than 4 resonance points. It is then possible to obtain the desired quality of control by activating several smoothing filters (with PT2 characteristics).

For this purpose, the 4 elements in "P-0-1120, Velocity control loop filter: filter type" are set to the value "1" or "0" (see description of Parameter P-0-1120).

Instead of the rejection filter, smoothing filters are activated in the control loop, the smoothing time constants of which ( $T_{gl}$ ) are contained in "P-0-1121, Velocity control loop filter: limit frequency of low pass".

Together with the PT1-filter (P-0-0004, Velocity loop smoothing time constant) at the velocity loop input you obtain filter characteristics with  $PT_N$ -behavior. Frequencies higher than the limit frequency ( $f_g = 1/2\pi T_{gl}$ ) are suppressed much more and cannot excite the control loop oscillation.

The following applies to the filter effect:

- P-0-0004, Velocity loop smoothing time constant  
→ Attenuation of 20 dB/decade
- P-0-1121, Velocity control loop filter: limit frequency of low pass  
→ Attenuation of 40 dB/decade

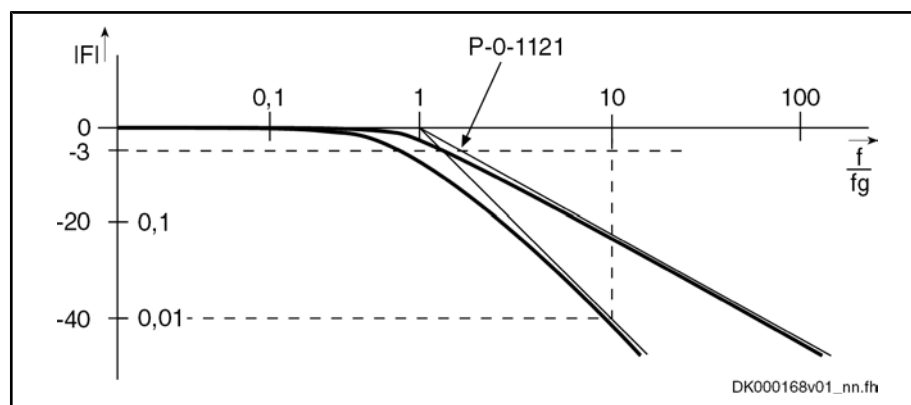
When activating all low-pass filters the maximum attenuation is 180 dB/decade. This corresponds to a very high filtering degree.

## Drive Control



When using the smoothing filters, take into account that each filter causes phase displacement in the control loop and therefore has a negative effect on the phase margin in the control loop (control loop stability).

Therefore the following applies: "As little filtering as possible, but as much filtering as necessary!"



IF1 Value of the transmission function (in dB)  
P-0-1121 Velocity control loop filter: limit frequency of low pass  
Fig. 6-78: Amplitude Characteristic of a PT1 and a PT2 Filter

## Notes on Commissioning

### Preparations for the Settings of the Velocity Loop

In order to be able to execute the settings of the velocity loop, a number of preparations must be carried out:

- The mechanical system of the machine must be set up in its final version, in order to provide for original conditions for the determination of the parameters.
- The drive controller must be connected correctly according to instructions.
- The operability of the safety limit switches (if available) must have been checked.
- The "velocity control" mode must have been selected in the drive.

### Start Settings

For the parameterization of the controller the start settings must be executed as illustrated below:

- S-0-0100, Velocity loop proportional gain  
→ Standard value of the connected motor
- S-0-0101, Velocity loop integral action time  
→ For a value equal to zero → No I-component
- P-0-0004, Velocity loop smoothing time constant  
→ Minimum input value → Filter is switched off  
→ P-0-0004 = 125  $\mu$ s (advanced performance)  
→ P-0-0004 = 250  $\mu$ s (basic performance)  
→ P-0-0004 = 500  $\mu$ s (economy performance)  
See also "Performance Data"
- P-0-1120, Velocity control loop filter: filter type  
→ For a value "0000" → Filter is switched off



When determining the velocity loop parameters there mustn't have been any friction torque compensation or reversal clearance compensation activated, because it influences the control behavior.

**Determination of the Critical Proportional Gain**

To determine the "critical proportional gain" proceed as follows:

1. Have the drive moving with a low velocity after switching on the drive enable.
  - Linear motor → 1000 ... 2000 mm/min
  - Rotary motor → 10 ... 20 rpm
2. Increase the value in "S-0-0100, Velocity loop proportional gain" until an instable ratio (continuous oscillation) occurs.
3. The frequency of the oscillation must be recorded by oscilloscoping the actual value (see also "Analog Outputs" or "Oscilloscope Function"). If the frequency of the oscillation is much higher than 500 Hz, increase the value in "P-0-0004, Velocity loop smoothing time constant" until the oscillation is reduced. Subsequently, increase the value in "S-0-0100, Velocity loop proportional gain" further until an oscillation occurs anew (instability).
4. Decrease the value "S-0-0100, Velocity loop proportional gain" until the continuous oscillation ceases automatically.

The value thus determined is the so-called "Critical velocity loop proportional gain".



By utilization of the filter cascade (P-0-1120, P-0-1121, P-0-1122, P-0-1123) a PT4-filtering can be activated.

**Determination of the Critical Integral Action Time**

For determination of the

"critical integral action time" proceed as follows:

1. Setting of the parameter "S-0-0100, Velocity loop proportional gain" =  $0.5 \times$  "critical proportional gain".
2. Reduce the value in "S-0-0101, Velocity loop integral action time" starting with the maximum value, until an instable behavior (continuous oscillation) occurs.
3. Increase the value in "S-0-0101, Velocity loop integral action time" until the continuous oscillation ceases automatically. The value thus determined corresponds to the "critical integral action time". Here, common values range between 5 to 20 ms.

**Calculation of the Theoretical Setting Values**

Based on the assumption of rigidly connected load and with some simplifications, it is possible to calculate the controller setting. The formulas below apply to the calculation of the proportional gain of the velocity loop:

$$S-0-0100 = \frac{(P-0-0510) + (P-0-4010)}{T_s \times \alpha} \times \frac{1}{60 \times 1000} \quad \left(\text{in } \frac{\text{N} \times \text{min}}{\text{mm}}\right)$$

- S-0-0100 Velocity loop proportional gain
- P-0-0510 Rotor inertia
- P-0-4010 Load inertia
- $T_s$  Sum of the time constants  $T_s = 406\mu\text{s} + (P-0-0004)$
- $\alpha$  Optimization variable  $\alpha = 2.5$

Fig.6-79: Calculation of the Value for the Proportional Gain of the Velocity Loop for Linear Motors

Drive Control

$$S-0-0100 = \frac{(P-0-0510) + (P-0-4010)}{T_s \times \alpha} \quad \left(\text{in } \frac{\text{Nm}}{\text{rad}}\right)$$

- S-0-0100 Velocity loop proportional gain
- P-0-0510 Rotor inertia
- P-0-4010 Load inertia
- $T_s$  Sum of the time constants  $T_s = 406\mu\text{s} + (P-0-0004)$
- $\alpha$  Optimization variable  $\alpha = 2.5$

Fig.6-80: Calculation of the Value for the Proportional Gain of the Velocity Loop for Rotary Motors

$$S-0-0100_{\text{IndraDrive}} = P-0-0051 \times S-0-0100_{\text{EcoDrive}} \quad \left(\text{in } \frac{\text{N} \times \text{min}}{\text{mm}}; \text{ in } \frac{\text{Nm}}{\text{rad}}\right)$$

- S-0-0100 Velocity loop proportional gain
- P-0-0051 Torque/force constant

Fig.6-81: Correlation of the Proportional Gain Between the IndraDrive and the EcoDrive Firmware

Characteristics of the Control Loop Setting

From the calculated critical values (see above) a controller setting can be derived that has the following features:

- Independent of changes at the axis due to sufficient distance to the stability limit
- Properties can be reliably reproduced in series machines

In the following table some of the most frequent modes of application and the respective characteristics of the control loop settings are illustrated.

Mode of application	Speed loop proportional gain	Speed loop integral action time	Notes
Feed axis of a standard machine tool	$K_p = 0,5 \times K_{p\_crit}$	$T_n = 2 \times T_{n\_crit}$	Good load stiffness and good control performance
Feed axis at perforating machine or nibbling machine	$K_p = 0.8 \times K_{p\_crit}$	$T_n = 0$	High proportional gain; no I-component in order to obtain short response times
Feed drive at follow-on cutting devices	$K_p = 0,5 \times K_{p\_crit}$	$T_n = 0$	Relatively non-dynamic controller setting without I-component in order to keep the material to be cut from getting distorted with the cutting device

Fig.6-82: Features of the Controller Settings

Parameterization of the Band-Stop Filters

The parameterization of the band-stop filters is carried out by means of the following parameters:

- P-0-1120, Velocity control loop filter: filter type
- P-0-1122, Velocity control loop filter: bandwidth of band-stop filter
- P-0-1123, Vel. cont. loop filter: center frequency of band-stop filter

Each of these parameters have 4 elements, which results in the following allocation of the relevant filter settings:

- **Band-stop filter 1:** P-0-1120 [0], P-0-1122 [0], P-0-1123 [0]
- **Band-stop filter 2:** P-0-1120 [1], P-0-1122 [1], P-0-1123 [1]
- **Band-stop filter 3:** P-0-1120 [2], P-0-1122 [2], P-0-1123 [2]
- **Band-stop filter 4:** P-0-1120 [3], P-0-1122 [3], P-0-1123 [3]

Presetting

The following procedure is recommended for the setting of the band-stop filter:

1. First set the rejection filters inactive.
2. Enter the following values in "P-0-1120, Velocity control loop filter: filter type".
  - P-0-1120 [0] = 0 → Filter 1 is switched off
  - P-0-1120 [1] = 0 → Filter 2 is switched off
  - P-0-1120 [2] = 0 → Filter 3 is switched off
  - P-0-1120 [3] = 0 → Filter 4 is switched off

**Determine Resonance Frequency**

The following procedure is recommended for determining the resonance frequency:

1. Use the oscilloscope function of the drive in order to display the actual velocity value. This value can be directly read by means of a fast Fourier transform (FFT) of the frequency response. For this, the utilization of the commissioning tool "IndraWorks Ds/D/MLD" is required.
2. In reversing duty increase the value in "S-0-0100, Velocity loop proportional gain" until distinctive oscillation is noticed (resonant oscillation).
3. Record the time behavior of the oscillation with the oscilloscope feature (alternatively with external oscilloscope) and analyze it with regard to clearly distinctive frequencies. When using the internal oscilloscope feature, the resonance frequency can be directly read via the "IndraWorks Ds/D/MLD" commissioning tool by means of the frequency display.
4. Set the drive inable and optimize the velocity while rejection filter is inactive.
5. Record the step response of the actual velocity value and the torque-/force-generating command current with small velocity command value step. The torque-generating command current must **not** reach the limitation!
6. Enter the most distinctive frequency in Hz in "P-0-1123, Vel. cont. loop filter: center frequency of band-stop filter".  
Enter a minimum bandwidth (e.g. 25 Hz) in "P-0-1122, Velocity control loop filter: bandwidth of band-stop filter".  
⇒ Re-record the previous step response!

**If the step response shows less overshooting and shorter period of oscillation:**

7. Check whether there is further improvement when increasing the value in "P-0-1122, Velocity control loop filter: bandwidth of band-stop filter" or when changing the value in "P-0-1123, Vel. cont. loop filter: center frequency of band-stop filter"..

**If the step response shows the same behavior:**

8. Check the determined resonance frequency; if need be, considerably increase the value in "P-0-1122, Velocity control loop filter: bandwidth of band-stop filter":
9. With the previously optimized values in "P-0-1122, Velocity control loop filter: bandwidth of band-stop filter" and "P-0-1123, Vel. cont. loop filter: center frequency of band-stop filter" optimize the velocity controller again.
10. If necessary, carry out another optimization procedure for parameters P-0-1122 and P-0-1123 due to the high-frequency or less attenuated resonance points that are now possibly occurring.

## Drive Control



If the rejection filter does not seem to show any effect, check whether the sampling time of the oscilloscope function might be too high, which means that the measured resonance frequency is merely the inverted version of the real frequency.

**Diagnostic and Status Messages**

<b>Velocity Deviation</b>	The velocity deviation (S-0-0347) is calculated by subtraction, from the effective velocity command value (P-0-0048) and the current actual velocity value (S-0-0040).
<b>Acceleration Torque/Force</b>	The acceleration torque is determined from the total inertia (P-0-0510 + P-0-4010) calculated from the automatic control loop setting and the value in "S-0-0164, Acceleration feedback value 1" and is displayed in "P-0-0451, Actual acceleration torque/force value".
<b>Process Torque/Force</b>	The current process torque is determined from the current total torque in "S-0-0084, Torque/force feedback value" and the determined "P-0-0451, Actual acceleration torque/force value" and displayed in "P-0-0452, Actual process torque/force value".
<b>Limitation of the Current Command Value (E8260)</b>	<p>The output signal of the velocity loop is limited to a minimum and a maximum torque. It is a torque / force command value that already includes the additive component for the friction torque compensation.</p> <p>This torque command value is limited in S-0-0082, S-0-0083 and S-0-0092. At the output of the limitation, the effective torque / force command value (P-0-0049) can be read.</p>



If the limitation is activated, the corresponding warning "E8260 Torque/force command value limit active" is generated and the respective bit (positive / negative limit) is set in P-0-0555, Status word of axis controller.

<b>Speed Loop Error (F8078)</b>	<p>The correct function of the velocity loop is monitored in the drive to avoid the so-called "runaway effect". Possible causes for errors are:</p> <ul style="list-style-type: none"> <li>• Incorrect commutation angle</li> <li>• Interchanged motor connection</li> </ul> <p>In the case of error the drive torque is immediately disabled and the error message "F8078 Speed loop error" is generated.</p>
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See also Troubleshooting Guide "F8078 Speed loop error"

**6.4.4 Position Loop (With Respective Feedforward Functions and Actual Value Adjustment)****Brief Description**

The following section only describes the position loop with the respective feedforward possibilities (velocity and acceleration feedforward).



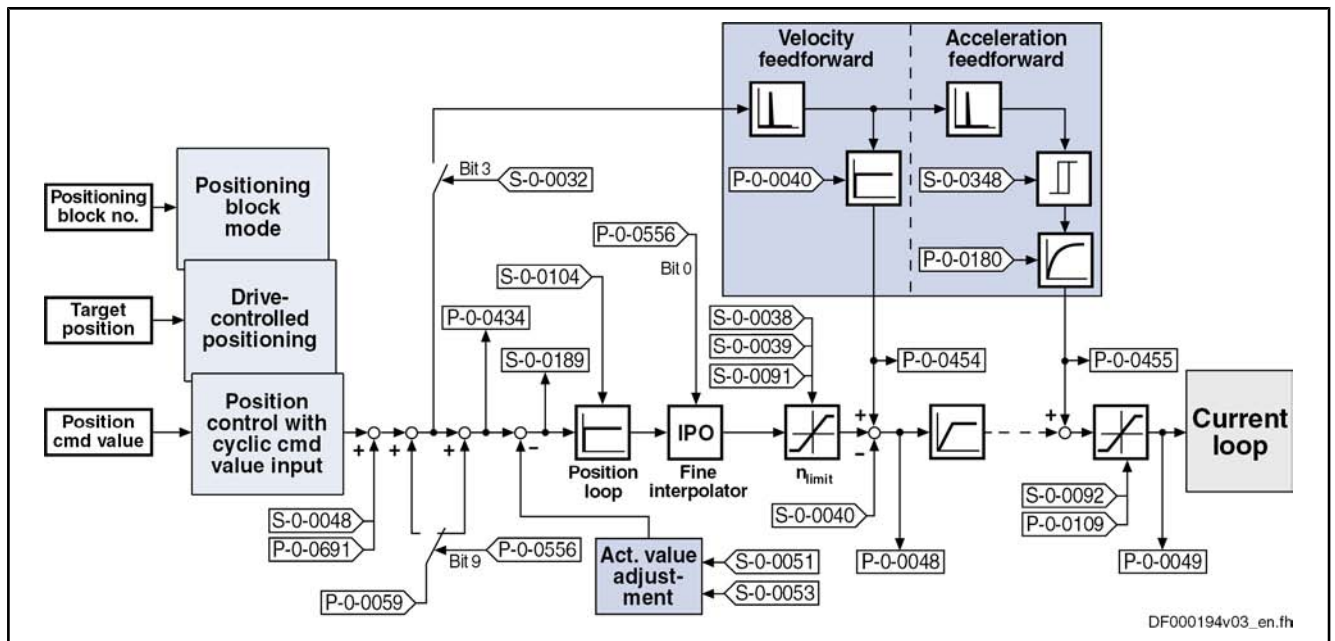


Fig. 6-83: Structure of the Position Loop



The preprocessing of the position command value (command value adjustment) is described in the corresponding section of the position control mode (e.g. position control with cyclic command value input, positioning block mode, ...).

**Features**

- Digital proportional loop, can be set via the following parameter:
  - S-0-0104, Position loop Kv-factor
- Lag error is minimized by:
  - Variable velocity feedforward (see P-0-0040)
  - and -
  - Variable acceleration feedforward (see S-0-0348), including smoothing filter
- Depending on the control performance which has been set, the cycle time  $T_{A\_position}$  is used for position loop calculations (see "Performance Data").
- With lag error or lagless, i.e. with velocity feedforward
- Model monitor for the lag error (see also F2028)
- Possibility of evaluating a "hybrid actual position value" from motor encoder and external position control encoder (up to now only motor encoder and measuring wheel encoder)

**Pertinent Parameters**

- S-0-0032, Primary mode of operation  
→ Bit 3 = 1 → Activation of lagless operation
- S-0-0038, Positive velocity limit value
- S-0-0039, Negative velocity limit value
- S-0-0040, Velocity feedback value
- S-0-0048, Additive position command value
- S-0-0051, Position feedback value 1
- S-0-0053, Position feedback value 2

## Drive Control

- S-0-0091, Bipolar velocity limit value
- S-0-0092, Bipolar torque/force limit value
- S-0-0104, Position loop Kv-factor
- S-0-0189, Following distance
- S-0-0348, Acceleration feedforward gain
- S-0-0386, Active position feedback value
- S-0-0520, Control word of axis controller
- -0-0521, Status word of position loop
- P-0-0040, Velocity feedforward evaluation
- P-0-0048, Effective velocity command value
- P-0-0049, Effective torque/force command value
- P-0-0059, Additive position command value, controller
- P-0-0109, Torque/force peak limit
- P-0-0180, Acceleration feedforward smoothing time constant
- P-0-0241, Actual pos. smoothing time constant for hybrid pos. control
- P-0-0434, Position command value of controller
- P-0-0454, Velocity feedforward actual value
- P-0-0455, Acceleration feedforward actual value
- P-0-0556, Config word of axis controller
- P-0-0691, Additive position command value, process loop

## Pertinent Diagnostic Messages

- F2028 Excessive deviation
- F2036 Excessive position feedback difference
- F2037 Excessive position command difference

## Functional Description



Activating the lagless operation causes a feedforward value determined from the position command value (velocity command value) to be added to the velocity command value at the position loop output.

## Velocity Feedforward

By means of the velocity feedforward, it is possible to reduce the lag error to a minimum (ideally = 0) at constant velocity.

It is possible to include the additive position command value for the controller (P-0-0059) in the calculation of the velocity feedforward. To do this set bit 9 of "P-0-0556, Config word of axis controller".

## Acceleration Feedforward

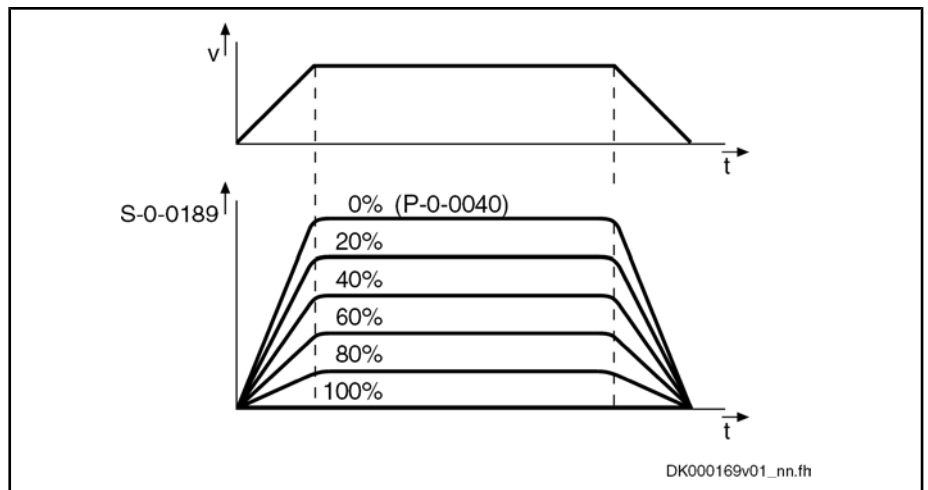
In order to achieve a reduction of the lag error during the acceleration process, the acceleration feedforward (see S-0-0348) has to be activated. For optimum parameterization of the acceleration feedforward the following values have to be entered in "S-0-0348, Acceleration feedforward gain":

- Linear motor → total mass (motor + load) in kg
- Rotary motor → total mass inertia (motor + load) in  $\text{kgm}^2$

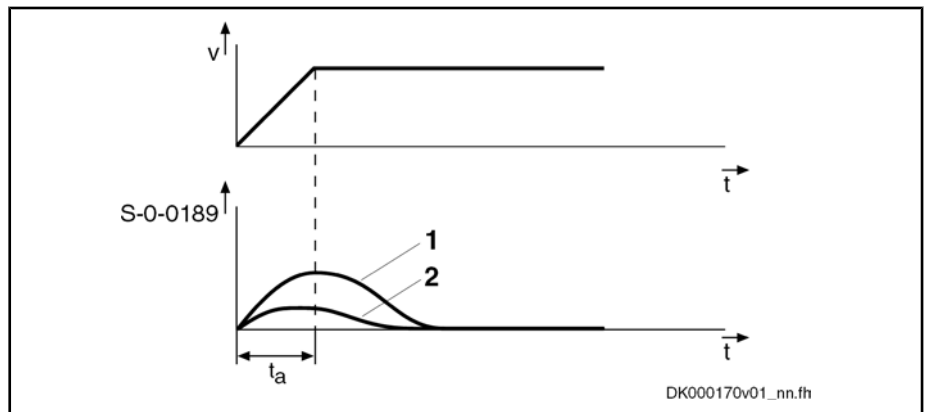


Adjust the input value in "S-0-0348, Acceleration feedforward gain" in dependency of the respective local mechanical system!

The illustrations below exemplify the operating principle of the respective feedforward procedure.



S-0-0189 Following distance  
P-0-0040 Velocity feedforward evaluation  
Fig.6-84: Operating Principle of the Velocity Feedforward



1 Without acceleration feedforward  
2 With acceleration feedforward  
 $t_a$  Acceleration phase  
S-0-0189 Following distance  
Fig.6-85: Operating Principle of Acceleration Feedforward (With P-0-0040 = 100%)

**Making the Actual Position Value Available**

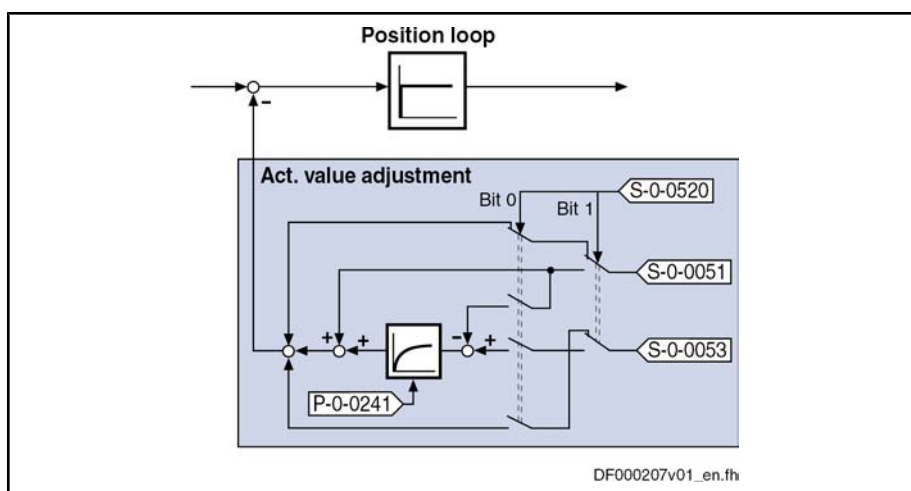
**"Hybrid Actual Position Value"**

The actual value for the position control can be made available by the motor encoder or the optional encoder. It is possible, however, to use both actual position values for position control ("hybrid actual position value").

The actual position value detected by the optional encoder is added to the actual position value of the motor encoder and is used for position control as the so-called "hybrid actual position value". The difference of both actual position values is smoothed via a filter which can be set (P-0-0241) and added to the actual position value of the motor encoder.

Using the hybrid actual position value is particularly advantageous if slip occurs between motor encoder and external encoder (see also "Measuring wheel mode") or if there is only little stiffness available.

## Drive Control



S-0-0051	Position feedback 1 value
S-0-0053	Position feedback 2 value
S-0-0520	Control word of axis controller
P-0-0241	Actual pos. smoothing time constant for hybrid pos. control

Fig. 6-86: Generating the Hybrid Actual Position Value

The generation of the hybrid actual position value is configured in "S-0-0520, Control word of axis controller", its use for control tasks is activated in the same parameter.

To be noticed:

- By the value "0" in "P-0-0241, Actual pos. smoothing time constant for hybrid pos. control", the actual position value of the motor encoder is ignored and only the actual position value of the optional encoder is used for position control.
- If the values of the s-0-0051 and S-0-0053 differ (might be the case for measuring systems to be evaluated in absolute form with different position data reference), abrupt changes in the velocity command value can occur when the hybrid actual position value is activated.



The position data reference of motor encoder and optional encoder remains unchanged when the hybrid actual position value is activated. As a prerequisite the optional encoder **must not** have been activated as measuring wheel encoder in "P-0-0185, Control word of encoder 2 (optional encoder)"!

## Notes on Commissioning

The cascade structure of the loops requires the optimization of the position loop to be only carried out after all outer control loops (velocity and current) have been optimized, because in the case of a cascade loop structure the dynamic response of the outer control loops limits the dynamic response of the higher-level control loops.

### Determining the Critical Position Loop Kv-Factor

To determine the critical position loop Kv-factor, proceed as follows:

1. Let the drive move with low velocity in position control after switching on drive enable:
  - Linear motor → 1000 ... 2000 mm/min
  - Rotary motor → 10 ... 20 rpm
2. "Increase S-0-0104, Position loop Kv-factor" until instable behavior (continuous oscillation) occurs.

	3. "Reduce S-0-0104, Position loop Kv-factor" until continuous oscillation decreases automatically. The value thus determined is the so-called "critical position loop Kv-factor".
<b>Characteristics of the Control Loop Setting</b>	<p>From the determined critical Kv-factor (see above), it is possible to derive a control loop setting with the following characteristics:</p> <ul style="list-style-type: none"> <li>• Independent of changes at the axis due to sufficient distance to the stability limit</li> <li>• Properties can be reliably reproduced in series machines</li> </ul> <p>The position loop normally is checked by optimizing the lag error. To do this, the following machine and application types have to be distinguished:</p> <ul style="list-style-type: none"> <li>• <b>High-end machine tools</b> (e.g. grinding machines) → Optimization with regard to a minimum lag error characteristic by the highest possible Kv-factors</li> <li>• <b>Standard positioning axes</b> (e.g. press transfer) → Optimization with regard to a minimum lag error characteristic is not required, the important thing is smoothest possible, jerk-free positioning. This is achieved, among other things, by relatively low Kv-factors resulting in very stable control loop settings.</li> </ul>
<b>Presettings for Using the Hybrid Actual Position Value</b>	First set the relevant parameter values for the mechanical arrangement of motor, motor encoder, axis and external (optional) encoder. The external encoder must have been configured as "position control encoder" (not as "measuring wheel encoder"!)" in "P-0-0185, Control word of encoder 2 (optional encoder)". Configure the hybrid actual position value in "S-0-0520, Control word of axis controller".
<b>Activating the Hybrid Actual Position Value</b>	<p>The hybrid actual position value can only be activated when the drive is ready for operation, by</p> <ul style="list-style-type: none"> <li>• Activating "hybrid actual position value" in "S-0-0520, Control word of axis controller" - and -</li> <li>• position-controlled operating mode of the drive.</li> </ul>
<b>Deactivating the Hybrid Actual Position Value</b>	<p>The option "hybrid actual position value" can be deactivated and switched to the actual position value of motor encoder or optional encoder by one of the following actions:</p> <ul style="list-style-type: none"> <li>• Deactivating "hybrid actual position value" in "S-0-0520, Control word of axis controller"</li> <li>• Switching to communication phase P2 or parameter mode</li> <li>• Switching the drive off</li> </ul>
<b>Setting the Jerk Attenuation for the Hybrid Actual Position Value</b>	Abrupt position differences between motor encoder and optional encoder can be attenuated by inputting a value greater than zero in "P-0-0241, Actual pos. smoothing time constant for hybrid pos. control".



The value  $0$  in P-0-0241 switches off the attenuation and causes only the actual position value of the optional encoder to be effective.

#### Procedure:

1. Enter value "0" in P-0-0241 and move axis at low velocity and little acceleration.
2. Increase infeed velocity and acceleration up to the maximum values.

## Drive Control

While increasing the velocity and acceleration, also increase the value of P-0-0241, if necessary, in order to achieve a satisfactory compromise of smoothness of running and minimum lag error!

## Diagnostic and Status Messages, Limitations

The following monitoring functions are carried out in the position loop:

### Excessive Deviation (F2028)

- **Monitoring of lag error by means of model calculation**

The deviation of the actual position value from the position command value is monitored by comparing an "actual position model value" internally calculated in the drive to the real actual position value (= **lag error monitoring**). If the difference of the theoretical and actual position value permanently exceeds the value of "S-0-0159, Monitoring window" it is obvious that the drive cannot follow the preset command value and the error message "F2028 Excessive deviation" is generated.

### Excessive Position Feedback Difference (F2036)

- **Monitoring of position difference (encoder 1 and encoder 2)**

When 2 measuring systems (1 motor encoder and possibly external length measuring system) are used simultaneously, the actual position value 1 and the actual position value 2, in cyclic operation (phase 4), are monitored for a maximum allowed actual position value difference indicated in "S-0-0391, Monitoring window feedback 2". If the absolute value of the difference is greater than the value of the monitoring window, the error message "F2036 Excessive position feedback difference" is generated.



The current position difference is displayed in "P-0-0391, Actual position value difference encoder1 - encoder2!"

### Limiting the Velocity Command Value

The following limitation is carried out in the position loop:

- The output of the position loop (P-0-0048) is limited to a maximum absolute velocity value. The output signal of the position loop is a velocity command value that already contains the additive component for velocity feedforward, plus a possibly preset additive velocity command value (S-0-0037). The limitation therefore has an effect on the sum of the different command values.

See also "Velocity Limitation"

## 6.5 Commutation Setting

### 6.5.1 Basics on Commutation Setting

#### Brief Description

The following Rexroth kit motors are manufactured according to the "synchronous motor" functional principle:

- Linear motor MLF
- Rotary motors MBS and MBT

As the motor is assembled in the machine, stator, rotor and measuring system cannot be put together by the manufacturer. The customer will make the electric-magnetic-mechanical allocation of the synchronous motor on site by determining and setting the commutation offset.

The same applies for the Rexroth housing motor MSP.

#### Measuring Systems for Synchronous Rexroth Motors

Absolute measuring systems should ideally be used for synchronous Rexroth kit motors. The advantage in this case is the absolute position detection of the rotor position which immediately ensures, when drive enable is set, the correct

assignment of current in the primary part to the magnetic field in the secondary part. This is realized by the commutation offset stored at initial commissioning. For some applications it is necessary to use relative measuring systems, because the available length of absolute measuring systems is limited, for example. The disadvantage in this case is that absolute detection of the rotor position is impossible. It is therefore necessary, after each time the drive is switched on again or after having changed the communication phase from "P2" to "P4" ("bb" or "Ab"), to set the commutation offset again. For linear motors, this disadvantage can be removed by using the Hall sensor box SHL01.1, because with regard to commutation setting the relative motor encoder then behaves like an absolute measuring system.



If you use a relative motor encoder, using the Hall sensor box SHL01.1 is absolutely recommended for linear motors! In this way, you achieve highest safety with regard to correct motor function and compliance with the power data!

**Measuring Systems for Synchronous Third-Party Motors**

Concerning operationally reliable drives with synchronous third-party motors and IndraDrive controllers, there are, with regard to the selected measuring system, the same principles applying as to synchronous Rexroth kit motors (see above); the Hall sensor box SHL, however, cannot be used for linear third-party motors!

**Overview of the Synchronous Motors to be Used for Motor Measuring Systems**

Motor measuring system	Synchronous Rexroth kit motor (rotary, linear)	Synchronous Rexroth kit motor (linear) with SHL01.1	Synchronous third-party motor
Absolute	+	--	+
Relative	o	+	o

- + Advantageous combination
- o Combination possible, initial commissioning might possibly require especially trained staff
- Combination not useful

*Fig. 6-87: Possible Combinations of Motor Measuring System and Synchronous Motors for Which Commutation Setting is Required*

## Drive Control



The measuring system should be realized with high resolution and as a motor encoder to be evaluated in absolute form. If it is necessary to use a relative measuring system, you should avoid using encoders with square-wave signals!

For synchronous motors in combination with a motor encoder which can be evaluated in absolute form, the advantage of setting the commutation offset only once (see above) can only be used with an encoder gear with  $i = 1$  or when there is no encoder gear available!

**As of MPx06V08**

In special cases a motor encoder to be evaluated in absolute form encoder gear can use the one-time setting of the commutation offset (rotary encoders, only).

There are 2 cases to be distinguished:

- Case 1, single-turn (or multi-turn) encoder:  
If n-fold motor revolution (n integral) causes exactly one encoder rotation
- Case 2, multi-turn encoder:  
If exactly one motor rotation causes m-fold encoder rotation (m integral)

See also "Absolute Measuring Systems" and "Mechanical Axis System and Arrangement of Measuring Systems"

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**Pertinent Parameters**

Apart from the motor parameters (see overview of parameters in "Basics on the Motors to be Controlled", there are further parameters available for commutation setting:

- P-0-0506, Amplitude for angle acquisition
- P-0-0507, Test frequency for angle acquisition
- P-0-0508, Commutation offset
- P-0-0517, Commutation: required harmonics component
- P-0-0518, C5600 Command subsequent optimization of commutation offset
- P-0-0521, Effective commutation offset
- P-0-0522, Control word for commutation setting
- P-0-0523, Commutation setting measured value
- P-0-0524, C1200 Commutation offset setting command
- P-0-3008, Commutation offset, encoder memory

**Pertinent Diagnostic Messages**

- C1200 Commutation offset setting command
- C1204 Error in offset calculation
- C1208 No adjustment with asynchronous motor
- C1209 Proceed to phase 4
- C1211 Commutation offset could not be determined.
- C1214 Command only possible with linear synchronous motor
- C1215 Command only possible in 'bb'
- C1216 Commutation determination not selected
- C1217 Setting only possible in 'Ab'
- C1218 Automatic commutation: Current too low



- C1219 Automatic commutation: Overcurrent
- C1220 Automatic commutation: Timeout
- C1221 Automatic commutation: Iteration without result
- C1222 Error when writing offset parameters
- C5600 Command subsequent optimization of commutation offset
- C5601 Command requires drive enable
- C5602 Axis blocked
- C5603 Timeout: Axis in motion
- F2032 Validation error during commutation fine adjustment
- F8010 Autom. commutation: Max. motion range when moving back
- F8011 Commutation offset could not be determined
- F8012 Autom. commutation: Max. motion range
- F8013 Automatic commutation: Current too low
- F8014 Automatic commutation: Overcurrent
- F8015 Automatic commutation: Timeout
- F8016 Automatic commutation: Iteration without result

## Overview of Methods for Determining the Commutation Offset

### Methods for Determining the Commutation Offset

The commutation offset can be determined with different methods. The method is chosen in accordance with the axis geometry, the practicability and the chances of success of the respective method depending on motor and mechanical axis system.

The following methods are possible:

- **Calculation method**
  - For relative motor encoder when using the hall sensor box (distance measurement, currentless → only possible with Rexroth linear kit motors, see documentation "Hall Sensor Box SHL01.1")
- **Measuring method**
  - For motor encoder that can be evaluated in absolute form (distance measurement, currentless → only possible with Rexroth linear kit motors)
- **Saturation method** (axis needs to be blocked or at standstill, with current)
  - Possible with all types of construction in combination with motor encoders that can be evaluated in absolute form and with relative motor encoders; but see "restrictions for saturation method" in table below
- **Sine-wave method** (requires unrestricted movement of axis, with current)
  - Possible with all types of construction in combination with motor encoders that can be evaluated in absolute form and with relative motor encoders; but see "restrictions for sine-wave method" in table below

**Recommendations for selecting the determination method:**

Drive Control

		Determination method			
		Calculation method (with Hall sensor box)	Measuring method	Saturation method	Sine-wave method
Motor type	Measuring system used →	Relative, linear	Absolute, linear	Absolute/relative	Absolute/relative
MBSxx0		--	--	+	o
MBSxx2 (high speed)		--	--	o	+
MBTxx0		--	--	+	o
MBTxx1		--	--	o	+
MLF		+	+	+	o
MSP		--	--	+	o

- + Recommended method
- o Method not recommended
- Method not possible

Fig.6-88: Recommendations for Selecting Determination Method for Commutation Offset Depending on Motor Type (for Rexroth Motors)



The sine-wave method (generally requires unrestricted movement of axis) should only be used if the saturation method cannot be used!

Restrictions for Saturation Method

Applications of synchronous motors	Restrictions for saturation method
Third-party motors without or with only little saturation effects	Saturation method cannot be used for determining commutation offset!
Applications with relative measuring system (without using the optimum commutation offset value with regard to the reference point)	Max. torque/force can be reduced by approx. 15% compared to the optimum value (autom. determining the commutation offset for "AF")!
Applications with relative measuring system that are using the optimum commutation offset value with regard to the reference point	Max. torque/force until reference mark is passed can be reduced by approx. 15%!
Drives that can be in motion during the determination of the commutation offset, e.g. coasting spindles, printing roller drives etc.	Saturation method only possible for motors in standstill!
Drives with a low degree of overload capacity	Saturation method only possible if amplifier current is sufficiently high (2...4-fold continuous motor current required)!

Fig.6-89: Typical Applications and Restrictions for Saturation Method

**Restrictions for Sine-Wave Method**

Applications of synchronous motors	Restrictions for sine-wave method
Linear axis with single motor or parallel motor	Only balanced (e.g. horizontal) axes with little friction!
Linear axes in Gantry arrangement	Only balanced (e.g. horizontal) axes with little friction! In addition, both drives have to carry out sequential commutation settings, "AF" then must not be active at the other drive!
Rotary axes with single drive	Only balanced axes with little friction; high inertia can cause problems!
Rotary axes, mechanically connected	See above "Linear axes in Gantry arrangement"!

*Fig. 6-90: Typical Applications and Restrictions for Sine-Wave Method*

**Significance of Commutation Offset**

A synchronous motor can only generate the torque or the force specified according to motor data, when the commutation offset is correct. If the value for the commutation offset is incorrect, lower action torque / force is to be expected. A highly incorrect value implies the danger of the motor moving in an uncontrolled way.

Therefore, "P-0-0521, Effective commutation offset" is write-protected. For initial commissioning of Rexroth kit motors, however, it is required to allow writing of P-0-0521 in order to set and optimize the value, if necessary. The initial commissioning mode must be activated for this purpose (see "P-0-0522, Control word for commutation setting"). During the initial commissioning of the motor, you have to determine the commutation offset value with due diligence.



For synchronous Rexroth motors with integrated motor encoder (MSK, MHD, MKD, MKE motors), it is not necessary to set the commutation offset! The correct value is provided in the motor encoder data memory and is automatically activated.

Depending on the motor encoder used, you have to determine the commutation offset for the following situations:

- With absolute motor encoder only during initial commissioning of the drive
- With relative motor encoder both during initial commissioning and each time the drive has been switched on (recommissioned)



Deviating values when determined again (recommissioning with relative motor encoder) can occur, this can cause deviating drive behavior (remedy: "optimum commutation offset with regard to reference point", see below)!

**Notes on Commissioning**

**Initial Commissioning**

**Commutation Offset During Initial Commissioning of Synchronous Motor**

Determining the commutation offset during the initial commissioning of a synchronous motor is of particular relevance. For this purpose, there are different methods available or applicable for determining the commutation offset, depending on motor and position measuring system (motor encoder). In addition, the effectiveness of the determined value should be checked and, if necessary, optimized.

The overview below illustrates the procedure for selecting the appropriate method of commutation offset determination for synchronous motors and the

Drive Control

determination of a value for "P-0-0508, Commutation offset" within the scope of initial commissioning.

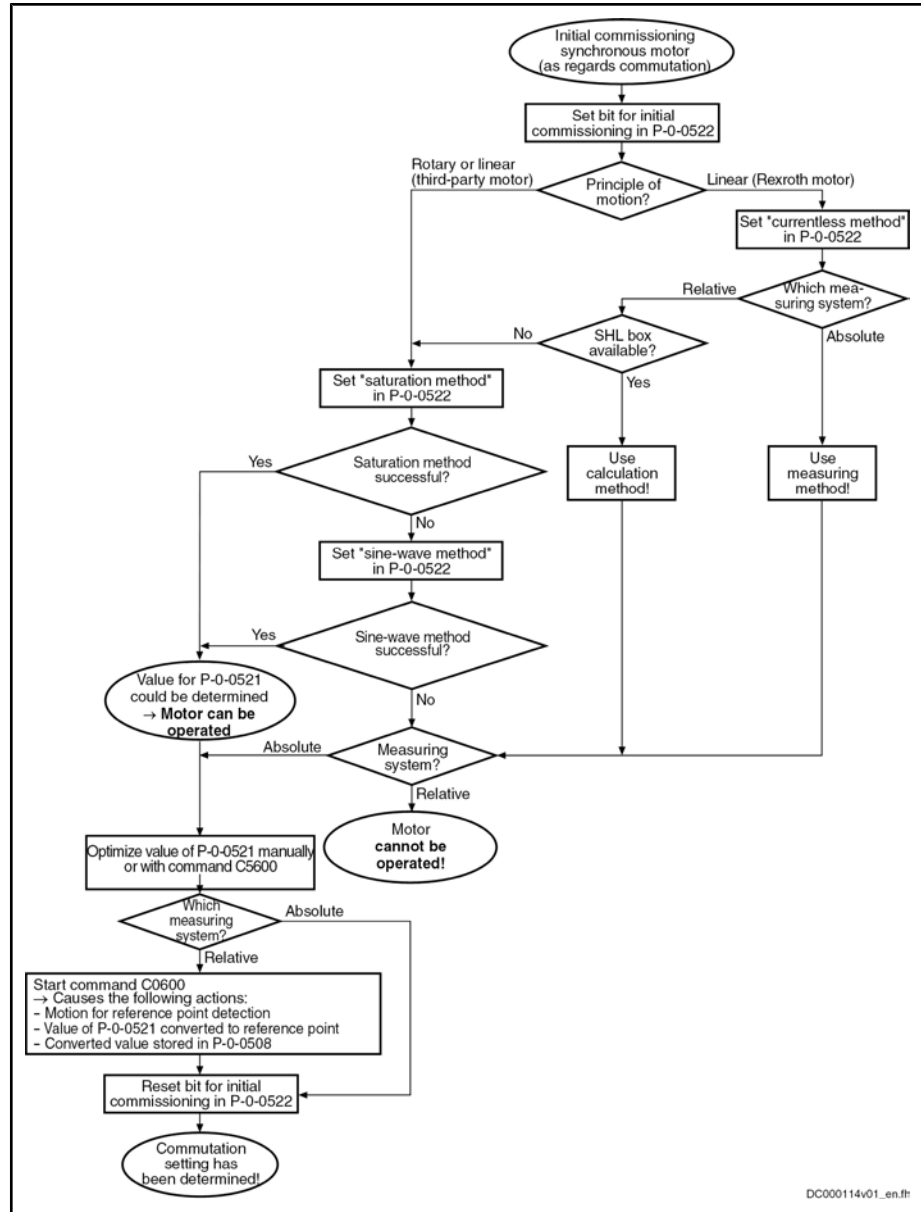


Fig.6-91: Selecting the Method for Determining Commutation Offset During Initial Commissioning of Synchronous Motor

Manually Optimizing the Offset Value

The automatically determined value for the commutation offset is stored in "P-0-0521, Effective commutation offset". When the initial commissioning mode is active (respective bit in P-0-0522), the value of P-0-0521 can be manually optimized. Optimization should be carried out using a force measurement device.

$$(P-0-0521)_m = (P-0-0521)_a \pm 256$$

m Manually  
a Automatically determined

Fig.6-92: Range of Values for Optimizing the Commutation Offset



**CAUTION**

Property damage caused by errors when controlling motors and moving parts!  
⇒ Before manually optimizing the commutation offset, move the axis to a non-critical position!

**Automatically Optimizing the Offset Value**

The value determined for "P-0-0521, Effective commutation offset" can be automatically optimized. This is done by starting "P-0-0518, C5600 Command subsequent optimization of commutation offset". For this purpose, the drive must be in drive enable ("AF") and in standstill. In addition, the axis must be able to move sufficiently (motion range see table).

Motor design	Motion range	Reference
Rotary	± 10 angular degrees	Motor shaft
Linear	± 0.1 × pole pair distance	Primary part

*Fig. 6-93: Minimum Required Motion Range for Executing Command C5600*

The controller optimizes the commutation offset which is already operational (value stored in P-0-0521) by transmitting test signals to the motor. The information for improvement of the commutation offset is taken from the motor motion (actual position value). Upon successful execution of command C5600, an improved value is available in "P-0-0521, Effective commutation offset".



The execution of "C5600 Command subsequent optimization of commutation offset" is always recommended when there isn't any of the restrictions which are mentioned for the sine-wave method (see above)!



**CAUTION**

**Property damage caused by errors when controlling motors and moving parts!**

⇒ Before automatically optimizing the commutation offset, move the axis to a noncritical position and make sure axis can move!

**Storing the "Optimum Commutation Offset with Regard to Reference Point"**

For synchronous motors with relative measuring system (motor encoder) and with initial commissioning mode activated, the value determined and, if necessary, optimized during initial commissioning is converted to the reference point by a homing procedure (start of command C0600) and stored in "P-0-0508, Commutation offset".

**Recommissioning a Synchronous Motor**

Readiness for operation of a synchronous motor is given after switch-on (putting into operation after initial commissioning already taken place), when the controller has stored or determined a commutation offset value for this motor.

**Synchronous Motors With Absolute Measuring System**

Immediate readiness for operation is generally given for absolute motor measuring systems and for linear Rexroth motors with relative measuring system and SHL box. The commutation offset value (P-0-0508) stored in the controller or in the measuring system during initial commissioning is activated by applying it to "P-0-0521, Effective commutation offset".

**Synchronous Motors With Relative Measuring System**

For relative motor measuring systems (exception: linear Rexroth motor with relative measuring system and SHL box), the drive, at first drive enable after switch-on or after re-initialization of the measuring system, automatically determines the commutation offset. When "AF" is set, this is automatically done by a method with current (for overview of methods see above "Overview of Methods for Determining the Commutation Offset"). The value is stored in

## Drive Control

### Optimum Commutation Offset With Regard to Reference Point

"P-0-0521, Effective commutation offset" and refers to the current position of the axis.

When drive-controlled homing (command C0600) is now started due to the relative measuring system, the value of P-0-0521 is converted to the reference point position when the reference point is passed. This converted value is compared to the optimum commutation offset value determined during initial commissioning and stored in P-0-0508.

If the comparison results in "positive validation", the difference between the converted value and P-0-0508 is added to the effective commutation offset value (P-0-0521) ("fine adjustment" of the commutation offset). If validation is negative, the value in P-0-0508 is probably incorrect (e.g. inverted value). The error message "F2032 Validation error during commutation fine adjustment" is generated and the drive switches off.



If fine adjustment of the commutation offset is not desired, it can be deactivated via  $P-0-0508 = 0$  or  $P-0-3008 = 0$  (can be written in communication phase "P2"). This causes the automatically determined value to remain effective!

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For synchronous motors with relative measuring system, the torque or force development of the motor is reproduced in accordance with the initial commissioning situation by using the "optimum commutation offset with regard to reference point"!

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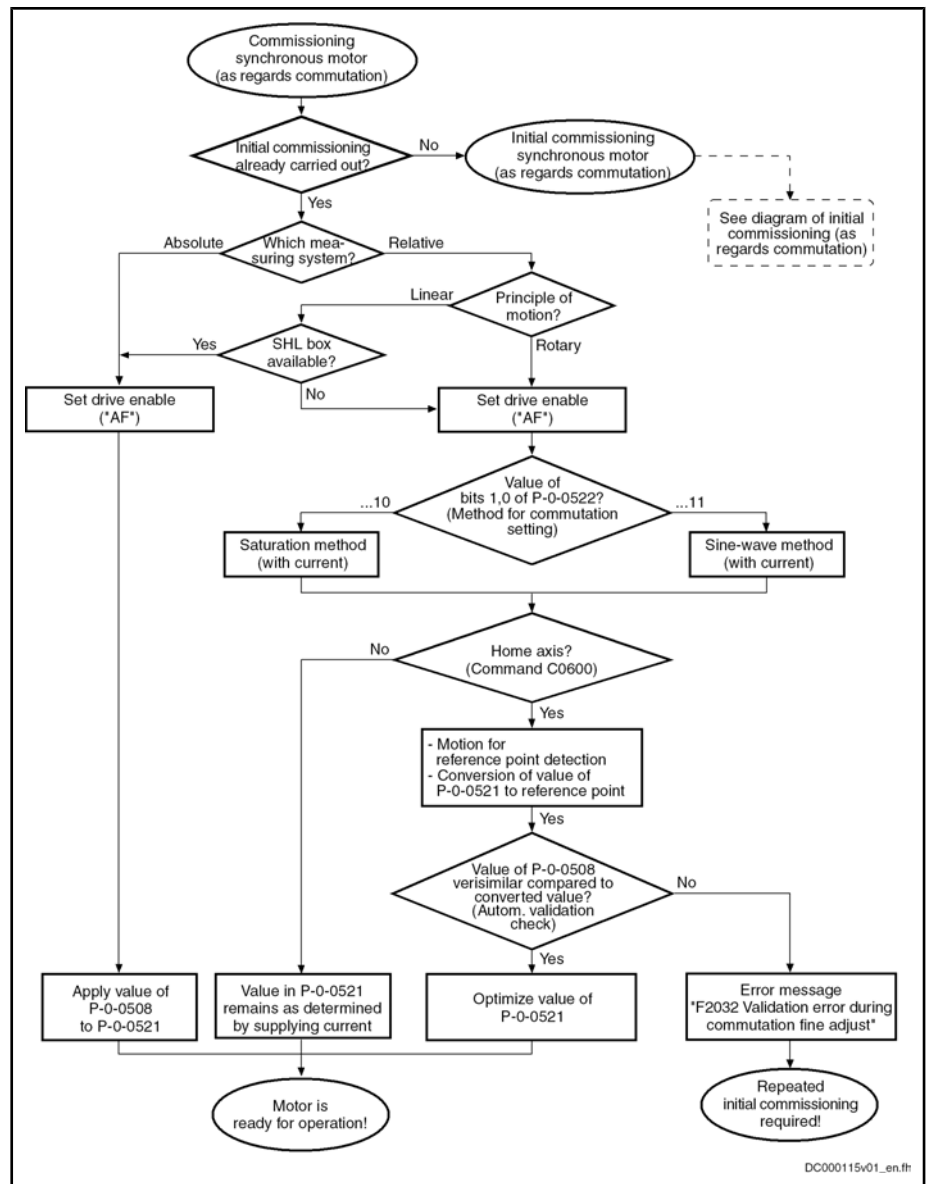


Fig. 6-94: Establishing Readiness for Operation of a Synchronous Motor for Recommissioning

## 6.5.2 Commutation Setting for Rexroth Motors MLF

### Brief Description

Linear Rexroth kit motors of the MLF and LSF lines are manufactured according to the "synchronous motor" functional principle. For kit motors, the motor components stator, rotor and measuring system are finally assembled on the customer side in the machine.

#### With Absolute Motor Encoder

The electric-magnetic-mechanical allocation of the synchronous motor therefore can only be made on site by determining and setting the commutation offset. This is done once during initial commissioning of the motor, if it has been equipped with a motor encoder to be evaluated in absolute form.

#### With Relative Motor Encoder

When a relative motor encoder is used, it is necessary to determine the commutation offset again each time after the drive was switched off.

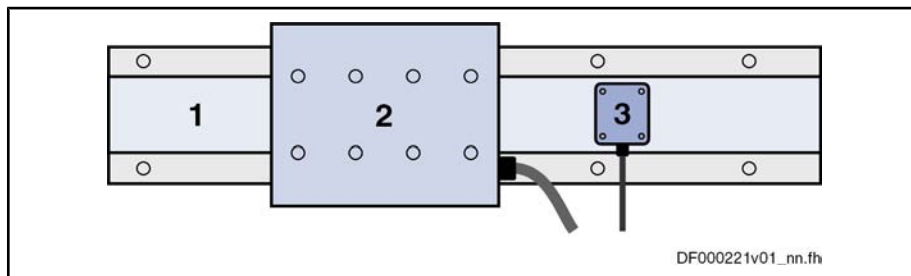
Deviating commutation offset values when determined again (recommissioning with relative motor encoder) can occur, this can cause deviating drive behavior.

## Drive Control

To avoid this, it is recommended that you use the Hall sensor box SHL01.1 which was developed for linear Rexroth motors.

**Hall Sensor Box SHL01.1**

The Hall sensor box SHL01.1 is an absolute measuring system within one pole pair distance of linear Rexroth motors. Via the signals of the Hall sensors, the controller detects the position of the motor windings compared to the magnetic field of the motor; therefore, the commutation setting is only required during initial commissioning. When the drive is recommissioned, the correct commutation offset is already available at drive enable ("AF").



- 1 secondary part
- 2 Primary part
- 3 Hall sensor box SHL

Fig.6-95: Linear Rexroth Motor With Hall Sensor Box SHL

For information on mounting and connection see the documentation on Hall Sensor Box SHL01.1.

## Functional Description

**Commutation Offset With Relative Motor Encoder and Hall Sensor Box SHL**

When using a linear Rexroth motor with relative measuring system as motor encoder and using the Hall sensor box SHL, the value for the commutation offset depends on the motor geometry and the mounting distance of the SHL box to the primary part. The value is independent of the axis position and determined once during initial commissioning (for further information see documentation on Hall Sensor Box SHL01.1).

**Commutation Offset With Absolute Motor Encoder, Measuring Method**

The measuring method for determining the commutation offset can only be used for linear Rexroth motors with linear motor encoder that can be evaluated in absolute form (e.g. EnDat encoder). The method is currentless, i.e. the motor does not generate any force. At drive enable (AF = Antriebsfreigabe), it is then immediately fully operational.



For rotary synchronous Rexroth kit motors, the commutation offset can only be determined with methods with current (saturation or sine-wave method) because there wasn't any measuring method defined!

To determine the commutation offset, the relative position of the primary part (electrically active part) must be determined with regard to the secondary part (electrically inactive part). This "relative position" is characterized by a value which has to be entered in "P-0-0523, Commutation setting measured value". The value for P-0-0523 is determined by distance measurement and geometric motor data (see separate motor documentation for "Rexroth IndraDyn L").

After the determined value was entered in parameter P-0-0523, the command parameter "P-0-0524, C1200 Commutation offset setting command" has to be



activated. The controller now calculates the value of the required commutation offset which is displayed in p"P-0-0521, Effective commutation offset".

## Notes on Commissioning

<b>Requirements</b>	<p>When using a hall sensor box or the measuring method, the following settings must be made in "P-0-0522, Control word for commutation setting" for initial commissioning:</p> <ul style="list-style-type: none"> <li>• Method for Determining the Commutation Offset → "Without Current"</li> <li>• Initial Commissioning Mode → "Active"</li> </ul> <p>The drive must be in status "A0013 Ready for power on" ("bb").</p>
<b>Using the Hall Sensor Box SHL</b>	<p>When using the Hall sensor box SHL, carry out the following steps for commissioning:</p> <ol style="list-style-type: none"> <li>1. Determine value for "P-0-0508, Commutation offset" according to documentation on hall sensor box SHL01.1 and enter it in parameter "P-0-0521, Effective commutation offset". <ul style="list-style-type: none"> <li><b>Note:</b> It is recommended that you optimize the determined commutation offset value. This can be done automatically by activating "C5600 Command subsequent optimization of commutation offset", if the sine-wave method is possible without restrictions for this axis. Otherwise, the commutation offset value should be manually optimized (see section "Basics on Commutation Setting").</li> </ul> </li> <li>2. Then reset command C5600 and set initial commissioning mode to "inactive" gain in P-0-0522.</li> </ol>
<b>Measuring Method with Absolute Motor Encoder</b>	<p>For the measuring method with absolute motor encoder, carry out the following steps for commissioning:</p> <ol style="list-style-type: none"> <li>1. Enter value for relative position of primary part compared to secondary part in "P-0-0523, Commutation setting measured value" (for how to determine this value see separate motor documentation "Rexroth Indra-Dyn L"). <ul style="list-style-type: none"> <li><b>Note:</b> The position of the primary part or the slide mustn't change any more after the required distance measurements!</li> </ul> </li> <li>2. Activate the command parameter "P-0-0524, C1200 Commutation offset setting command"</li> <li>3. The controller enters the value determined for the commutation offset in "P-0-0521, Effective commutation offset" and "p-0-0508, Commutation offset" and "P-0-3008, Commutation offset, encoder memory" apply this value. <ul style="list-style-type: none"> <li><b>Note:</b> It is recommended that you optimize the determined commutation offset value. This can be done automatically by activating "C5600 Command subsequent optimization of commutation offset", if the sine-wave method is possible without restrictions for this axis. Otherwise, the commutation offset value should be manually optimized (see section "Basics on Commutation Setting").</li> </ul> </li> <li>4. Then reset command C5600 and set initial commissioning mode to "inactive" gain in P-0-0522.</li> </ol>

### 6.5.3 Saturation Method

#### Brief Description

For rotary synchronous Rexroth kit motors, IndraDrive controllers only provide methods with current to determine the commutation offset. The saturation

## Drive Control

method is one of these methods; when it is used, "motor standstill is necessary". A possibly available holding brake should remain applied!



For synchronous Rexroth motors with integrated motor encoder (MSK, MHD, MKD, MKE motors), it is not necessary to set the commutation offset! The correct value is provided in the motor encoder data memory and is automatically activated.

The saturation method can also be used for linear synchronous Rexroth kit motors, if they have only been equipped with a relative measuring system (without Hall sensor box SHL), and for motors with an absolute measuring system for which distance measurement at the axis is impossible due to the mounting.

As a prerequisite for successful application of the saturation method, the iron material of the motor must be magnetically saturated when current is supplied, i.e. the controller must be able to provide sufficiently high current to the motor. For synchronous motors which are not magnetically saturated at maximum allowed current, this method is unsuited for determining the commutation offset!



If the saturation method cannot be used, the controller provides the sine-wave method (works with current, too) for determining the commutation offset.

When the requirements have been fulfilled, the saturation method can be used both for initial commissioning and for recommissioning.



The restrictions to be observed when using the saturation method are described in the section "Basics on Commutation Setting". This section outlines the different methods which can be used for determining the commutation offset.

## Functional Description

### Application-Related Aspect

The saturation method for determining the commutation offset can be used for all types of synchronous motors. It provides the advantage that distance measurement is not required. Stator and rotor of the motor can be inaccessibly installed in the machine. In the case of the saturation method, the commutation offset is determined with current supplied. The controller sets drive enable automatically for the duration of the measurement.

### Method

By a test signal the voltage and frequency of which requires motor-specific values ("P-0-0506, Amplitude for angle acquisition", "P-0-0507, Test frequency for angle acquisition"), the controller determines the commutation offset of the synchronous motor. It is therefore necessary that the generated test current causes magnetic saturation effects in the motor.

The motor-specific setting of voltage and frequency of the test current is carried out automatically when the value "0" has been entered in P-0-0506 at the start of "P-0-0524, C1200 Commutation offset setting command". The detected motor-specific value for P-0-0506 is stored and used for commutation setting for further operations.



If the test current does not cause any magnetic saturation effect in the motor, the command C1200 can only be used for commutation setting with restrictions.

→ If the maximum current of the controller is not sufficient to cause magnetic saturation in the motor (e.g. in the case of command error C1218), use a controller with higher type current!

→ If the generated test current is too low in spite of sufficient controller type current (e.g. in the case of command error C1218), measures as described in the Troubleshooting Guide for "C1218 Automatic commutation: Current too low" should be taken!

Should it be impossible to determine a commutation angle in spite of these measures (e.g. command error C1221), the saturation method cannot be used for commutation setting!

## Notes on Commissioning

### Saturation Method for Synchronous Motors with Absolute Measuring System

In the case of synchronous kit motors with absolute measuring system, the saturation method is **only started by a command at the initial commissioning** and the determined commutation offset value is stored in the controller or in the encoder data memory. In addition, the value can be manually or automatically optimized during initial commissioning.

#### Sequence of the Saturation Method

#### Sequence of the saturation method for synchronous motors with absolute measuring system:

1. In "P-0-0522, Control word for commutation setting" activate:
  - Initial commissioning mode
  - and -
  - Saturation method
2. Make presettings for automatic determination of motor-specific parameter values (P-0-0506, P-0-0507) of test signal required for determining the commutation offset:
  - Enter value "0" in "P-0-0506, Amplitude for angle acquisition"
3. Switch drive to operating mode ("AB"); start saturation method by "P-0-0524, C1200 Commutation offset setting command"
4. After current was supplied and commutation offset value has been successfully determined, this value, due to initial commissioning mode, is simultaneously stored in the following parameters in the case of absolute measuring systems:
  - P-0-0508, Commutation offset
  - P-0-0521, Effective commutation offset
  - P-0-3008, Commutation offset, encoder memory(falls vorhanden)

The execution of the command is now completed, it can be reset. The drive now is operational.

**Note:** It is recommended that you optimize the determined commutation offset value. This can be done automatically by activating "C5600 Command subsequent optimization of commutation offset", if the sine-wave method is possible without restrictions for this axis. Otherwise, the commutation offset value should be manually optimized (see section "Basics on Commutation Setting").

## Drive Control

5. In "P-0-0522, Control word for commutation setting" deactivate the initial commissioning mode by the respective bit. The value in "P-0-0508, Commutation offset" or "P-0-3008, Commutation offset, encoder memory" is now write-protected.

Each time the drive is switched on again or the measuring system is initialized, the value stored in "P-0-0508, Commutation offset" resp. "P-0-3008, Commutation offset, encoder memory" is applied to "P-0-0521, Effective commutation offset" and becomes effective as the value for commutation offset.

### Saturation Method for Synchronous Motors with Incremental Measuring System

In the case of synchronous kit motors with incremental measuring system, the saturation method is automatically started when setting drive enable after the drive is switched on or after every initialization of the measuring system. The drive is operational only after the commutation offset has been successfully determined!



The force development of the motor is guaranteed in a reproducible way when, at the homing of the axis, the optimized commutation offset value stored during initial commissioning becomes effective ("optimum commutation offset with regard to reference point")!

#### Sequence of the Saturation Method

#### Sequence of the saturation method for initial commissioning of synchronous motors with incremental measuring system:

1. In "P-0-0522, Control word for commutation setting" activate:
  - Initial commissioning mode
  - and -
  - Saturation method
2. Make presettings for automatic determination of motor-specific parameter values (P-0-0506, P-0-0507) of test signal required for determining the commutation offset:
  - Enter value "0" in "P-0-0506, Amplitude for angle acquisition"
3. Switch drive to operating mode ("AB"); start saturation method by "P-0-0524, C1200 Commutation offset setting command"
4. After the current was supplied and the commutation offset value has been successfully determined, this value is contained in "P-0-0521, Effective commutation offset". The drive now is operational. In addition, the motor-specific values for P-0-0506 and P-0-0507 were stored.

**Recommendation:** Optimize the commutation offset! This can be done automatically by activating "C5600 Command subsequent optimization of commutation offset", if the sine-wave method is possible without restrictions for this axis. Otherwise, the commutation offset value should be manually optimized (see section "Basics on Commutation Setting").

5. Now switch drive to parameter mode (P2). After switching back to operating mode, set "AF" and test function of drive. This automatically starts determination of commutation offset with stored parameters (P-0-0506, P-0-0507, P-0-0517). Motor is supplied with current and commutation offset determined again.

Test commutation behavior of drive at several different motor or axis positions. If it is not satisfying (deviations from P-0-0521 greater than +/- 30 or "F8078 Speed loop error" at command value input), increase the value

- of "P-0-0517, Commutation: required harmonics component" until there are only minor deviations from P-0-0521 and the function is reliable!
6. After the force or torque development of the motor required for the axis was confirmed in the test, start "S-0-0148, C0600 Drive-controlled homing procedure command". By this command, due to the active initial commissioning mode, the value of P-0-0521 referring to an arbitrary position is converted to the position of the reference point and stored in "P-0-0508, Commutation offset" and "P-0-3008, Commutation offset, encoder memory" (if available).
  7. In "P-0-0522, Control word for commutation setting" deactivate the initial commissioning mode via the respective bit! Value in P-0-0508 resp. P-0-3008 is now read-only.

**Recommissioning** of synchronous motors after initial commissioning took place is the same for the methods with current. For detailed information see section "Basics on Commutation Setting".



"Optimum commutation setting with regard to reference point" is generally recommended for relative measuring systems!

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## 6.5.4 Sine-Wave Method

### Brief Description

For synchronous motors, IndraDrive controllers, in addition to the saturation method, provide the sine-wave method, also with current, to determine the commutation offset. When this method is used, "unrestricted movement of axis is required". The axis must be able to move easily and freely!

Before using the sine-wave method, carefully check whether it is possible to use the saturation method, because unrestricted movement of the axis generally causes problems. For the saturation method movement of axis is not necessary, it should be blocked, if possible.

When the requirements have been fulfilled, the sine-wave method is suited to only a limited extent for initial commissioning and for recommissioning.



The restrictions to be observed when using the sine method are described in the "Basics on Commutation Setting". This section outlines the different methods which can be used for determining the commutation offset.

---

### Functional Description

#### Application-Related Aspect

The sine-wave method for determining the commutation offset can be used for all types of synchronous motors. However, it should only be used if the saturation method cannot be used for determining the commutation offset.

The disadvantage of the sine-wave method is that the motor has to be put into motion by supplying current. Limitations of the motivity (e.g. friction or blocking) can reduce the quality of offset determination or even cause offset determination to fail!



Observe the restrictions for the sine-wave method (see table "Typical applications and restrictions for sine-wave method" in section "Basics on Commutation Setting")!

---

#### Method

By a test signal the voltage and frequency of which requires motor-specific settings ("P-0-0506, Amplitude for angle acquisition", "P-0-0507, Test frequency

## Drive Control

for angle acquisition"), the controller determines the commutation offset of the synchronous motor. It is therefore necessary that the generated test current puts the motor into motion.



The maximum motion range for the sine-wave method is +/- 45mech/PPN for rotary motors and 1/2 pole pare distance for linear motors.

The motor-specific setting of voltage and frequency of the test current is carried out automatically when the value "0" has been entered in "P-0-0524, C1200 Commutation offset setting command". The detected motor-specific values for P-0-0506 and P-0-0507 are stored and used for commutation setting for further operations.

## Notes on Commissioning

### Sine-Wave Method for Synchronous Motors with Absolute Measuring System

In the case of synchronous kit motors with absolute measuring system, the sine-wave method is **only started by a command at the initial commissioning** and the determined commutation offset value is stored in the controller or in the encoder data memory. In addition, the value can be manually or automatically optimized during initial commissioning.

#### Sequence of Sine-Wave Method

#### Sequence of the sine-wave method for synchronous motors with absolute measuring system:

1. In "P-0-0522, Control word for commutation setting" activate:
  - Initial commissioning mode
  - and -
  - Sine-Wave Method
2. Make presetting for automatic determination of motor-specific parameter values (P-0-0506, P-0-0507) of the test signal required for determining the commutation offset:
  - Enter value "0" in "P-0-0506, Amplitude for angle acquisition"
3. Switch drive to operating mode ("AB"); start sine method by "P-0-0524, C1200 Commutation offset setting command"
4. After current was supplied and commutation offset value has been successfully determined, this value, due to initial commissioning mode, is simultaneously stored in the following parameters in the case of absolute measuring systems:
  - P-0-0508, Commutation offset
  - P-0-0521, Effective commutation offset
  - P-0-3008, Commutation offset, encoder memory(if available)

The execution of the command is now completed, it can be reset. The drive now is operational.

**Note:** It is recommended that you optimize the determined commutation offset value. This can be done automatically by activating "C5600 Command subsequent optimization of commutation offset" (see section "Basics on Commutation Setting").

5. In "P-0-0522, Control word for commutation setting" deactivate the initial commissioning mode by the respective bit. The value in P-0-0508 resp. P-0-3008 is now write-protected.

Each time the drive is switched on again or the measuring system is initialized the value stored in the parameters P-0-0508 resp. P-0-3008 is applied to P-0-0521 and becomes effective as the commutation offset value.

### Sine-Wave Method for Synchronous Motors with Incremental Measuring System

For synchronous kit motors with incremental measuring system the sine-wave method is automatically started when drive enable is set after the drive was switched on or after changing from communication phase "P2" to "P4" ("bb" or "Ab"). The drive is operational only after the commutation offset has been successfully determined!



The force development of the motor is only guaranteed in a reproducible way when, at the homing of the axis, the value stored during initial commissioning with relation to the reference point becomes effective as commutation offset!

#### Sequence of Sine-Wave Method

#### Sequence of the sine-wave method for initial commissioning of synchronous motors with incremental measuring system:

1. In "P-0-0522, Control word for commutation setting" in communication phase "P2" (parameter mode) activate:
  - Initial commissioning mode
  - and -
  - Sine-Wave Method
2. Make presetting for automatic determination of motor-specific parameter values (P-0-0506, P-0-0507) of the test signal required for determining the commutation offset:
  - Enter value "0" in "P-0-0506, Amplitude for angle acquisition"
3. Switch drive to operating mode ("AB"); start sine method by "P-0-0524, C1200 Commutation offset setting command".
4. After the current was supplied and the commutation offset value has been successfully determined this value is contained in "P-0-0521, Effective commutation offset". The drive now is operational. In addition, the motor-specific values for P-0-0506 and P-0-0507 were stored.

**Note:** If the drive does not find any valid value for P-0-0521 and aborts the execution of the command with an error message, modified settings with regard to the search mode can lead to success:

- If the mechanical axis system shows distinctive friction, the settings for the search direction in P-0-0522 should be made for "increase of amplitude with priority".
- If the mechanical axis system shows resonances in the search range of P-0-0507 and develops heavy noise when the amplitude is increased, the settings for the search direction in P-0-0522 should be made for "increase of frequency with priority".

**Recommendation:** It is recommended that you optimize the determined commutation offset value. This can be done automatically by activating "C5600 Command subsequent optimization of commutation offset" (see section "Basics on Commutation Setting").

5. Now start "S-0-0148, C0600 Drive-controlled homing procedure command". By this command, due to the active initial commissioning mode, the value of P-0-0521 referring to an arbitrary position is converted to the position of the reference point and stored in "P-0-0508,

## Drive Control

Commutation offset" and "P-0-3008, Commutation offset, encoder memory" (if available).

6. In P-0-0522, Control word for commutation setting deactivate the initial commissioning mode by the respective bit! The value in P-0-0508 resp. P-0-3008 is now write-protected.

**Recommissioning** of synchronous motors after initial commissioning took place is the same for the methods with current. For detailed information see the "Basics on Commutation Setting" .



"Optimum commutation setting with regard to reference point" is generally recommended for relative measuring systems!

## 6.6 Limitations

### 6.6.1 Overview of Limitations

To protect the mechanical axis system, the controllers and the motors against overload, IndraDrive devices have different possibilities of limitation:

- Torque/Force Limitation
  - Axis-side torque/force limit values, depending on the preceding sign
  - Axis-side torque/force limit values, related to the absolute value (independent of the preceding sign)
- Current limitation
  - Absolute current limit values, depending on controller or motor
  - Dynamic current limitation, depending on the thermal load of controller or motor
- Velocity limitation
  - Motor-side velocity limit values
  - Axis-side velocity limit values
- Position limitation
  - Evaluation of axis-side travel range limit switches
  - Firmware-side travel range limit values

The existing limiting facilities are active depending on the method of motor control.

#### Voltage-Controlled Open-Loop Operation (U/f Control)

With voltage-controlled, sensorless operation, the following limitations are available to protect the device or motor:

- Torque/force limitation via stall protection loop
- Current limitation via current limitation loop
- Position limitation by
  - Travel range limit switches
  - Software limit switches

#### Closed-Loop Operation of Motors (FXC, FOC, FOCsl)

In closed-loop operation (flux-controlled or current-controlled), there are the following parameterizable limitations to protect the device or motor:

- Torque/force limitation
- Current limitation
- Velocity limitation
- Position limitation by



- Travel range limit switches
- Software limit switches

## 6.6.2 Current and Torque/Force Limitation

### Brief Description

Current limitation and torque/force limitation avoid mechanical overload of the axis and thermal overload of motor and controller.

Torque/force limit values due to axis conditions and processing take effect statically as positive and negative limits of the torque/force command value. The thermal overload protection might possibly reduce these limits dynamically, depending on the current thermal load of motor and controller.

- Features**
- User-side limit values for torque/force (drive-internally converted to current limit values):
    - Bipolar limit values (S-0-0092, P-0-0109)
    - Unipolar limit values (S-0-0082, S-0-0083)
  - Display of current torque/force command value in "P-0-0049, Effective torque/force command value"
  - Display of process torque resp. process force in "S-0-0084, Torque/force feedback value"
  - Absolute current limit values on the drive-side in "S-0-0110, Amplifier peak current" and "S-0-0109, Motor peak current"
  - Dynamic current limitation depending on work load reduces maximum current to the thermally allowed continuous current on the basis of motor and amplifier temperature model (depending on motor type and possibly selected cooling type, as well as on PWM frequency and amplifier type); currently available maximum current and thermally possible continuous current displayed in the parameters:
    - P-0-4045, Maximum possible continuous current
    - P-0-4046, Effective peak current
  - Resulting torque/force limit values from the user-side torque/force limitations and the (dynamic) current limitation depending on work load are displayed in the parameters:
    - P-0-0442, Actual value torque limit positive (stationary)
    - P-0-0443, Actual value torque limit negative (stationary)
    - P-0-0444, Actual value peak torque limit
  - Status word for analysis of the currently active torque/current limitation (P-0-0445)
  - Display of effective torque-generating current command value ("limited" current command value) in parameter
    - P-0-0038, Torque-generating current, command value
  - Display of actual current values in the parameters
    - P-0-0440, Actual output current value (absolute value)
    - P-0-0043, Torque-generating current, actual value
    - P-0-0044, Flux-generating current, actual value
- Pertinent Parameters**
- S-0-0082, Torque/force limit value positive
  - S-0-0083, Torque/force limit value negative
  - S-0-0092, Bipolar torque/force limit value

## Drive Control

- S-0-0109, Motor peak current
- S-0-0110, Amplifier peak current
- S-0-0111, Motor current at standstill
- S-0-0112, Amplifier nominal current
- S-0-0384, Amplifier temperature
- P-0-0001, Switching frequency of the power output stage
- P-0-0038, Torque-generating current, command value
- P-0-0049, Effective torque/force command value
- P-0-0051, Torque/force constant
- P-0-0109, Torque/force peak limit
- P-0-0141, Thermal drive load
- P-0-0440, Actual output current value (absolute value)
- P-0-0441, Overload warning
- P-0-0442, Actual value torque limit positive (stationary)
- P-0-0443, Actual value torque limit negative (stationary)
- P-0-0444, Actual value peak torque limit
- P-0-0445, Status word torque/current limit
- P-0-0556, Config word of axis controller
- P-0-0640, Cooling type
- P-0-4034, Thermal time constant of winding
- P-0-4035, Thermal time constant of motor
- P-0-4037, Thermal short-time overload of winding
- P-0-4045, Maximum possible continuous current
- P-0-4046, Effective peak current
- P-0-4058, Amplifier type data
- P-0-4059, Electric type data of power section

### Pertinent Diagnostic Messages

- E2050 Device overtemp. Prewarning
- E2051 Motor overtemp. prewarning
- E2056 Torque limit = 0
- E2061 Device overload prewarning
- E8055 Motor overload, current limit active
- E8057 Device overload, current limit active
- F2018 Device overtemperature shutdown
- F2019 Motor overtemperature shutdown
- F2021 Motor temperature monitor defective
- F2022 Device temperature monitor defective

## Torque/Force Limitation

The torque/force limit can be freely parameterized by the user and provides bipolar and unipolar limits.

Parameters for bipolar limits:

- S-0-0092, Bipolar torque/force limit value
- P-0-0109, Torque/force peak limit

Parameters for unipolar limits:

- S-0-0082, Torque/force limit value positive
- S-0-0083, Torque/force limit value negative



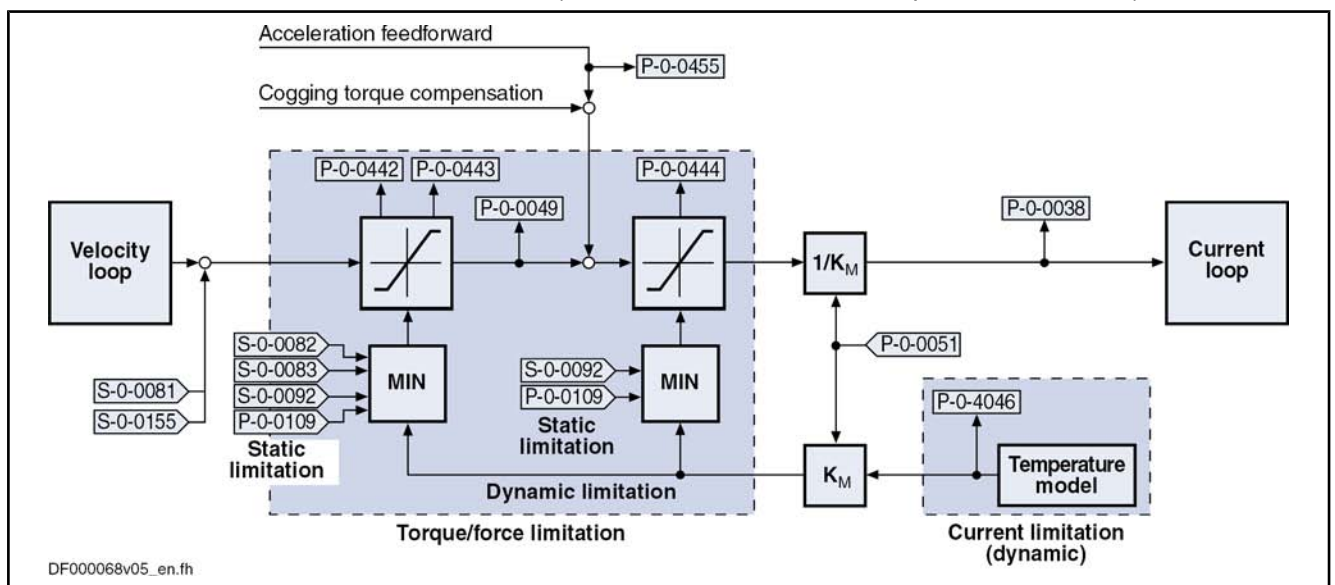
It is always the lowest value of the torque/force limit values entered in the parameters S-0-0082, S-0-0083, S-0-0092 or P-0-0109 that takes effect!

Depending on the method of motor control, the torque/force limitation influences the control of the motor in different ways.

**Motor Control Methods**  
FOC, FOCsl, FXC

In closed-loop motor operation, the unipolar torque limitation takes effect on the torque command value output by the velocity loop. The bipolar torque/force limitation takes effect on the value limited in unipolar form, including possibly added feedforward values.

In addition to the user-side static limit values, the current limitation takes effect dynamically, via "P-0-4046, Effective peak current" on the resulting torque/force limit values (converted via "P-0-0051, Torque/force constant").



- |          |   |
|----------|---|
| S-0-0081 | Additive torque/force command value             |
| S-0-0082 | Torque/force limit value positive               |
| S-0-0083 | Torque/force limit value negative               |
| S-0-0092 | Bipolar torque/force limit value                |
| S-0-0155 | Friction compensation                           |
| P-0-0038 | Torque-generating current, command value        |
| P-0-0049 | Effective torque/force command value            |
| P-0-0051 | Torque/force constant                           |
| P-0-0109 | Torque/force peak limit                         |
| P-0-0442 | Actual value torque limit positive (stationary) |
| P-0-0443 | Actual value torque limit negative (stationary) |
| P-0-0444 | Actual value peak torque limit                  |
| P-0-0455 | Acceleration feedforward actual value           |
| P-0-4046 | Effective peak current                          |

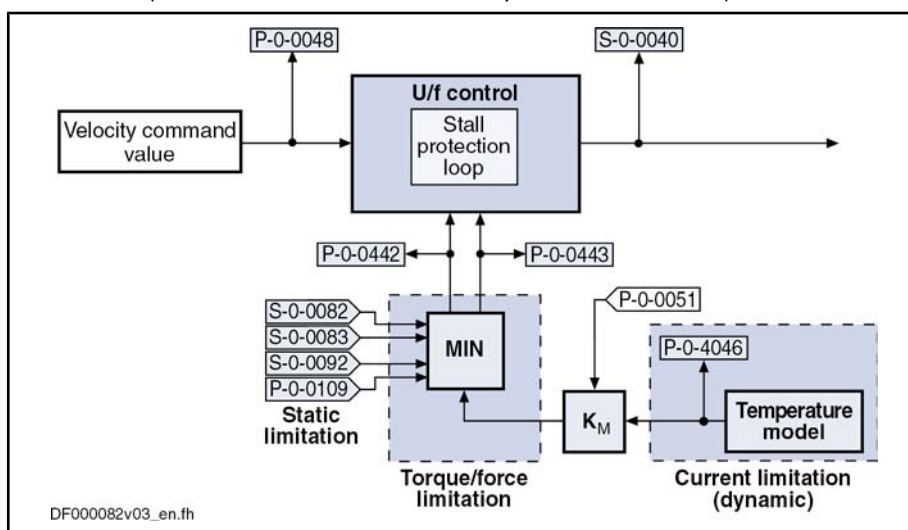
Fig. 6-96: Torque/Force Limitation With the Motor Control Methods FOC, FOCsl and FXC

**U/f Control**

In voltage-controlled, sensorless motor operation (U/f), the torque limitation only takes effect on the stall protection loop. The static negative and positive torque limit values are generated from the lowest values of the torque/force limit values entered in S-0-0082, S-0-0083, S-0-0092 or P-0-0109.

## Drive Control

In addition to the user-side static limit values, the current limitation takes effect dynamically, via "P-0-4046, Effective peak current" on the resulting torque/force limit values (converted via "P-0-0051, Torque/force constant").



S-0-0040	Velocity feedback value
P-0-0048	Effective velocity command value
P-0-0051	Torque/force constant
P-0-0442	Actual value torque limit positive (stationary)
P-0-0443	Actual value torque limit negative (stationary)
P-0-4046	Effective peak current

Fig.6-97: Torque/Force Limitation in Sensorless U/f Operation of the Motor

## Current Limitation

## Principles of Current Limitation



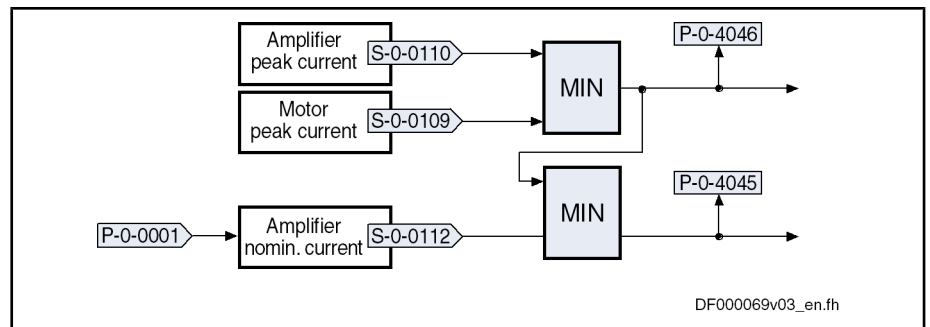
The current limitation cannot be parameterized by the user; it takes effect automatically and protects the motor and the amplifier against inadmissible load.

We basically distinguish the following principles of current limitation:

- **Absolute current limitation** (depending on maximum possible peak currents and continuous currents of motor and drive controller)
- **Dynamic peak current limitation** (depending on work load, realized by motor and amplifier temperature models)

## Absolute Current Limitation

The figure below illustrates the generation of the maximum values for continuous current and peak current from the motor- and controller-specific current data (without thermal load of motor and controller).



S-0-0110	Amplifier peak current
S-0-0109	Motor peak current
S-0-0112	Amplifier nominal current
P-0-0001	Switching frequency of the power output stage
P-0-4045	Maximum possible continuous current
P-0-4046	Effective peak current

Fig. 6-98: Generating the Maximum Values for Continuous Current and Peak Current

#### Maximum Possible Continuous Current (P-0-4045)

The maximum possible continuous current (P-0-4045) is the minimum value from the maximum allowed continuous current of the controller (S-0-0112, Amplifier nominal current) and the effective peak current (P-0-4046, Effective peak current).

The nominal current of the amplifier (S-0-0112, Amplifier nominal current) basically depends on the switching frequency of the power section (P-0-0001). With a setting of 12 kHz or 16 kHz in "P-0-0001, Switching frequency of the power output stage", the currently effective switching frequency can be reduced depending on the work load. This increases the allowed continuous current compared to the value at a higher switching frequency (see below "Continuous Current of Controller Depending on Work Load at PWM of 12 kHz or 16 kHz"). However, this increase in continuous current, as well as the reduction of the continuous current at motor standstill, are not displayed in "P-0-4045, Maximum possible continuous current".

#### Effective Peak Current (P-0-4046)

The output current of the controller is dynamically limited, depending on the thermal load of the motor or controller. The current limit value is displayed in "P-0-4046, Effective peak current". The maximum value results from the minimum of the values of "S-0-0109, Motor peak current" and "S-0-0110, Amplifier peak current".

### Dynamic Current Limitation

With dynamic current limitation, the thermal load of controller and motor is determined by means of temperature model calculation, depending on the value in "P-0-0440, Actual output current value (absolute value)" and the duration of effectiveness of this current. Due to the current load, the maximum possible amplifier current or motor current can be limited to the continuously possible current (continuous current):

- **Limitation of amplifier current**

It is used to protect the drive controller against overload. The firmware-side temperature model calculation takes place on the basis of the amplifier type data determined by the hardware.

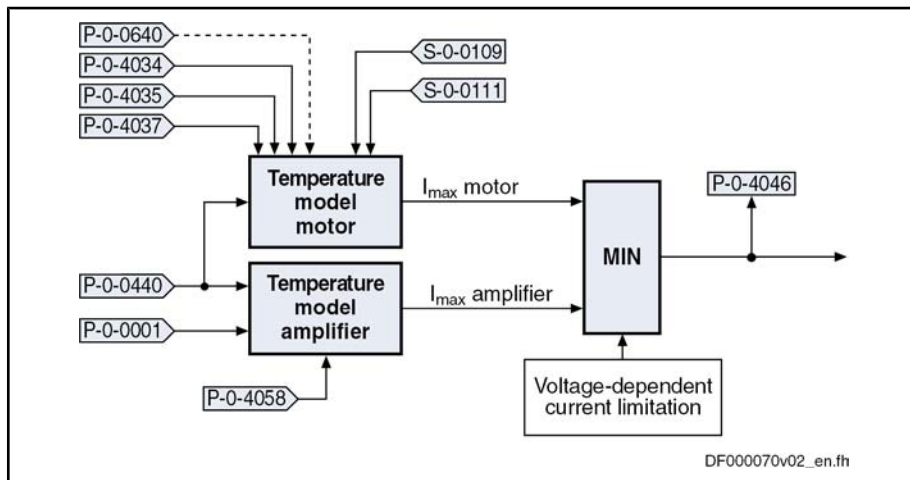
**Note:** The amplifier type data are determined at the factory and stored in "P-0-4058, Amplifier type data" on the power section.

- **Limitation of motor current**

Drive Control

It is used for overload protection of the motor with peak load and short-time overload operation. The firmware-side temperature model calculation takes place on the basis of motor-specific temperature model data.

**Note:** In addition, the temperature sensor of the motor might possibly support thermal overload protection (continuous current, rms current).



- S-0-0109 Motor peak current
- S-0-0111 Motor current at standstill
- P-0-0001 Switching frequency of the power output stage
- P-0-0440 Actual output current value (absolute value)
- P-0-0640 Cooling type
- P-0-4034 Thermal time constant of winding
- P-0-4035 Thermal time constant of motor
- P-0-4037 Thermal short-time overload of winding
- P-0-4046 Effective peak current
- P-0-4058 Amplifier type data

Fig.6-99: Generating the Dynamic Peak Current Limit Value (Temperature Model)

**Properties**

Basic properties of dynamic current limitation:

- The value taking effect is always the lowest value resulting from motor current or amplifier current limitation.
- The currently maximum possible continuous current is displayed in P-0-4045, the effective peak current in P-0-4046.

Depending on the method of motor control, the current limitation influences the control of the motor in different ways.

**Motor Control Methods**  
FOC, FOCsl, FXC

In closed-loop motor operation, the current limitation, via the value of parameter "P-0-4046, Effective peak current", possibly takes a reducing effect on the user-side, static torque/force limit values. The dynamic torque/force limit value resulting from the value of P-0-4046 is determined via "P-0-0051, Torque/force constant".

The current (limited) torque/force command value is displayed in P-0-0049, the corresponding torque-generating command current in parameter P-0-0038.

**U/f Control**

In voltage-controlled, sensorless motor operation (U/f), the current limitation takes effect on the current limitation loop and the stall protection loop:

- For the **current limitation loop**, the effective peak current (P-0-4046) is the limit value to which the actual output current value (P-0-0440) is limited by reducing the motor voltage by means of a control process.
- For the **stall protection loop**, the current limitation, in addition to the user-side static limit values, takes effect dynamically via the effective peak

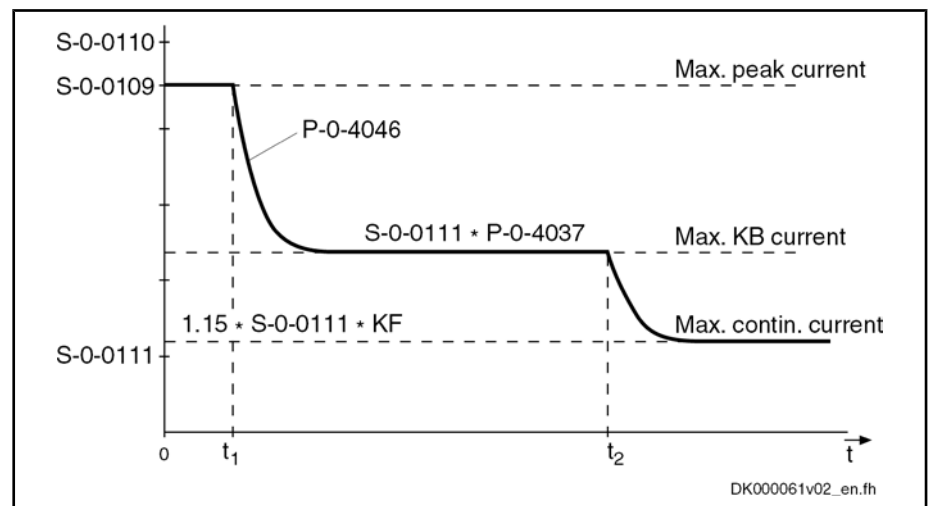
current (P-0-4046) on the resulting positive and negative torque/force limit values (P-0-0442, P-0-0443) (converted via "P-0-0051, Torque/force constant").



The static negative and positive torque limit values are generated from the lowest values of the torque/force limit values entered in S-0-0082, S-0-0083, S-0-0092 or P-0-0109.

### Motor Temperature Model

The value "P-0-4046, Effective peak current" is only generated by the motor temperature model, if the controller has been sufficiently dimensioned compared to the motor. When the motor has not been thermally preloaded, the following curve results at full motor load:



S-0-0109	Motor peak current
S-0-0110	Amplifier peak current
S-0-0111	Motor current at standstill
P-0-4037	Thermal short-time overload of winding
P-0-4046	Effective peak current
$t_1$	Max. duration after which the motor temperature model reduces to the max. KB current
$t_2$	Max. duration after which the motor temperature model reduces to the max. continuous current
KB	Short-time operation (KB = "Kurzzeitbetrieb")
KF	Cooling type factor (see note below)

Fig. 6-100: Curve of Effective Peak Current (P-0-4046) at Full Motor Load, Generated by Motor Temperature Model

Depending on the load current of the motor, the times  $t_1$  or  $t_2$  can be determined. They apply to motors which have not been thermally loaded and therefore are theoretical maximum values. In motor operation,  $t_1$  and  $t_2$  depend on the following factors:

- Motor-controller combination
- Thermal preload of drive
- Load cycle

The time  $t_1$  applies to load currents greater than, the time  $t_2$  to load currents smaller than the maximum allowed short-time operation current. The values are determined according to the following formula:

## Drive Control

$$t_1 = -\ln \left[ 1 - \left( \frac{(P-0-4037) \times (S-0-0111)}{I_{L1}} \right)^2 \right] \times (P-0-4034)$$

$$t_2 = -\ln \left[ 1 - \left( \frac{1,15 \times KF \times (S-0-0111)}{I_{L2}} \right)^2 \right] \times \frac{(P-0-4035)}{KF}$$

$t_1$	Max. duration after which the motor temperature model reduces to the max. KB current
$t_2$	Max. duration after which the motor temperature model reduces to the max. continuous current
$I_{L1}$	Assumed load current (> max. KB current)
$I_{L2}$	Assumed load current (max. continuous current < $I_{L2}$ < max. KB current)
S-0-0111	Motor current at standstill
P-0-4034	Thermal time constant of winding
P-0-4035	Thermal time constant of motor
P-0-4037	Thermal short-time overload of winding
KF	Cooling type factor (see note below)
<i>Fig.6-101:</i>	<i>Calculating the Time for the Effective Peak Current (at Starting Condition "Motor has not Been Thermally Loaded")</i>



The **cooling type factor** depends on the cooling type and the resulting setting of "P-0-0640, Cooling type" (see also Parameter Description):

- 1.0 → For Standard Cooling (MAD, MAF, MBT, MBS, MLF) and for non-Ventilated Motors MHD, MSK, MKD, MKE
- 1.5 → For ventilation (only MHD, MSK, MKD, MKE)
- 1.9 → For liquid cooling (only MHD, MSK, MKD, MKE)

**Amplifier Temperature Model**

In addition to the motor temperature model, the value of "P-0-4046, Effective peak current" is limited by the amplifier temperature model. The variables of the model calculation are:

- Chronological sequence of "P-0-0440, Actual output current value (absolute value)"
- P-0-4058, Amplifier type data
- P-0-0001, Switching frequency of the power output stage
- Output frequency of the motor voltage

The value of "S-0-0112, Amplifier nominal current" (maximum continuous current of the controller) depends on the setting in "P-0-0001, Switching frequency of the power output stage". At motor standstill (below an output frequency threshold), however, the allowed continuous current value is reduced, compared to the value of S-0-0112, by the temperature model calculation (dynamic reduction of continuous current at motor standstill). At the corresponding motor load, the value of "P-0-4046, Effective peak current" falls below the value of S-0-0112 (unless the motor is the current-limiting component!).



The current data of the amplifiers (power sections of the IndraDrive controllers) for continuous and cyclic load are contained in the separate documentation "Supply Units and Power Sections; Project Planning Manual".



**Continuous Current of Controller  
Depending on Work Load at PWM  
of 12 kHz or 16 kHz**

The physical data of motor-controller combinations for servo, main drive and S1 print applications can be retrieved via the selection list program "DriveSelect" (Intranet). "DriveSelect" takes the influence of the motor and amplifier temperature models into account!

The continuous current of the controller is reduced as the switching frequency of the power output stage (PWM frequency) is increased. When the value in "P-0-0001, Switching frequency of the power output stage" has been set to 12 kHz or 16 kHz, it is possible, however, to reduce the switching frequency depending on the thermal load of the controller. This reduces the thermal load of the power output stage and increases the allowed continuous current of the controller. The respective setting is made in "P-0-0556, Config word of axis controller". This causes the following behavior:

- If the value of "P-0-0141, Thermal drive load" rises to the value set in "P-0-0441, Overload warning", the switching frequency is internally reduced to 8 kHz. The message "E2061 Device overload prewarning" is generated.
- If the value of "P-0-0141, Thermal drive load" falls below a controller-specific threshold, the value of the switching frequency entered in P-0-0001 takes effect again. The warning "E2061 Device overload prewarning" disappears.



The reduction of the switching frequency depending on the work load only influences the allowed continuous current of the controller. The maximum output current remains at the value belonging to the switching frequency set in P-0-0001! The respective documentation of the power sections contains the current data related to the controller (see "Supply Units and Power Sections; Project Planning Manual").

When the default values for the control loop parameters are loaded ("RL" or command C07\_0), the values of the current loop parameters, which have been stored in the encoder data memories of the motors and relate to the PWM frequency of 4 kHz, are converted to the value set in P-0-0001. When the option "reduction of switching frequency depending on work load" has been activated, conversion to the reduced switching frequency takes place!



In the case of manual optimization of the current loop parameters, select the lower switching frequency (PWM). For this purpose enter the value "0" in "P-0-0441, Overload warning", before optimizing!

**Notes on Commissioning****Current Limitation**

The user cannot parameterize the current limitation, because the limit values are resulting from the amplifier and motor data taken as a basis or the application-specific load cycle.

**Unipolar Torque Limitation**

Bipolar torque/force limits are generally determined to protect the mechanical system, because this allows defining the allowed stress of the mechanical components (e.g. gear, coupling). The limit values to be entered therefore depend on the mechanical axis system.

**Bipolar Torque Limitation**

In certain cases of application, however, the process can require realizing a variable torque limit. This can be done via "S-0-0092, Bipolar torque/force limit value", because this parameter can be cyclically transmitted via the bus or assigned to an analog input.

## Drive Control




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"P-0-0109, Torque/force peak limit" is used to determine the absolute limit and therefore always has to be defined by means of the mechanical limits.

---

## Diagnostic and Status Messages

For diagnostic purposes, the status of all partial limits is mapped to a status word for torque/force limitation and current limitation (see Parameter Description P-0-0445). As soon as a limit value has been reached, the respective bit is set. This allows immediately recognizing the limiting value and identifying limits possibly parameterized incorrectly.

To protect the amplifier or drive controller and motor, monitoring functions have been implemented that can activate, in conjunction with the current and torque limitation, the warnings and error messages listed below.

**Warnings**

General:

- E2056 Torque limit = 0

Device-specific warnings:

- E2050 Device overtemp. Prewarning
- E2061 Device overload prewarning
- E8057 Device overload, current limit active

Motor-specific warnings:

- E2051 Motor overtemp. prewarning
- E8055 Motor overload, current limit active

**Error Messages**

Device-specific error messages:

- F2018 Device overtemperature shutdown
- F2022 Device temperature monitor defective

Motor-specific error messages:

- F2019 Motor overtemperature shutdown
- F2021 Motor temperature monitor defective

## 6.6.3 Velocity Limitation

### Brief Description

A unipolar velocity limitation was implemented in the drive that allows limiting the velocity command value to a positive and negative threshold freely definable and differing with regard to the absolute value.

**Features**

- Unipolar velocity limit values (S-0-0038, S-0-0039)
- Cyclically configurable, bipolar velocity limit value (S-0-0091)

**Pertinent Parameters**

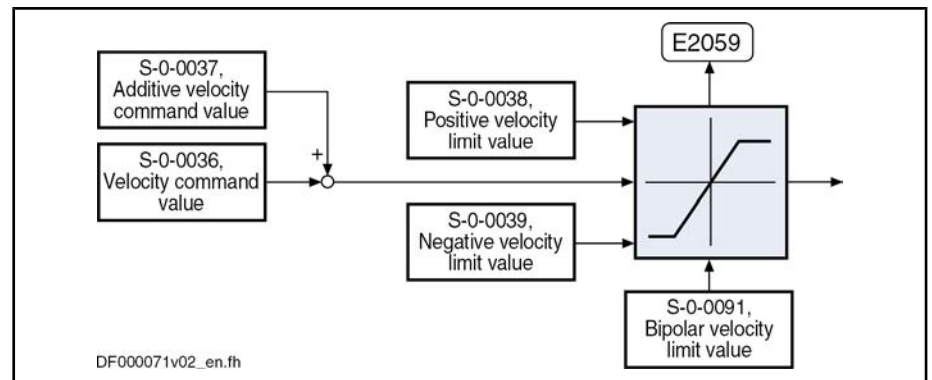
- S-0-0036, Velocity command value
- S-0-0037, Additive velocity command value
- S-0-0038, Positive velocity limit value
- S-0-0039, Negative velocity limit value
- S-0-0091, Bipolar velocity limit value

**Pertinent Diagnostic Messages**

- E2059 Velocity command value limit active
- E2063 Velocity command value > limit value
- F8079 Velocity limit value exceeded

## Functional Description

The figure below illustrates the functional principle of velocity limitation:



E2059 Velocity command value limit active

Fig. 6-102: Functional Principle of Velocity Limitation

## Notes on Commissioning

The **effective limit** for the maximum allowed positive and negative velocities is determined by means of the **minimum values** of the following parameters:

- **Lower (negative) limit** → Resulting from the minimum value of "S-0-0091, Bipolar velocity limit value" and "S-0-0039, Negative velocity limit value"
- **Upper (positive) limit** → Resulting from the minimum value of "S-0-0091, Bipolar velocity limit value" and "S-0-0038, Positive velocity limit value"



The limits have to be adjusted to the mechanical properties! When determining the data, you have to take into account that all velocity command values are thereby limited to this value.

This has to be taken into consideration when defining the travel profiles (target position, velocity and acceleration), because an inadmissible lag error can possibly occur due to the limitation that is taking effect.



The default value for S-0-0038 and S-0-0039 is "0". These two parameters are thereby switched off. In this case, only "S-0-0091, Bipolar velocity limit value" takes effect.

## Diagnostic and Status Messages

- E2059 Velocity command value limit active  
If the resulting velocity command value is within the limit, the "E2059" warning is displayed.
- E2063 Velocity command value > limit value  
"S-0-0036, Velocity command value" is limited to the effective positive and negative velocity limit, when the value in S-0-0036 is higher than this limit. In this case the warning "E2063" is generated.
- F8079 Velocity limit value exceeded  
The value of the parameter "S-0-0040, Velocity feedback value" is monitored, as soon as it is outside the standstill window S-0-0124. When it exceeds the 1.125-fold effective positive or negative velocity limit, the error message "F8079" is generated.

Drive Control

## 6.6.4 Position Limitation/Travel Range Limit Switches

### Brief Description

To avoid accidents and damages to the machine, comprehensive preventive safety precautions are provided. Part of these safety precautions is the limitation of the allowed working range (travel range) by the drive. For this purpose, position monitoring functions and position limitations have been implemented in the drive.



**CAUTION**

**The travel range monitoring function (travel range limit switches or software limit switches) only fulfills the requirements for protecting machinery, but is not sufficient for personal protection!**

#### Realizing Travel Range Monitoring

The drive provides two possibilities of determining and monitoring a limitation of the working range (travel range):

- Monitoring of **position limit values (software limit switches)**  
Monitoring of the motor position for exceeding one of the two position limit values (positive/negative → S-0-0049/S-0-0050) by the homed actual position value (S-0-0403), i.e. value related to the machine zero point.
- Monitoring of **travel range limit switches**  
Monitoring for activation of one of the two travel range limit switches (Limit +, Limit-) that are connected to the digital inputs of the drive.



The functionality of the travel range limit switches is only guaranteed, if the corresponding digital inputs have been configured for this purpose!

See "Digital Inputs/Outputs"

#### Features of Travel Range Limit Switch

- 2 travel range limit switches (Limit+, Limit-) can be monitored at the drive
- Signal behavior of travel range limit switches (N/C and N/O) can be set
- Travel range limit switches activated via parameter
- Reaction (error/warning) when exceeding travel range can be set
- Status display of travel range limit switches
- Command values monitored for validity when limit switch activated
- Travel range limit switches evaluated and position limit value monitor activated in 2 ms clock

#### Features of Position Limit Values

- 2 position limit values ("software limit switch") that can be parameterized; only operational when axis has been homed
- Reaction (error/warning) when exceeding position limit values can be set
- Position limit values activated via parameter
- Automatic reference to measuring system that has been homed
- Command values monitored for validity when position limit values exceeded

#### Pertinent Parameters

- S-0-0012, Class 2 diagnostics
- S-0-0049, Positive position limit value
- S-0-0050, Negative position limit value
- S-0-0055, Position polarities

- S-0-0147, Homing parameter
  - S-0-0403, Position feedback value status
  - P-0-0090, Travel range limit parameter
  - P-0-0222, Travel range limit switch inputs
- Pertinent Diagnostic Messages**
- E2053 Target position out of travel range
  - E8029 Positive position limit exceeded
  - E8030 Negative position limit exceeded
  - E8042 Both travel range limit switches activated
  - E8043 Positive travel range limit switch activated
  - E8044 Negative travel range limit switch activated
  - F6029 Positive position limit exceeded
  - F6030 Negative position limit exceeded
  - F6042 Both travel range limit switches activated
  - F6043 Positive travel range limit switch activated
  - F6044 Negative travel range limit switch activated

## Travel Range Limit Switches

At the drive, it is possible to connect and monitor 2 travel range limit switches (Limit+, Limit-) that can be connected to the digital inputs on the control section.



The travel range limit switch inputs are polled every 2 ms so that the assigned error reaction is started at the earliest approx. 3 ms after the limit switch has been activated.

- Activating the Monitoring** Monitoring for exceeding the travel range limit switches is only carried out when the monitor was activated via bit 1 of "P-0-0090, Travel range limit parameter".
- Reaction when Exceeding Travel Range** The drive reaction to exceeding the travel range can be determined via bit 2 of "P-0-0090, Travel range limit parameter".
- Exceeding Travel Range as an Error** When "0" is entered in bit 2 of P-0-0090, exceeding the travel range is handled as an error with the reaction "velocity command value reset".
- Drive behavior:
- After the velocity command value has been reset, the drive switches off the internal drive enable and thus is torque-free.
  - The "ready-for-operation" contact opens.
- See also "Velocity Command Value Reset" in section "Error Reactions: Best Possible Deceleration"
- Exceeding Travel Range as a Warning** When "1" is entered in bit 2 of P-0-0090, exceeding the travel range is handled as a warning with the reaction "velocity command value reset".
- Drive behavior:
- The drive does not switch off the internal drive enable.
  - As long as the warning condition is present, i.e. the limit switch is activated, only such command values are accepted that lead back to the allowed range. Checking the command values depends on the active operation mode (see below "Notes on Commissioning").
- See also "Velocity Command Value Reset" in section "Error Reactions: Best Possible Deceleration"

Drive Control



Shutting down the axis using a velocity command value ramp is not possible! Shutdown is always carried out as quickly as possible with maximum allowed torque/force.

### Position Limit Values (Software Limit Switches)

**Parameters for Position Limit Values**

To define the travel range via position limit values, the following parameters are available:

- S-0-0049, Positive position limit value
- S-0-0050, Negative position limit value



The position limit values are polled every 2 ms so that the assigned error reaction is started at the earliest approx. 3 ms after the position limit has been exceeded.

**Requirements for Activating the Function**

Requirements for using (activating) the position limit value monitor:

- The position data reference of the drive must have been established (i.e. the encoder system of the active operation mode must be in reference). The status bit in "S-0-0403, Position feedback value status" then is "1".
- Monitoring of the position limit values was activated in "S-0-0055, Position polarities" (bit 4 = 1).

**Reference Point for Position Limit Value Monitoring**

When 2 measuring systems are used the drive, for position limit value monitoring, automatically refers to the measuring system that has been homed.



When 2 measuring systems are used and both systems are in reference, the encoder selected in S-0-0147 (bit 3) is used.

**Exceeding the Position Limit Values**

Exceeding the position limit values is detected when the actual position value of the active operation mode is outside the travel range defined by the position limit values.

**Reaction When Exceeding Position Limit Values**

The drive reaction to exceeding the position limit value can be determined via bit 2 of "P-0-0090, Travel range limit parameter".

**Exceeding Position Limit Values as an Error**

When "0" is entered in bit 2 of P-0-0090, exceeding the position limit value is handled as an error with the reaction "velocity command value reset" (see also section "Error Reactions:) Best Possible Deceleration").

Drive behavior:

- After the speed command value has been reset, the drive switches off the internal drive enable and thus is torque-free.
- The "ready-for-operation" contact opens.

See also "Velocity Command Value Reset" in section "Error Reactions: Best Possible Deceleration"

**Exceeding Position Limit Values as a Warning**

When "1" is entered in bit 2 of P-0-0090, exceeding the the position limit value is handled as a warning with the reaction "velocity command value reset".

Drive behavior:

- The drive does not switch off the internal drive enable.
- As long as the warning condition is present, i.e. the limit switch is activated, only such command values are accepted that lead back to the allowed range. Checking the command values depends on the active operation mode (see below "Notes on Commissioning").

See also "Velocity Command Value Reset" in section "Error Reactions: Best Possible Deceleration"



Shutting down the axis using a velocity command value ramp is not possible! Shutdown is always carried out as quickly as possible with maximum allowed torque/force.

**Leaving the Inadmissible Travel Range**

After the allowed travel range has been exceeded, the command values are checked for validity and only such command values are accepted that lead back to the allowed travel range.



Moving to the allowed travel range is also possible in the case of error!

**Notes on Commissioning**

When parameterizing the position limit values, take the positions of the travel range limit switches into account. The working range defined with the two position limit values (S-0-0049, S-0-0050) should be within the working range defined with the travel range limit switches. As long as the position data reference hasn't been established yet (axis not homed), the function of the software limit switches (position limit values) is not yet guaranteed. Independent thereof is the function of the travel range limit switches that always causes the drive to be switched off when the defined limit is exceeded and therefore avoids collision (machine protection).

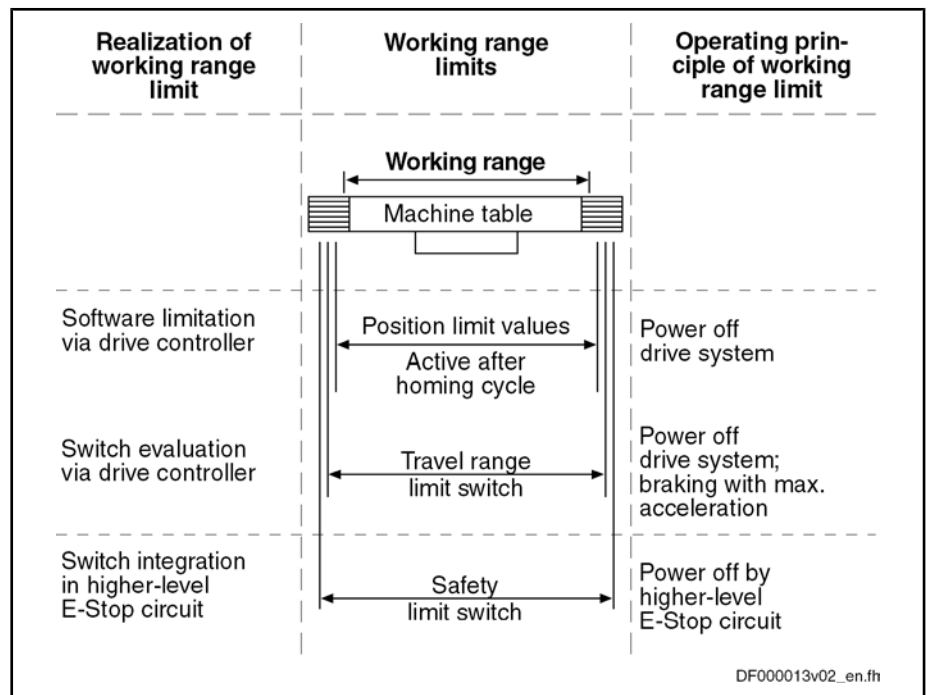


Fig. 6-103: Realizations and Operating Principles of Working Range Limitations




The safety limit switches that can be included in the E-Stop circuit (see separate documentation "Project Planning Manual for Power Sections"), are the last safeguard by the drive. In addition, the control master can monitor the position limit values.

**Activating the Position Limit Value Monitor**


The monitor of the position limit values is activated by setting bit 4 in "S-0-0055, Position polarities".

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 Before activating the position limit value monitoring, it is necessary to establish the drive's position data reference, because position limit values are only useful and operational when the axis was homed.

**Activating the Travel Range Limit Switches**

The travel range limit switches are activated by setting bit 1 in "P-0-0090, Travel range limit parameter".

 When activating the travel range limit switches, make sure that the respective digital inputs (Limit+, Limit-) were configured accordingly, because otherwise the limit switch function is not guaranteed.  
See "Digital Inputs/Outputs"

**Signal Behavior of Travel Range Limit Switches (N/O and N/C)**

Via bit 0 of "P-0-0090, Travel range limit parameter", it is possible to set whether the connected travel range limit switches are evaluated as N/O or N/C. This allows activating an inversion of the signal.

**Recommissioning in Case of Error**

After a limit switch or limit value error occurred (diagnostic messages F6043/F6044 or F6029/F6030), the following steps are required for recommissioning:


- Clear the error message via the command "S-0-0099, C0500 Reset class 1 diagnostics" or by pressing the "Esc" key on the standard control panel.
- Activate the drive with a positive edge of the drive enable signal.

If the error condition is still present, i.e. if the limit switch is still activated or if the position limit values are still exceeded, only such command values are accepted that lead back to the allowed range. Checking the command values depends on the active operation mode.

The following applies:

Operating mode	Command value check
Torque control	Polarity of the torque/force command value (S-0-0080)
All operation modes with drive-internal velocity control	Polarity of the internal velocity command value
All operation modes with drive-internal position control	Polarity of the velocity resulting from the preset position command value

Fig.6-104: Checking the Command Values in the Case of Error

 If command values leading out of the allowed travel range continue to be preset, the error message (or warning) for travel range limit switch errors/position limit value errors will be generated again!

**Diagnostic and Status Messages**

**Diagnostic Messages When Travel Range Limit Values Exceeded**

In case the position limit values are exceeded, the corresponding diagnostic message depends on the handling set in "P-0-0090, Travel range limit parameter" (bit 2):

Handling	Display	Diagnosis
as error (bit 2 = 0)	F6029	F6029 Positive position limit exceeded
	F6030	F6030 Negative position limit exceeded



Handling	Display	Diagnosis
as warning (bit 2 = 1)	E8029	E8029 Positive position limit exceeded
	E8030	E8030 Negative position limit exceeded

Fig.6-105: Diagnostic Messages When Position Limit Values Exceeded

**E2053 Target Position out of Travel Range**

When "drive-internal interpolation" is used as active operation mode, the drive checks whether the target position is outside the position limit values (S-0-0049 or S-0-0050). If this is the case, the drive does not move. It generates the warning "E2053 Target position out of travel range" and additionally sets bit 13 in "S-0-0012, Class 2 diagnostics".

**Diagnostic Messages When Travel Range Limit Switch Activated**

Exceeding the travel range limit switches is detected when they are activated. When this monitor reacts, the corresponding diagnostic message depends on the handling set in "P-0-0090, Travel range limit parameter" (bit 2):


Handling	Display	Diagnosis
as error (bit 2 = 0)	F6042	F6042 Both travel range limit switches activated
	F6043	F6043 Positive travel range limit switch activated
	F6044	F6044 Negative travel range limit switch activated
as warning (bit 2 = 1)	E8042	E8042 Both travel range limit switches activated
	E8043	E8043 Positive travel range limit switch activated
	E8044	E8044 Negative travel range limit switch activated

Fig.6-106: Diagnostic Messages When Travel Range Limit Switches Exceeded

**States of Travel Range Limit Switches**

The states of the connected travel range limit switches are displayed in "P-0-0222, Travel range limit switch inputs":

- Bit 0 → Status of positive limit switch (Limit+)
- Bit 1 → Status of negative limit switch (Limit-)

 See also Parameter Description "P-0-0222, Travel range limit switch inputs"

**Connecting the Travel Range Limit Switches**

See "Digital Inputs/Outputs"

 See separate documentation "Control Sections for Drive Controllers - Project Planning Manual"

**6.7 Power Supply**

**6.7.1 Possibilities of Power Supply for IndraDrive**

**Brief Description**

For IndraDrive devices we basically distinguish two lines:

- Modular line, consisting of supply unit and modular inverter (IndraDrive M)
- Non-modular line, so-called converter devices, including power supply and inverter (IndraDrive C)

The power supply of the motors controlled via inverter is realized by a direct voltage power bus (DC bus). In the case of the modular line, this bus is supplied

## Drive Control

by the supply unit connected to the mains. Converters are supplied by the mains connection via the integrated supply unit.

**Pertinent Parameters**

- S-0-0380, DC bus voltage
- P-0-0114, Undervoltage threshold
- P-0-0118, Power supply, configuration
- P-0-0460, Module group, control word
- P-0-0461, Module group, status word
- P-0-0806, Current mains voltage crest value
- P-0-0809, Properties of charging circuit
- P-0-0810, Minimum mains crest value
- P-0-0815, Nominal mains voltage crest value
- P-0-0816, Amplifier temperature 2
- P-0-0819, Energy counter
- P-0-0833, Braking resistor threshold
- P-0-0844, Braking resistor load
- P-0-0858, Data of external braking resistor
- P-0-0859, Data of internal braking resistor
- P-0-0860, Converter configuration
- P-0-0861, Power supply status word

**Pertinent Diagnostic Messages**

- E2026 Undervoltage in power section
- E2040 Device overtemperature 2 prewarning
- E2050 Device overtemp. Prewarning
- E2061 Device overload prewarning
- E2086 Prewarning supply module overload
- E2802 HW control of braking resistor
- E2810 Drive system not ready for operation
- E2814 Undervoltage in mains
- E2816 Undervoltage in power section
- E2818 Phase failure
- E2819 Mains failure
- E2820 Braking resistor overload prewarning
- E2829 Not ready for power on
- E8025 Overvoltage in power section
- E8028 Overcurrent in power section
- E8057 Device overload, current limit active
- E8058 Drive system not ready for operation
- F2026 Undervoltage in power section
- F2086 Error supply module
- F2087 Module group communication error
- F2814 Undervoltage in mains
- F2816 Softstart fault power supply unit
- F2817 Overvoltage in power section

- F2818 Phase failure
- F2819 Mains failure
- F2820 Braking resistor overload
- F2821 Error in control of braking resistor
- F2825 Switch-on threshold braking resistor too low
- F2833 Ground fault in motor line
- F2834 Contactor control error
- F2836 DC bus balancing monitor error
- F2840 Error supply shutdown
- F2860 Overcurrent in mains-side power section
- F8838 Overcurrent external braking resistor

### Possible Device Combinations and Mains Connection



The possible device combinations are only described in principle for the purpose of explanation. As regards combinations of device types actually possible and specific facts to be observed, see separate documentation "Rexroth IndraDrive – Drive System, Project Planning Manual" (DOK-INDRV\*-SYSTEM\*\*\*\*-PR\*\*-EN-P; part no.: R911309635) .

#### Central Supply

The figures below illustrates the principle of central supply:

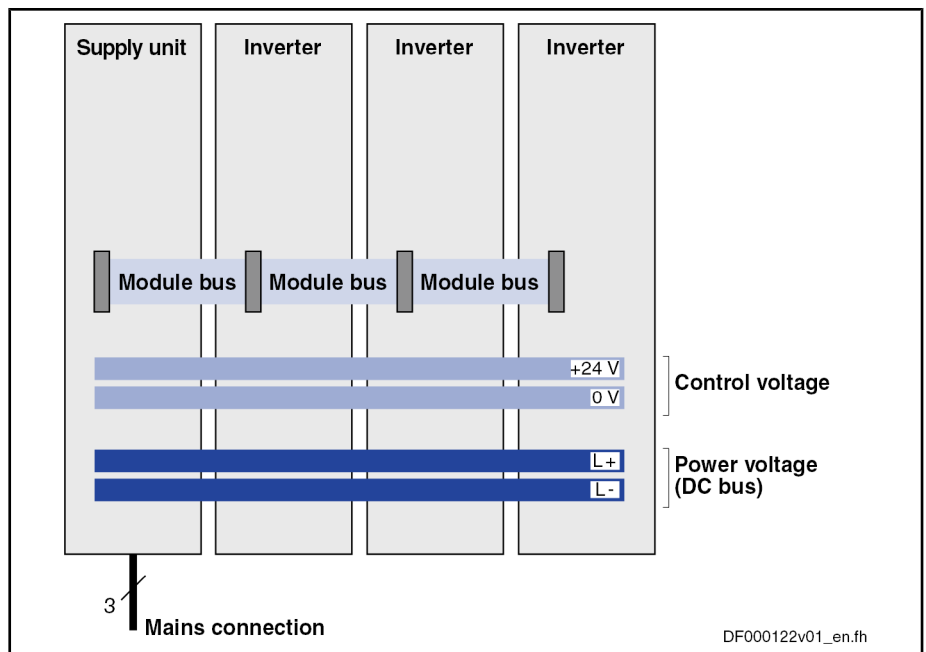


Fig.6-107: Mains Supply via Supply Unit

Drive Control

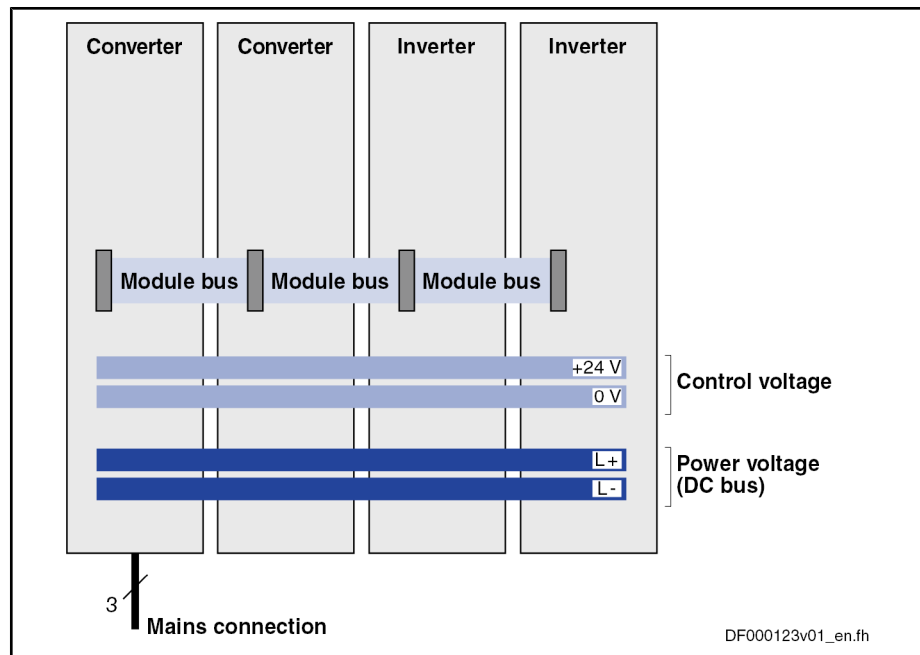


Fig.6-108: Mains Supply via Converter

Group Supply

The figure below illustrates the principle of group supply:

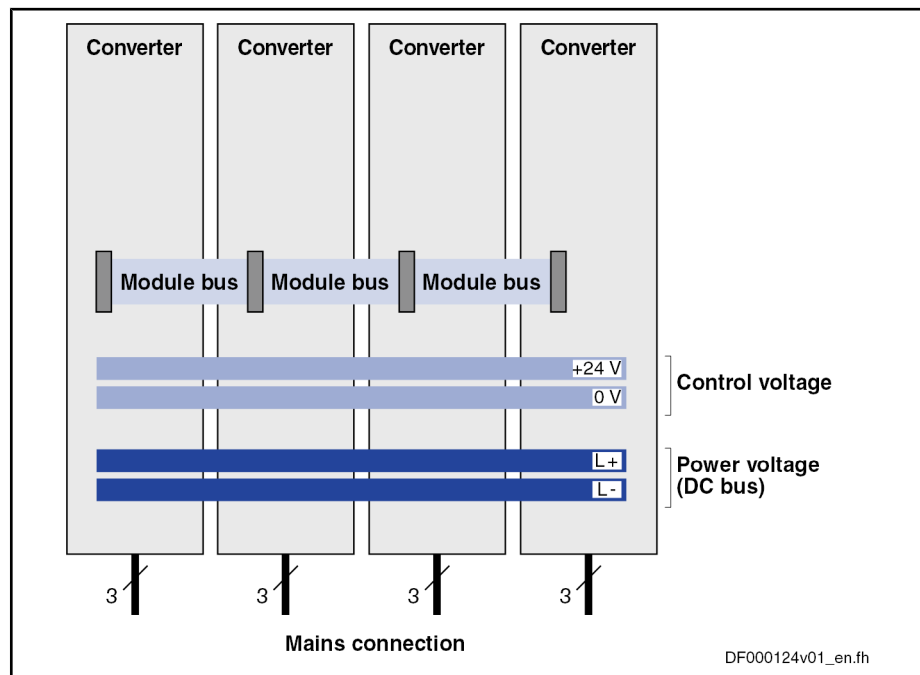


Fig.6-109: Mains Supply via all Devices


Communication in Drive Group

Depending on the task of a drive system or of several drives cooperating in a process, it can be appropriate to rapidly carry out a common reaction to certain events. This requires the exchange of signals (communication) between the cooperating devices. For this purpose, IndraDrive devices are interconnected via the module bus.

Note Regarding Converters

A converter combines supply unit and inverter in one device. In a "drive system" (several drives the DC buses and module buses of which are interconnected) a converter can fulfill the following functions:

- Supplying its integrated inverter and further inverters

	- or -
	<ul style="list-style-type: none"> <li>• Operation only as inverter on a DC bus (only for HCS02.1)</li> </ul>
<b>Regenerated Energy</b>	In the case of regenerative operation (e.g. deceleration mode) of the motors connected to a drive controller, the regenerated energy is first absorbed by the DC bus. Depending on the supply unit or supply section, the absorbed energy is regenerated to the supply mains or converted to heat via a braking resistor.
<b>Braking Resistor</b>	The braking resistor is connected on the DC bus side. Depending on the device line, an internal braking resistor is available or an external braking resistor can be connected.
<b>Description of Hardware</b>	As regards hardware, connections and signals, the module bus is described in the documentations of the devices (Project Planning Manuals).
	<hr/>  <p>Recommendations on mains connection and control of the power supply, including external braking resistor and DC bus short circuit, are contained in the separate documentation "Rexroth IndraDrive – Drive System, Project Planning Manual" (DOK-INDRV*-SYSTEM*****-PR**-EN-P; part no.: R911309635) .</p> <hr/>

## 6.7.2 Functional Description

### Information on the Module Bus

<b>Function of the Module Bus</b>	<p>The module bus establishes the exchange of signals between the inverters or converters, or from the inverters to the supply unit. Independent of the master communication, this allows the devices to exchange information on internal status variables of the drive system and error situations without delay. Axis drives and supply units can therefore react in a coordinated way.</p> <p>The module bus transmits the following information:</p> <ul style="list-style-type: none"> <li>• With regard to the supply unit: <ul style="list-style-type: none"> <li>– Supply Unit Ready for Operation</li> <li>– Ready for power output</li> <li>– DC bus voltage in or outside of allowed range of values</li> <li>– Warning against overload of supply unit</li> <li>– Signal for resetting supply errors</li> </ul> </li> <li>• With regard to inverters or converters: <ul style="list-style-type: none"> <li>– Inverters or converters ready for operation</li> </ul> </li> </ul>
<b>Hierarchy of Status Information</b>	The status information transmitted by inverter, supply unit or converter via the module bus has a hierarchical order.

## Drive Control

Status information	Generated by				Priority
	SU	CV	IV	HLB	
Resetting of supply errors	--	■	■	■	high
Supply units or converters not ready for operation ("supply error")	■	■	■ <sup>1)</sup>	■	↑
Inverters or converters not ready for operation "inverter error")	--	■ <sup>2)</sup>	■ <sup>2)</sup>	■	↑
Failure of DC bus supply ("DC bus not ok" in operation)	■	■	--	--	↑
"Supply overload" prewarning	■	■	--	■	↑
DC bus ready for power output ("DC bus ok", after switching power voltage on)	■	■	--	--	↑
All module bus nodes error-free	■	■	■	■	↑
					low

SU Supply unit

CV Converters

IV Inverter

HLB DC bus resistor unit

1) only if F8 errors signaled at supply unit (P-0-0118)

2) only if F2/F4/F6 errors signaled in drive system (P-0-0118)

*Fig.6-110: Module bus Status Information and its Priority in the Hierarchy*

If several pieces of status information from one or several module bus nodes are present at the same time, the status information highest in hierarchy determines the signal status of the module bus.

### Resetting Error Messages of the Supply Unit

Error messages of supply unit output via:

- Display of supply unit

- and -

- Inverter or Converter Connected at Module bus (Collective Error Message "F2086 Error supply module")

Error messages of supply unit cleared via:

- "Esc" button at display of supply unit

- or -




- Module bus, triggered by command "S-0-0099, C0500 Reset class 1 diagnostics" for an inverter of the module group

- or -

- "Reset" input at the DC bus resistor unit HLB (if available)



Inverters can reset error messages of the supply unit via the module bus, as supply units do not have any master communication interface. In the case of converters, error messages of the integrated supply unit are reset via their own master communication interface. Resetting error messages at the supply has the highest priority in order that power supply can be immediately reestablished!

<b>Supply Unit Ready for Operation</b>	<p>The supply unit or the supply section of the converter signals "ready for operation" to the module bus when the required control voltage is provided at the device and there isn't any supply error present.</p> <p>If the supply unit is no longer ready for operation due to an error, the information is transmitted via the module bus with high priority, because power supply is no longer guaranteed.</p>
<b>Inverters Ready for Operation</b>	<p>The inverter or converter signals "ready for operation" to the module bus when the required control voltage is provided at the device, communication phase P4 has been reached and there isn't any error present in the inverter or inverter section of the converter.</p>
<b>HLB Ready for Operation</b>	<p>The DC bus resistor unit HLB signals "ready for operation" to the module bus when the required control voltage is provided at the device and the thermal load of the components is in the allowed range.</p>
<b>Voltage Messages of the Supply</b>	<p>The supply unit or the supply section of the converter signals the following states via the module bus:</p> <ul style="list-style-type: none"> <li>• After switching the mains voltage on, the voltage in the DC bus has exceeded the minimum value, the charging process has been completed and there is readiness for power output ("DC bus ok").</li> <li>• In the case of load, the voltage in the DC bus has fallen below the minimum value or there is mains failure ("DC bus not ok").</li> </ul> <p>When the voltage in the DC bus has fallen below the minimum value ("DC bus not ok"), this is displayed via the inverters or converters connected to the module bus and can be read by the control master via the master communication (warning "E2026 Undervoltage in power section" or error "F2026 Undervoltage in power section", depending on the power supply configuration in P-0-0118). The control master can thereby detect imminent overload in the supply circuit (mains) and react in an appropriate way.</p> <hr/> <p> Data of minimum voltage in DC bus and of power supply configuration (P-0-0118) are contained in the following section "Basics on Power Supply" .</p> <hr/>
<b>Overload Warning of the Supply</b>	<p>The supply unit or the supply section of the converter signals "supply module overload prewarning" via the module bus, if the power supply risks automatically switching off soon, due to imminent overload. The warning can be triggered due to high heat sink temperature or high braking resistor load, for example.</p> <p>The message "prewarning supply module overload" is output via the inverters or converters connected to the module bus (E2086). The control master can thereby detect imminent supply overload and react in an appropriate way.</p> <hr/> <p> The exact causes of this warning are shown on the display of the supply unit or converter by detailed diagnostic message texts.</p> <hr/>
<b>Overload Warning of HLB</b>	<p>The DC bus resistor unit HLB signals "supply module overload prewarning" via the module bus, if one of the following situations occurs:</p> <ul style="list-style-type: none"> <li>• Load of the braking resistor &gt; 90%</li> <li>• Heat sink temperature sensor signals maximum temperature</li> <li>• Ambient air temperature sensor signals maximum temperature</li> </ul> <hr/> <p> The message "prewarning supply module overload" can be generated by HLB, too, because HLB contains a braking resistor which can be thermally overloaded.</p> <hr/>

## Drive Control

**Diagnosis of Module Bus Status** The control information currently transmitted by an inverter or converter via the module bus is displayed in "P-0-0460, Module group, control word".

The messages currently available on the module bus are displayed in "P-0-0461, Module group, status word".



See also Parameter Description "P-0-0460, Module group, control word" and "P-0-0461, Module group, status word"

## Basics on Power Supply

Supply units and the supply section of a converter provide the DC bus voltage for the inverters or the inverter section of the converter.

**Power On** The mains voltage for charging the DC bus can only be switched on when all devices connected via the module bus are signaling the status "error-free". If one of the devices displays an error,

- the activation of the internal mains contactor is prevented for supply units,
- The activation of the external mains contactor is prevented (message "E2810 Drive system not ready for operation") for converters by the opened "Rel1" contact that has to be available in the switch-off path of the mains contactor.



For this purpose, the status information "supply ready for operation" (respective bit in "P-0-0861, Power supply status word") has to be assigned to the "Rel1" contact of the control section for converters; no other signal may be assigned to this contact. **Otherwise it is possible to switch power on, although an error condition is present!**



Recommendations on the hardware-side control of supply units or converters are contained in the separate documentation "Rexroth IndraDrive – Drive System, Project Planning Manual" (DOK-INDRV\*-SYSTEM\*\*\*\*-PR\*\*-EN-P; part no.: R911309635).

**Soft Start** When the mains voltage is switched on, the DC bus is charged via a so-called "soft start device". This limits the charging current for the DC bus first uncharged to the value indicated in the documentation of the respective device.

The soft start causes a "charging time" between the activation of the mains voltage and the minimum voltage in the DC bus required for power output. The charging time is monitored; when a maximum time has been exceeded, "F2816 Softstart fault power supply unit" (displayed for supply unit and converter) is signaled. The soft start fault is signaled to the other devices via the module bus as a supply error with "F2086 Error supply module" (displayed for supply unit and other converters).

If the soft start process has been successfully completed, the supply signals via the module bus that the DC bus is ready for power output ("DC bus ok").

**Minimum Voltage for Power Output** In the case of power output of the DC bus and correct mains voltage, the minimum value of the DC bus voltage for signaling the readiness for power output ...

- in the case of supply units, is 75% of the crest value of the mains voltage detected when switching on (cannot be set),
- In the case of converters, is 75% of the crest value of the mains voltage detected when switching on, unless a higher minimum value has been set via "P-0-0114, Undervoltage threshold".



In case the voltage value has fallen below the minimum voltage, the error message "F2026 Undervoltage in power section" is generated and power is switched off.



In the case of HMV supply units, the readiness for power output is additionally signaled by the relay contact "UD" closed (see documentation "Supply Units and Power Sections, Project Planning Manual").



The crest value of the mains voltage is detected when the mains contactor is activated. It is displayed "P-0-0815, Nominal mains voltage crest value" (only for converters, not for supply units).

#### Power Off

In the case of error, power is switched off automatically,

- in the case of supply units, by switching the integrated mains contactor off,
- In the case of converters, by opening the "Rel1" contact that has to be available in the switch-off path of the mains contactor.



For this purpose, the status information "supply ready for operation" (respective bit in "P-0-0861, Power supply status word") has to be assigned to the "Rel1" contact of the control section for converters; no other signal may be assigned to this contact. **Otherwise power is not switched off automatically!**

Depending on the hardware-side design and control of the supply unit or converter, "DC bus short circuit" (for decelerating synchronous motors) can be activated, too.



Recommendations on the hardware-side control of supply units or converters are contained in the documentation of the respective device.

Criteria for power off (for supply units) or opening the "Rel1" contact (for converters):

- Error in supply (see below "Diagnostic and Status Messages")
- Fatal error in inverter or converter (F8xxx), is signaled at supply unit by corresponding configuration of the inverter or converter as regards power supply (P-0-0118)
- Charged DC bus has fallen below "minimum voltage for power output" (see above)



When an inverter signals missing readiness for operation to the module bus, power is not switched off when DC bus is ready for power output (exception see above "Fatal Error... (F8xxx), ...")!

#### Mains Failure Detection

Due to hardware differences, there are different requirements for mains failure detection in supply units and converters:

- The supply unit has an integrated mains contactor, the mains voltage must have been provided at the mains input terminals of the supply unit before power is switched on.
- The converter doesn't have an integrated mains contactor, the mains voltage is only provided at the mains input terminals of the converter by switching power on.

## Drive Control

The mains voltage is therefore monitored when

- the mains contactor has been switched on in the case of supply units,
- the mains contactor has been switched on and drive enable has been set in the case of converters.



For converters the mains failure monitor is only convenient when the drive is active ("AF"). The disconnection of power (mains contactor disconnection) would otherwise always cause the error message "F2819 Mains failure" although the mains voltage is available without error at the mains contactor. For this reason, error reset would be required even if the device status is correct!

**Immediate Measure at Mains Failure**

When the failure of mains voltage is detected, the following immediate measures are taken:

- The warning "E2818 Phase failure" resp. "E2819 Mains failure"(for supply units), or "E2819 Mains failure" (for converters) is displayed.
- The message "Failure DC bus supply" is signaled via the module bus.

**Permanent Mains Failure**

In the case of HMV supply units, the mains failure is additionally signaled by the relay contact "UD" opened (see documentation "Supply Units and Power Sections, Project Planning Manual").

In case the mains voltage fails permanently, the DC bus voltage is continuously decreasing, the voltage value falls below the "minimum voltage for power output" (see above). The following reactions are then triggered:

- In the case of supply units, the integrated mains contactor is switched off. The converter opens the "Rel1" contact which must be used to switch the external mains contactor off.
- The error message "E2819 Mains failure" appears on the display of the supply unit or converter.
- The message "Readiness for operation of supply unit missing" is signaled via the module bus.

**Temporary Mains Failure**

If the voltage value, in the case of temporary mains voltage failure, does **not** fall below the "minimum voltage for power output" (see above), there are the following reactions:

- The warning "E2818 Phase failure" resp. "E2819 Mains failure"(for supply units), or "E2819 Mains failure" (for converters) disappears automatically from the display.
- The message "DC bus ready for power output" is generated via the module bus again.

The behavior of the drives connected via the module bus in the case of temporary mains failure depends on the reaction to undervoltage in the DC bus that was set (configuration of power supply in P-0-0118).

There are the following possibilities:

- Error reaction triggered according to setting in "P-0-0119, Best possible deceleration"
- No error reaction (i.e. the message is handled as "non-fatal warning")

**Configuration of Power Supply**

For each of the drive connected by the module bus it is possible to make basic settings for power supply in "P-0-0118, Power supply, configuration":

- Reaction to drive errors signaled via module bus
- Individual drive errors signaled via module bus

- Drive-side handling of undervoltage (voltage value of DC bus falling below a minimum) defined as error or warning
- Fatal drive errors (F8xxx) signaled to supply unit because of power off and possibly DC bus short circuit for shutting down synchronous motors

## Information on Inverters

### DC Bus Voltage Monitoring

The motors are controlled via inverters. Inverters can be designed as modular devices or together with a supply unit be integrated in converters. For motor control, the inverter converts the DC bus voltage into alternating voltage (AC).

By means of the DC bus voltage level, the inverter evaluates whether the connected motor can be supplied with sufficient power or not. The inverter can do this with the following procedures:

- Evaluation of the message "Failure dc bus supply" signaled by the supply unit via the module bus

- or -

- Monitoring of the internally measured DC bus voltage with regard to an individual minimum threshold value

The desired procedure is determined in "P-0-0114, Undervoltage threshold":

- P-0-0114 = 0 → Drive detects undervoltage, when the supply unit signals "DC bus not ok" via the module bus
- P-0-0114 → 0 → determination and activation of undervoltage threshold active in the drive greater 75% of nominal mains voltage crest value

Depending on the configuration of the power supply (P-0-0118), undervoltage is handled as an error (error reaction according to setting in P-0-0119) or non-fatal warning (no reaction).

## Information on Converters

### Operating Converters as Inverters

In a converter the supply unit and inverter are combined in one device. As each inverter can provide or receive information via parameters, the information concerning the supply section of the converter can be queried or transmitted via parameters.

It is possible to operate converters of the HCS02.1 type as inverters only. When doing this, power supply is carried out by a DC bus (power voltage); there is no mains voltage applied to the converter. The inverter operation of a converter is configured via the respective bit in "P-0-0860, Converter configuration".



Converters of the HCS03.1 type cannot be operated as inverters on a DC bus!

### Mains Voltage Data

When a converter is directly connected to the supply mains (converter operation), the following mains voltage data are made available:

- P-0-0806, Current mains voltage crest value
- P-0-0810, Minimum mains crest value
- P-0-0815, Nominal mains voltage crest value

In P-0-0810 it is possible to set a threshold value, for triggering the warning "E2814 Undervoltage in mains", higher than the minimum value of the mains connection voltage range; this possibly enables the control master to react to the situation in the mains. The tolerance limit can be influenced via the level of the threshold value.

### Identifying the Charging Circuit for DC Bus

The control section of the converter receives data on the properties of the charging circuit hardware for the soft start via "P-0-0809, Properties of charging

## Drive Control

circuit". The content of this list parameter is stored in read-only form on the hardware of the converter power section and can be displayed for test purposes.

**Status of Power Supply**

The converter signals the status of power supply, mains voltage, DC bus charging status and the readiness for operation of the supply unit via "P-0-0861, Power supply status word". This allows diagnosing the converter in the case of error.

**Supply Section Ready for Operation**

The readiness for operation of the supply section of a converter is displayed via a bit in P-0-0861. This status information has to be assigned to the "Rel1" contact of the control section; the "Rel1" contact has to be integrated in the mains contactor control circuit. There mustn't be any other information assigned to the "Rel1" contact because otherwise the power of the converter cannot be switched off automatically!

See also "Digital Inputs/Outputs"



Data on the hardware-side control of converters are contained in the documentation of the device.

**Data on the Braking Resistor and the DC Bus Resistor Unit HLB01****External/Internal Braking Resistor**

Converters of the HSC02.1 type and HMV supply units are equipped with an integrated braking resistor. For the devices with higher maximum current, it is possible to connect an external braking resistor as an alternative to the internal braking resistor (device option). The presetting for whether an internal or external braking resistor becomes active is made in "P-0-0860, Converter configuration".

Converters of the HCS03.1 type do not have an internal braking resistor. Depending on the device option it is possible, however, to connect an external braking resistor.

When an external braking resistor is used, its technical data have to be entered in "P-0-0858, Data of external braking resistor". If an internal braking resistor is available, its data are contained on the manufacturer side in "P-0-0859, Data of internal braking resistor" and stored in write-protected form in a parameter memory on the power section.

The external braking resistor has to be activated in "P-0-0860, Converter configuration"!



When an external braking resistor is connected, the minimum resistor value that can be connected has to be taken into consideration (see documentation of the respective device).

**DC Bus Short Circuit**

The function "DC bus short circuit" can be triggered at DC bus resistor units HLB01.

**Switch-On/Switch-Off Threshold of Braking Resistor**

For the switch-on/switch-off threshold of the braking resistor in the case of HCS drive controllers there are

- reference values that can be selected
  - and -
- dynamic adjustment to the current load of the braking resistor.

The reference values for the switch-on/switch-off threshold can be set to fixed standard values or variable values in "P-0-0860, Converter configuration".



See also Parameter Description "P-0-0860, Converter configuration"

For the switch-on or switch-off threshold of the braking resistor in the case of supply units of the HMV type and the DC bus resistor unit HLB01 there is

- for HMV01.1E-..., a fixed or a mains voltage dependent reference value, depending on the signal level at the HMV terminal X32/3
- for HMV01.1R-... and HLB01, a fixed reference value for the switch-on threshold of DC820V
- and -
- dynamic adjustment to the current load of the braking resistor.



Explanations on the reference values for the switch-on/switch-off thresholds of the braking resistor and on the control of X32 are contained in the documentation of the supply units of type HMV (see documentation "Supply Units and Power Sections, Project Planning Manual").

As parameterization is impossible for HMV supply modules and the DC bus resistor unit HLB, the available options are limited:

- **Regenerative supply units HMV01.1R and DC bus resistor unit HLB01**  
→ The Basic switch-on threshold of the braking resistor is 820 V. there always is dynamic adjustment to the active load.
- **Infeeding supply units HMV01.1E**  
→ Via an interface input, the customer can choose between mains-oriented threshold and fixed threshold. The default setting (open-circuited interface) is mains-oriented. The basic switch-on threshold then is 80 V above the mains voltage crest value measured at the first power on. In the "fixed threshold" mode the basic switch-on threshold is 820V. In both operation modes there always is dynamic adjustment to the active load.

#### Dynamic Adjustment of the Switch-On Threshold

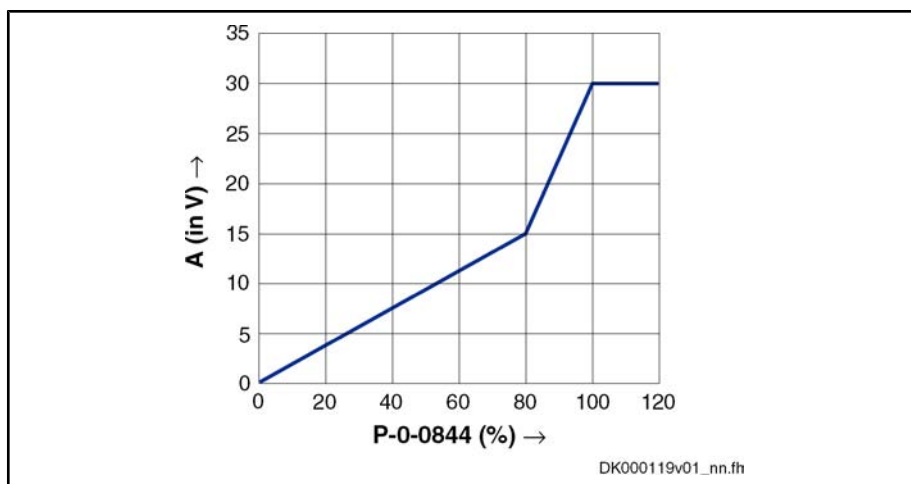
The dynamic adjustment to the current load of the braking resistor provides the following advantages:

- Protects the braking resistor from overload
- Equal load of all braking resistors active in a common DC bus.

The current load of the braking resistor is displayed in "P-0-0844, Braking resistor load".

Depending on the load, the switch-on threshold of the braking resistor is increased according to the following characteristic:

## Drive Control



P-0-0844      Braking resistor load (in %)  
 A              adjustment value for reference value (in V)

Fig. 6-111: Increase of Switch-On Threshold of Braking Resistor Depending on the Load

The effective switch-on threshold results from the reference value of the braking resistor switching voltage (see P-0-0860, bits 10,11); an adjustment value depending on the load (P-0-0844) is added to this reference value according to this characteristic. The effective switch-on threshold is displayed in "P-0-0833, Braking resistor threshold".



In the case of a braking resistor load of 100%, the switch-on threshold is not increased any more, because braking takes priority over the protection of the device!



In the case of HMV supply units, overload of the braking resistor and overtemperature of supply are additionally signaled by the relay contact "WARN" (see documentation "Supply Units and Power Sections, Project Planning Manual").

## 6.7.3 Notes on Commissioning

### Configuration of Power Supply

The required or desired axis-specific settings of the power supply of the device connected by the module bus have to be made in parameter "P-0-0118, Power supply, configuration".

The following settings or definitions can be made:

- Signaling of drive errors inside the drive system and reaction to signaled errors
- Handling of undervoltage as error or warning
- Signaling of fatal drive errors to the supply for switching power off (if necessary with DC bus short circuit)

### Setting the Undervoltage Threshold

If an individual threshold value is to be used for monitoring with regard to undervoltage, enter the desired value in

- P-0-0114, Undervoltage threshold

Otherwise, the undervoltage threshold is 75% of the mains voltage crest value that was measured when the mains was switched in.

### Configuration of Converter Operated as Inverter

If a converter is to be operated as an inverter at a DC bus, the bit for power supply has to be set in:

<p><b>Setting Threshold Value for Message "Mains Undervoltage"</b></p>	<ul style="list-style-type: none"> <li>• P-0-0860, Converter configuration.</li> </ul> <p>The "Rel1" contact for the mains contactor control circuit has to be configured. To do this, the status information "supply ready for operation" from</p> <ul style="list-style-type: none"> <li>• P-0-0861, Power supply status word</li> </ul> <p>has to be assigned to the "Rel1" contact of the control section.</p> <p>The wiring of the "Rel1" contact has to correspond to the data contained in the documentation of the converter devices!</p> <p>In the case of converters, the threshold value for the message "mains undervoltage" can be set in</p> <ul style="list-style-type: none"> <li>• P-0-0810, Minimum mains crest value.</li> </ul> <p>If there isn't any value entered, the default setting remains active (see Parameter Description for P-0-0810)!</p>
<p><b>Selecting the Braking Resistor</b></p>	<p>For certain converters of the HCS02.1 type, it is possible to determine whether the internal braking resistor is to be switched off and an externally connected braking resistor is to be activated. The selection is made in</p> <ul style="list-style-type: none"> <li>• P-0-0860, Converter configuration.</li> </ul> <p>If an external braking resistor is to be used, the data required for control by the converter have to be entered in</p> <ul style="list-style-type: none"> <li>• P-0-0858, Data of external braking resistor.</li> </ul>
<p><b>Switch-On/Switch-Off Threshold for Braking Resistor</b></p>	<p>In the case of converters, the reference values for the switch-on/switch-off thresholds of the braking resistor can be selected. This is made in</p> <ul style="list-style-type: none"> <li>• P-0-0860, Converter configuration.</li> </ul> <p>In accordance with the setting in P-0-0860, the switch-on threshold can be dynamically increased depending on the load. The switch-on threshold currently effective is displayed in</p> <ul style="list-style-type: none"> <li>• P-0-0833, Braking resistor threshold.</li> </ul> <p>The current load of the braking resistor is displayed in</p> <ul style="list-style-type: none"> <li>• P-0-0844, Braking resistor load.</li> </ul>



**CAUTION**

**Property damage caused by inadmissibly high voltage on the motor terminals!**

⇒ For third-party motors, observe the maximum allowed terminal voltage!

## 6.7.4 Diagnostic and Status Messages

<p><b>Module Bus</b></p>	<p>Displaying module bus status:</p> <ul style="list-style-type: none"> <li>• P-0-0461, Module group, status word</li> </ul> <p>Displaying device-side module bus control information:</p> <ul style="list-style-type: none"> <li>• P-0-0460, Module group, control word</li> </ul> <p>Displaying interrupted module bus communication:</p> <ul style="list-style-type: none"> <li>• F2087 Module group communication error</li> </ul>
<p><b>Mains Voltage</b></p>	<p>Mains voltage diagnoses:</p> <ul style="list-style-type: none"> <li>• P-0-0806, Current mains voltage crest value</li> <li>• P-0-0815, Nominal mains voltage crest value</li> </ul> <p>Mains voltage warnings:</p> <ul style="list-style-type: none"> <li>• F2814 Undervoltage in mains</li> </ul>

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- F2818 Phase failure
- F2819 Mains failure

Mains voltage error messages:

- F2814 Undervoltage in mains
- F2816 Softstart fault power supply unit
- F2818 Phase failure
- F2819 Mains failure
- F2834 Contactor control error
- F2840 Error supply shutdown
- F2860 Overcurrent in mains-side power section

**DC Bus** DC bus diagnosis:

- S-0-0380, DC bus voltage

DC bus warnings:

- E2026 Undervoltage in power section
- E2816 Undervoltage in power section
- E8025 Overvoltage in power section

DC bus error messages:

- F2026 Undervoltage in power section
- F2817 Overvoltage in power section
- F2833 Ground fault in motor line
- F2836 DC bus balancing monitor error

**Braking Resistor** Braking resistor diagnoses:

- P-0-0833, Braking resistor threshold
- P-0-0844, Braking resistor load

Braking resistor warnings:

- E2802 HW control of braking resistor
- E2820 Braking resistor overload prewarning
- E2829 Not ready for power on

Braking resistor error messages:

- F2820 Braking resistor overload
- F2821 Error in control of braking resistor
- F2825 Switch-on threshold braking resistor too low
- F8838 Overcurrent external braking resistor

**Power Section Supply** Power section warnings:

- E8028 Overcurrent in power section
- E8057 Device overload, current limit active

Power section error messages:

- F8060 Overcurrent in power section

**Drive System** Reaction to signaled errors of other drives in the drive system:

- E8058 Drive system not ready for operation

Supply in this case signals:

- E2810 Drive system not ready for operation



Error message if supply has switched off in the case of error:

- F2086 Error supply module



## 7 Operation Modes

### 7.1 General Information on the Operation Modes

#### 7.1.1 Supported Operation Modes



The operation modes supported by the firmware depend on the hardware and firmware and are contained in "S-0-0292, List of supported operation modes".

The following overview illustrates by which base packages or functional packages the respective operation mode is supported (if not stated otherwise, this applies to all 3 firmware variants).

Operation mode	In base package (characteristic)	In functional package ... (on the basis of a base package with the following characteristics)		
		Servo function	Synchronization	Main spindle
Standard operation modes:				
- Torque/force control	CL	-	-	-
- Velocity control	OL/CL	-	-	-
- Position control	CL	-	-	-
- Drive-internal interpolation	CL	-	-	-
- Drive-controlled positioning	CL	-	-	-
- Positioning block mode	CL	-	-	-
Synchronization modes:				
- Velocity synchronization	-	-	OL/CL	-
- Phase synchronization	-	-	CL	-
- Electronic cam	-	-	CL	-
- MotionProfile	-	-	CL	-

OL Open-loop characteristic

CL Closed-loop characteristic

*Fig. 7-1: Supported Operation Modes*

To use a functional package, it must have been activated (enabled). The currently enabled functional packages are displayed in "P-0-2004, Active functional packages".

See also "Enabling of Functional Packages"

#### 7.1.2 Operation Mode Handling

##### Selecting the Operation Mode

It is possible to configure up to 8 different operation modes (depending on "S-0-0292, List of supported operation modes") in the drive. Assignment and configuration are made via the following parameters:

- S-0-0032, Primary mode of operation

## Operation Modes

- S-0-0033, Secondary operation mode 1
- S-0-0034, Secondary operation mode 2
- S-0-0035, Secondary operation mode 3
- S-0-0284, Secondary operation mode 4
- S-0-0285, Secondary operation mode 5
- S-0-0286, Secondary operation mode 6
- S-0-0287, Secondary operation mode 7



If the value "0" was entered in one of these parameters, the "F2007 Switching to non-initialized operation mode" error message is generated when this operation mode is activated.

---

### Activating the Operation Mode

The operation mode is activated and controlled via bits 8, 9 and 11 in "P-0-0116, Device control: control word":

The following applies to P-0-0116:

- Bits 8 and 9 → Selecting primary mode of operation and secondary operation modes 1 to 3
- Bit 11 → Selecting secondary operation modes 4 to 7 (only SERCOS)



The secondary operation modes 4 to 7 can only be used via SERCOS interface. Bit 11 therefore only takes effect in the control word of the device control (P-0-0116) in conjunction with S-0-0134 (master control word for SERCOS)!

---

The figure below illustrates the interrelation of the control word of the respective master communication and the device control word/device status word with regard to the operation mode selection.

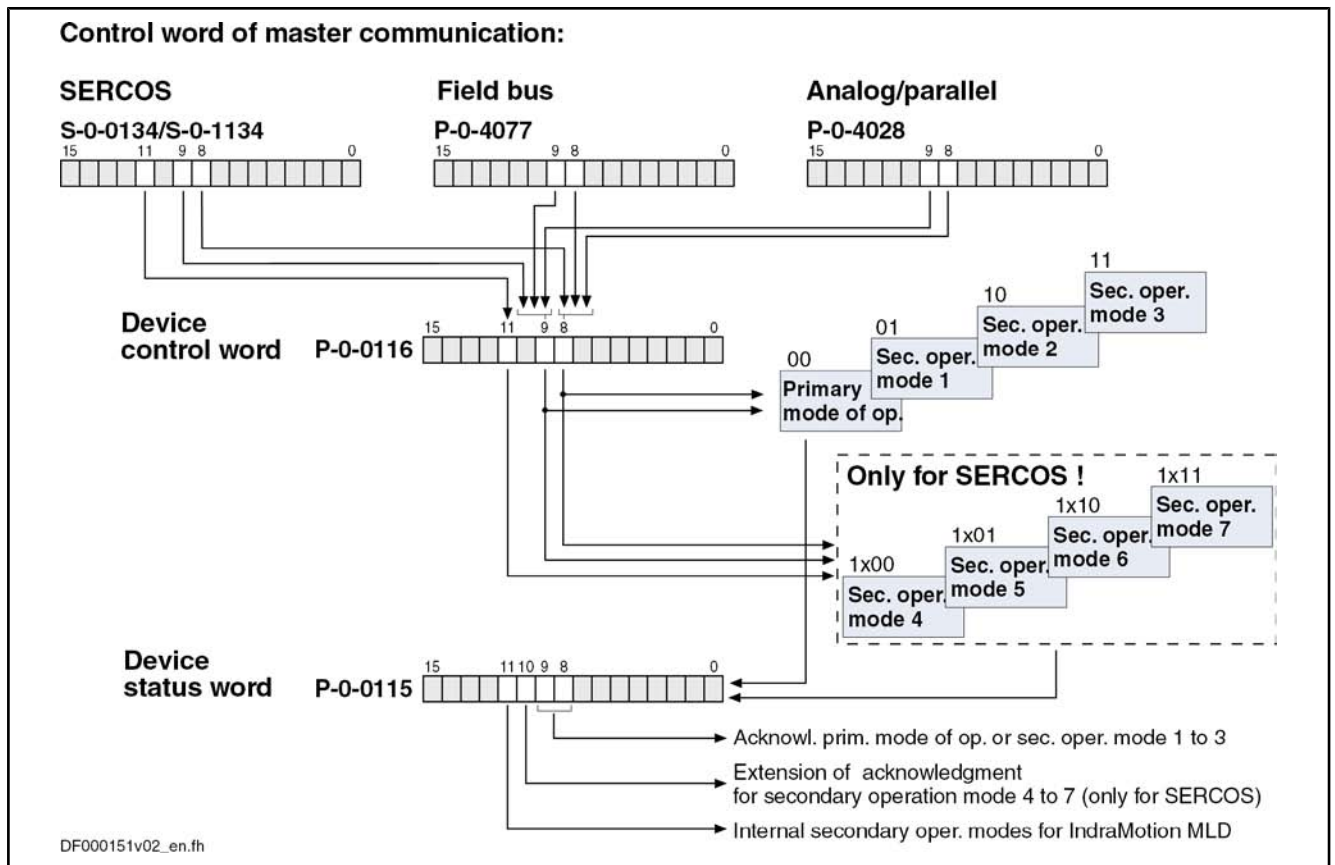


Fig.7-2: Operation Mode Selection via Control Word



The control bits (8 and 9) contained in P-0-0116 are also contained in the control words depending on the master communication (cf. S-0-0134, P-0-4077, P-0-4068 and P-0-4028) and can therefore be written via the control words.

**Acknowledging the Active Operation Mode**

An operation mode defined via the operation mode selection is active when:

- The drive (control section and power section) is ready for operation
- and -
- The drive enable signal sees a positive edge.

As regards the activation of an operation mode, there are the following kinds of feedback:

- With active operation mode the display of the control panel reads "AF".
- In "S-0-0390, Diagnostic message number" the respective diagnostic message number of the active operation mode is displayed (e.g. "A0101" in "velocity control" mode).
- In "S-0-0095, Diagnostic message", the active operation mode is displayed in text form (e.g. "A0101 Velocity control").
- In "P-0-0115, Device control: status word", bit 3 ("drive follows external command values") is used to acknowledge whether the drive is running in the preset operation mode or not.
- In "P-0-0115, Device control: status word", bits 8, 9 and 10 ("acknowledgment of operation mode") are used to signal the operation mode presently active.

## Operation Modes



The status bits contained in P-0-0115 (3, 8, 9 and 10) are also contained in the status words depending on the master communication (S-0-0135, P-0-4078) and can therefore be read in the status words. Bit 10, however, is only activated with SERCOS interface!

See also "Device Control and State Machines"

## Changing the Operation Mode

When drive enable is activated, the drive, after having gone through the initialization routines, changes to the operation mode that was selected via bits 8 and 9 of the specific control word of the respective master communication (S-0-0134, P-0-4077, P-0-4068 4028 or P-0-0116).



The change of operation modes is carried out within one position loop clock (Advanced: 250 µs; Basic: 500 µs). Another position loop clock passes until the command values of the activated operation mode become effective, because the initialization of the operation mode is carried out first.

## Special Cases

With the following **exceptional circumstances**, the desired operation mode is not carried out in spite of the operation mode having been correctly selected:

- **Drive error** is present  
→ The corresponding error reaction is carried out.
- **Fatal warning** was triggered  
→ The corresponding reaction is carried out.
- A "**drive command**" (e.g. homing procedure, set absolute measuring, ...) is executed  
→ The command started is carried out.
- **Drive HALT**  
→ This drive function is carried out.

See also "Device Control and State Machines"

## Drive-Controlled Change of Operation Mode

In order to achieve a quick and smooth change of operation mode in running operation, it is possible to make a "drive-controlled change of operation mode". Drive-internally this procedure ensures that, when the operation mode is changed, the transition is carried out in a synchronized way, even if the command value changes abruptly.

See also "Command Value Adjustment with Position Control"

## Command Value Acceptance and Acknowledgment

## Immediate Command Value Acceptance

Each preset command value is accepted immediately, when the respective command value parameter (e.g. S-0-0036, S-0-0080, S-0-0258, ...) is written in the case of the operation modes:

- Torque/Force Control
- Velocity Control
- Position Control With Cyclic Command Value Input
- Drive-Internal Interpolation
- Synchronization Modes:
  - Velocity Synchronization With Real/Virtual Master Axis
  - Phase Synchronization With Real/Virtual Master Axis

- Electronic Cam With Real/Virtual Master Axis
- MotionProfile With Real/Virtual Master Axis

#### Command Value Acceptance After Master Request

In the **positioning modes** (drive-controlled positioning, positioning block mode), however, the command value (target position, velocity, positioning block, ...) is only accepted, when the master explicitly requests this by a "command value acceptance".

The command value acceptance is carried out in a different way, according to the positioning mode or profile type:

- Operation mode "drive-controlled positioning"  
Acceptance of preset command value (position, velocity) by toggling bit 0 of "S-0-0346, Positioning control word"  
→ **Toggle mechanism**
- Operation mode "positioning block mode"  
Acceptance of the positioning block selected via "p-0-4026, Positioning block selection" by a 0-1 edge of bit 0 of "p-0-4060, Positioning block control word", when the parallel interface or, in the case of field buses, the I/O mode is used as master communication  
→ **Edge control**



When the positioning block mode is used for field buses in the freely configurable operating mode (P-0-4084 = 0xFFFFE) or with SERCOS interface, the toggle mechanism is used **in spite of the above rule**.

---

#### Command Value Acknowledgment

The explicit acknowledgment of the command value acceptance only takes place for the positioning modes (drive-controlled positioning, positioning block mode).

It is possible to check in the master whether and when the preset command value was accepted in the drive (command value acceptance handshake).

The command value acknowledgment is carried out in a different way, according to the positioning mode:

- Operation mode "drive-controlled positioning"  
The drive acknowledges the command value acceptance by toggling bit 0 of "S-0-0419, Positioning command acknowledge".
- Operation mode "positioning block mode"  
The drive acknowledges the command value acceptance by displaying the effective positioning block in "P-0-4051, Positioning block acknowledgment".



In the positioning block mode, too, the acceptance of a new positioning block causes bit 0 of S-0-0419 to be toggled, because in this case the internal processing of the positioning command values is identical to the "drive-controlled positioning" mode.

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## 7.2 Torque/Force Control

### 7.2.1 Brief Description



Assignment to functional firmware package, see chapter "Supported Operation Modes".

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## Operation Modes

In the "torque/force control" mode, a torque/force command value is preset for the drive. If required, this command value can be filtered. When the operation mode has been activated, the diagnostic message is "A0100 Torque control Torque control".

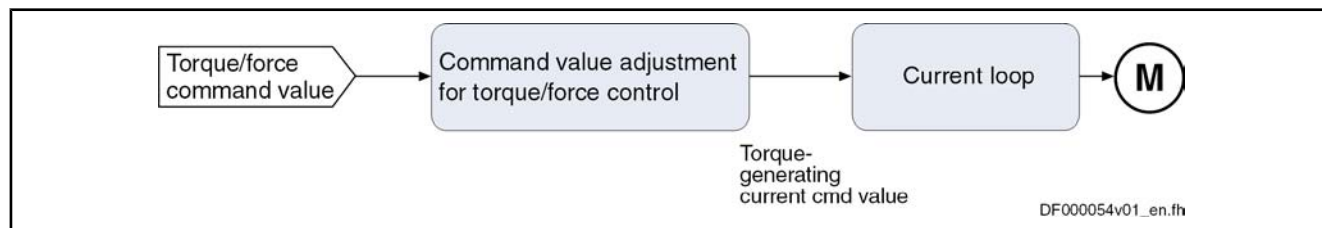


Fig. 7-3: "Torque/Force Control" Block Diagram

- Features**
- Torque/force control with regard to the sum of the command values preset in parameters "S-0-0080, Torque/force command value" and "S-0-0081, Additive torque/force command value"
  - Torque/force command value is generated internally by the velocity loop; value of S-0-0081 can be added as additive component
  - Limitation of the preset command value to limit value that can be parameterized
  - Filtering the command value by means of "S-0-0822, Torque/force ramp" and "S-0-0823, Torque/force ramp time"

- Pertinent Parameters**
- S-0-0080, Torque/force command value
  - S-0-0081, Additive torque/force command value
  - S-0-0082, Torque/force limit value positive
  - S-0-0083, Torque/force limit value negative
  - S-0-0092, Bipolar torque/force limit value
  - S-0-0109, Motor peak current
  - S-0-0110, Amplifier peak current
  - S-0-0111, Motor current at standstill
  - S-0-0822, Torque/force ramp
  - S-0-0823, Torque/force ramp time
  - S-0-0824, Status "Torque/force command value attained"
  - P-0-0001, Switching frequency of the power output stage
  - P-0-0038, Torque-generating current, command value
  - P-0-0049, Effective torque/force command value
  - P-0-0051, Torque/force constant
  - P-0-0109, Torque/force peak limit
  - P-0-4046, Effective peak current

- Pertinent Diagnostic Messages**
- A0100 Torque control
  - E8057 Device overload, current limit active
  - E8260 Torque/force command value limit active
  - F8079 Velocity limit value exceeded



## 7.2.2 Command Value Adjustment in Torque/Force Control

### Principle of Command Value Adjustment

**Filtering the Command Value** The command value preset by "S-0-0080, Torque/force command value" is filtered. The filter effect can be changed by setting of "S-0-0822, Torque/force ramp" and "S-0-0823, Torque/force ramp time".

The message "torque/force command value reached" (S-0-0824) signals that the output value of the filter has reached the input value (S-0-0080).

**Additive Current Command Value** In addition, it is possible to add an unfiltered additive command value via "S-0-0081, Additive torque/force command value". If required, this value can be cyclically configured.

**Command Value Limitation** We distinguish the following command value limitations:

- Torque/Force Limitation
- Current limitation

On the user side, it is only possible to directly set the torque/force limits. By setting the switching frequency (P-0-0001), the value of the current limit is indirectly influenced.

**Output Variable** The output variable of the command value adjustment for torque/force control is the torque-generating component of the current command value  $I_{qcmd}$  (P-0-0038).

**Block Diagram** The figure below illustrates command value processing in the "torque/force control" mode as a block diagram.

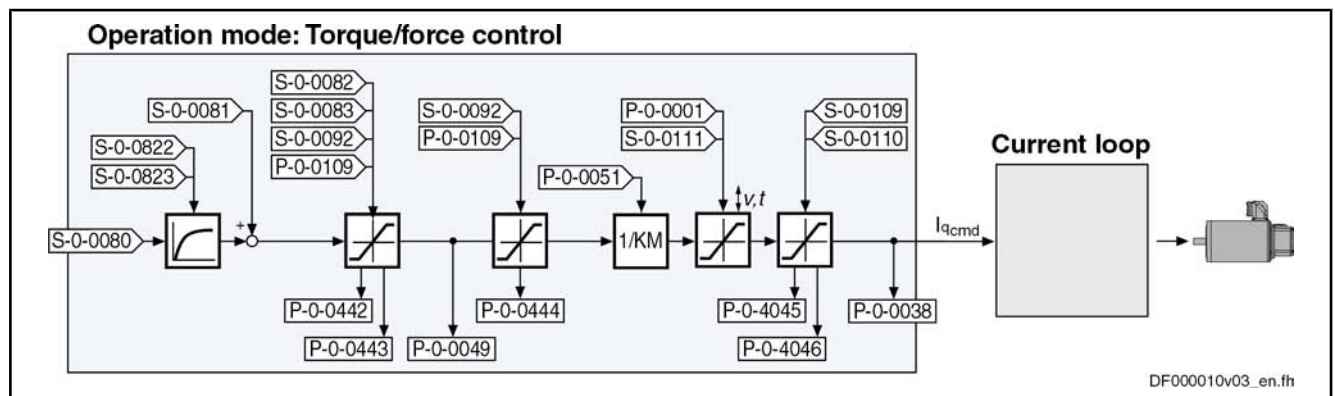


Fig.7-4: Command Value Adjustment in Torque/Force Control

The currently effective actual limit values are displayed (P-0-0442, P-0-0443, P-0-0444; P-0-4045, P-0-4046); so is the output variable of the command value adjustment in torque/force control, the torque-generating component of the current command value (P-0-0038).

**Velocity Monitor** In torque/force control, the velocity of the drive is reached depending on the component of the drive torque or the drive force acting on the acceleration. As the velocity of a motor or an axis has to stay within the allowed range in order to avoid damage, the actual velocity value is monitored, as soon as it is outside the standstill window S-0-0124.

If the value of "S-0-0040, Velocity feedback value" exceeds the 1.125-fold value of "S-0-0091, Bipolar velocity limit value", the drive generates the error message "F8079 Velocity limit value exceeded" and switches off with the error reaction that was set.

### Notes on Commissioning for Command Value Limitation

On the user side, the following limitations are available:

## Operation Modes

- Maximum allowed torque/force (S-0-0092, P-0-0109)
- Motive and regenerative load at stationary velocity (S-0-0082, S-0-0083)



See also separate documentation "Parameter Description for IndraDrive Controllers"



It is also possible to directly view (in N or Nm) the value of "P-0-0049, Effective torque/force command value" as intermediate value.



The content of "P-0-0046, Status word of current controller" results from the current and torque limits.

See also section below "Current Loop"

## 7.2.3 Current Loop

### Operating Principle of the Current Loop

The current loop is a typical PI loop and can be set via the following parameters:

- S-0-0106, Current loop proportional gain 1
- S-0-0107, Current loop integral action time 1

See also "Control Loop Structure"

See also "Motor Control"



In fact, the torque is not closed-loop controlled but open-loop controlled. Given the linear relation between torque and current (see P-0-0051), it is possible, however, to assume closed-loop torque/force control. Just the absolute torque precision is limited due to manufacturing tolerances of the motor (max.  $\pm 10\%$ ).

### Control Loop Performance and Cycle Times

According to the available hardware (Basic or Advanced design), the current control loop is closed every 62.5  $\mu\text{s}$  (Advanced) or 125  $\mu\text{s}$  (Basic). (See also "P-0-0556, Config word of axis controller", bit 2.)

### Notes on Commissioning for the Current Loop

The parameter values for the current loop of Rexroth motors are defined by the manufacturer. In the case of motors with encoder data memory, they are automatically written with the correct values during commissioning.

In the case of motors without encoder data memory, the correct values for the current loop parameters and other motor parameters can be loaded via the "IndraWorks Ds/D/MLD" commissioning tool.

## 7.2.4 Diagnostic Messages and Monitoring Functions

### Diagnostic Status Message

The activated "torque/force control" mode is displayed by the following diagnostic message:

- A0100 Torque control

### Monitoring Functions

Monitoring functions specific to the operation mode:

- Device Overload**
  - The thermal load of the device depending on the measured current is permanently calculated by a temperature model. When a threshold value is exceeded, the warning "E8057 Device overload, current limit active" is generated (see Troubleshooting Guide).
- Command Value Limit Active**
  - If necessary, the drive firmware limits the torque/force command value in dynamic and static form. If such a limitation has been activated, this is signaled by the warning "E8260 Torque/force command value limit active".
- Velocity Limit Value Exceeded**
  - The value of the parameter "S-0-0040, Velocity feedback value" is monitored, as soon as it is outside the standstill window S-0-0124. If it exceeds the 1.125-fold value parameterized in "S-0-0091, Bipolar velocity limit value", the error message "F8079 Velocity limit value exceeded" is generated.

## 7.3 Velocity Control

### 7.3.1 Brief Description



Assignment to functional firmware package, see chapter "Supported Operation Modes".

In the "velocity control" mode a velocity command value is preset for the drive. The velocity command value is limited by ramps and filters.

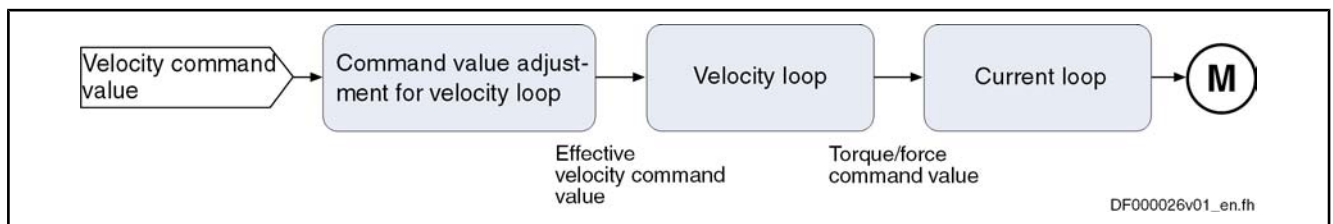


Fig. 7-5: "Velocity Control" Block Diagram

- Features**
- Inputting a velocity command value (sum of "S-0-0036, Velocity command value" and "S-0-0037, Additive velocity command value") via analog inputs or master communication interface (SERCOS, field bus, ...)
  - Selection of predefined and internally stored velocity command values (31 fixed values) is possible via binaurally coded digital inputs (e.g. for jogging forward/backward, feeding, setting up, ...) with separately definable acceleration and deceleration ramps (31 different ramps), as well as jerk filter to be set (31 different time constants)
  - Use of a drive-internal command value generator for generating command value ramps ("motor potentiometer")
  - Inversion of the provided velocity command value before it is processed in the ramp-function generator
  - Window comparator for masking critical velocity ranges in the command value channel (e.g. machine resonances) with corresponding acceleration adjustment (see P-0-1209)
  - Ramp-function generator with separately adjustable, two-stage acceleration and deceleration limits of the preset velocity command value; switching from ramp 1 to ramp 2 is done with selectable velocity and run-up stop that can be parameterized
  - Velocity control via a digital PI loop with extensive filter measures

## Operation Modes

- Monitoring the command velocity and actual velocity for exceeding Parameter "S-0-0091, Bipolar velocity limit value"
- Smoothing of velocity control loop difference via filter that can be parameterized
- Smoothing of preset command value by means of average filter (jerk limitation by means of moving average filter)
- Fine interpolation of the velocity command values; transmission of these command values in the position loop clock; fine interpolator can be switched on or off (P-0-0556, bit 0)
- Velocity control loop monitoring (cannot be parameterized) to prevent the drive from running away; monitor can be switched on or off (P-0-0556, bit 1)
- Velocity loop internally generates the torque/force command value to which the value of parameter "S-0-0081, Additive torque/force command value" can be added as an additive component.
- Control word and status word especially for "velocity control" mode (P-0-1200 and P-0-1210)

## Pertinent Parameters

- S-0-0036, Velocity command value
- S-0-0037, Additive velocity command value
- S-0-0091, Bipolar velocity limit value
- S-0-0100, Velocity loop proportional gain
- S-0-0101, Velocity loop integral action time
- P-0-0004, Velocity loop smoothing time constant
- P-0-0048, Effective velocity command value
- P-0-0556, Config word of axis controller
- P-0-1119, Velocity mix factor feedback 1 & 2
- P-0-1120, Velocity control loop filter: filter type
- P-0-1126, Velocity control loop: acceleration feedforward
- P-0-1200, Control word 1 velocity control
- P-0-1201, Ramp 1 pitch
- P-0-1202, Final speed ramp 1
- P-0-1203, Ramp 2 pitch
- P-0-1206, Memory of velocity command values
- P-0-1207, Lower limit of velocity masking window
- P-0-1208, Upper limit of velocity masking window
- P-0-1209, Acceleration factors for velocity masking window
- P-0-1210, Status word of velocity control mode
- P-0-1211, Deceleration ramp 1
- P-0-1213, Deceleration ramp 2
- P-0-1214, Control word 2 velocity control
- P-0-1215, Motor potentiometer, acceleration
- P-0-1216, Motor potentiometer, deceleration
- P-0-1217, Motor potentiometer, step size
- P-0-1218, Motor potentiometer, command value
- P-0-1222, Velocity command filter

- P-0-1223, List of acceleration ramps
  - P-0-1224, List of deceleration ramps
  - P-0-1225, List of smoothing time constants
- Pertinent Diagnostic Messages**
- A0101 Velocity control
  - E2059 Velocity command value limit active
  - E2063 Velocity command value > limit value
  - F8078 Speed loop error
  - F8079 Velocity limit value exceeded

Operation Modes

### 7.3.2 Command Value Adjustment in Velocity Control

#### Overview

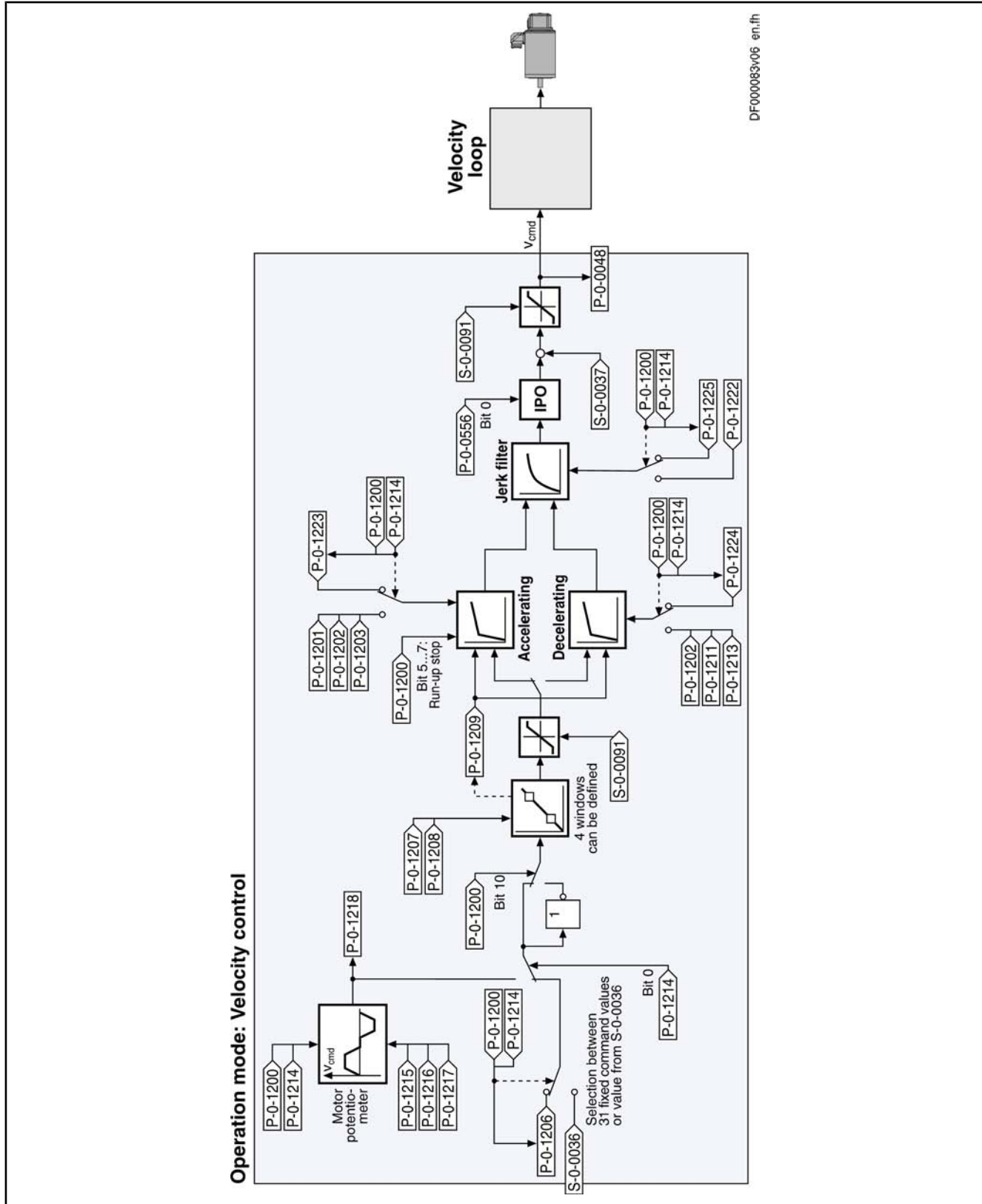


Fig.7-6: Command Value Adjustment in Velocity Control



The value of "S-0-0037, Additive velocity command value" can be added to "S-0-0036, Velocity command value" directly at the input of the velocity loop.

In the "velocity control" mode velocity command values can be input in the following ways:

- Cyclic command value input by means of parameter "S-0-0036, Velocity command value" via the master communication (analog interface, SERCOS, field bus) or IndraMotion MLD
- Using velocity command values internally stored in the drive in "P-0-1206, Memory of velocity command values" (list parameter); selection via digital inputs, master communication interface (SERCOS, field bus) or IndraMotion MLD, for example
- Internal generation of command value ramps by a so-called motor potentiometer
- Generation of a cyclic command value by means of the drive-integrated PLC (IndraMotion MLD) in conjunction with MC blocks (cf. P-0-1460)

The velocity command value is processed by the so-called ramp-function generator.



Information on the status of the ramp-function generator is contained in P-0-1210.

See Parameter Description "P-0-1210, Status word of velocity control mode"

## Command Value Generation via Memory of Fixed Command Values

Via the selection bits of parameter "P-0-1200, Control word 1 velocity control" (bit 0...4), you can choose from up to 31 velocity command values (P-0-1206) stored in the drive.



By default, you can only select 5 fixed command values via P-0-1200; one fixed command value is assigned to each individual bit (0...4).

### Activating the Fixed Command Values

As soon as at least one of the bits 0...4 has been set in parameter P-0-1200, the corresponding element from the list parameter "P-0-1206, Memory of velocity command values" takes effect.

The following assignment applies to the selection via bits 4...0 of P-0-1200:

- For **direct selection** (P-0-1214, bit 8 = 0)
  - 00000 → Value from S-0-0036 active
  - 00001 → Fixed value 1 from P-0-1206 selected and active
  - 00010 → Fixed value 2 from P-0-1206 selected and active
  - 00100 → Fixed value 3 from P-0-1206 selected and active
  - 01000 → Fixed value 4 from P-0-1206 selected and active
  - 10000 → Fixed value 5 from P-0-1206 selected and active
- For **binary selection** (P-0-1214, bit 8 = 1)
  - 00000 → Value from S-0-0036 active
  - 00001 → Fixed value 1 from P-0-1206 selected and active
  - 00010 → Fixed value 2 from P-0-1206 selected and active

## Operation Modes

- 00011 → Fixed value 3 from P-0-1206 selected and active
- etc.
- 11111 → Fixed value 31 from P-0-1206 selected and active

Via the same control bits of parameter P-0-1200, it is in addition possible to select ramp pitches, as well as time constants for the command value smoothing filter (see sections "Ramp-Function Generator" and "Jerk Limitation").



See also Parameter Descriptions "P-0-1200, Control word 1 velocity control" and "P-0-1214, Control word 2 velocity control"

## Command Value Generation via Motor Potentiometer

In the operation mode "velocity control", the command value generator (so-called motor potentiometer) provides the possibility of generating a velocity command value characteristic (parameter P-0-1218, Motor potentiometer, command value) via digital input signals ("ramp+" and "ramp-").

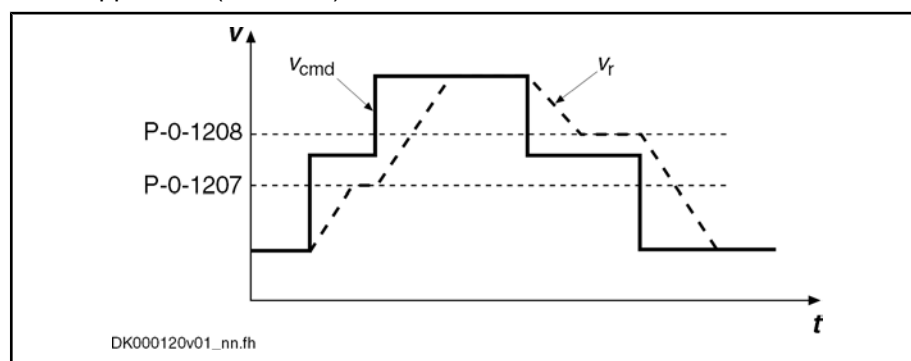
The motor potentiometer is activated by setting bit 0 = 1 in "P-0-1214, Control word 2 velocity control".

## Inverting the Velocity Command Value

Before it is processed in the ramp-function generator, the provided velocity command value can be inverted. The motor potentiometer is inverted by setting bit 10 = 1 in "P-0-1200, Control word 1 velocity control".

## Masking the Command Value

The masking windows (max. 4) that can be defined via "P-0-1207, Lower limit of velocity masking window" and "P-0-1208, Upper limit of velocity masking window" are used to suppress resonance phenomena of a machine or in an installation. The drive should not be permanently moved at velocities within these windows. A velocity command value within the value range of one of the 4 definable windows is either reduced to the lower limit (P-0-1207) or increased to the upper limit (P-0-1208).



P-0-1207 Lower limit of velocity masking window

P-0-1208 Upper limit of velocity masking window

$v_{cmd}$  Velocity Command Value

$v_r$  Velocity ramp

Fig. 7-7: Function "Velocity Masking Window With Hysteresis"

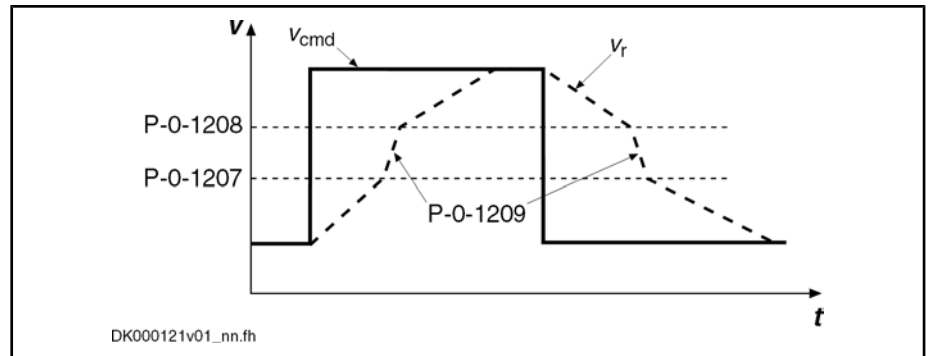


See also Parameter Descriptions "P-0-1207, Lower limit of velocity masking window" and "P-0-1208, Upper limit of velocity masking window"

The subsequent ramp-function generator passes the range of the velocity window; the values indicated in "P-0-1209, Acceleration factors for velocity



"masking window" have a multiplying effect on the acceleration values of the ramp-function generator (P-0-1201, P-0-1203, P-0-1211 and P-0-1213).



P-0-1207	Lower limit of velocity masking window
P-0-1208	Upper limit of velocity masking window
P-0-1209	Acceleration factors for velocity masking window
$v_{cmd}$	Velocity Command Value
$v_r$	Velocity ramp

Fig. 7-8: Operating Principle of the Acceleration Factors From P-0-1209



See also Parameter Description "P-0-1209, Acceleration factors for velocity masking window"

## Ramp-Function Generator

For the ramp-function generator, we make the following distinction:

- Cyclic command value input via S-0-0036 or motor potentiometer  
→ 2 ramps (acceleration and deceleration) and a jerk filter take effect  
**Note:** For command value input via S-0-0036, also the ramp pitches and the filter time constants can be selected from the list parameters P-0-1223, P-0-1224, P-0-1225 by the control bits in P-0-1200. This option is activated via bit 9 in "P-0-1214, Control word 2 velocity control".
- Command value input via memory of fixed command values (P-0-1206)  
→ 31 sets with individually definable command velocities, jerk limits and acceleration and deceleration ramps can be defined

### Command Value Input via S-0-0036 or Motor Potentiometer

The increase (acceleration) and deceleration of the velocity command value input via "S-0-0036, Velocity command value" or a motor potentiometer can be limited in steps via 2 ramps.

- Acceleration process  
→ In the first step, the increase of the command value is limited via "P-0-1201, Ramp 1 pitch" (acceleration ramp 1). If the command velocity exceeds the threshold entered in "P-0-1202, Final speed ramp 1" the increase of the command value is limited with the value "P-0-1203, Ramp 2 pitch" (acceleration ramp 2).
- Deceleration or braking process  
→ For deceleration "P-0-1211, Deceleration ramp 1" resp. "P-0-1213, Deceleration ramp 2" are used accordingly.



This allows parameterizing different ramps for the acceleration and braking process.

## Operation Modes

**Command Value Input via Memory  
of Fixed Command Values**

With command value input via the memory of fixed command values (P-0-1206), separate ramp values can be defined for each of the 31 fixed command values via the following list parameters:

- P-0-1223, List of acceleration ramps
- P-0-1224, List of deceleration ramps

These are single-step ramps, i.e. one ramp pitch applies to the entire speed range. Via control bits (bits 0...4) in "P-0-1200, Control word 1 velocity control", the single-step ramps can be selected.



The fixed command values (P-0-1206) and the corresponding time constants of the jerk filter (P-0-1225) are selected via the control bits in parameter P-0-1200!

The assignment of bits 0...4 of parameter P-0-1200 depends on bit 8 of parameter "P-0-1214, Control word 2 velocity control" (see "Activating the Fixed Command Values" in section "Command Value Generation via Memory of Fixed Command Values").

**Run-Up Stop**

When there is acceleration-dependent torque limitation occurring or due to installation-dependent failures/irregularities, it is necessary to interrupt the acceleration ramp. For this purpose, the function "run-up stop" was introduced that is controlled via parameter "P-0-1200, Control word 1 velocity control".

Possible settings for activating the function "run-up stop" via the respective bits of P-0-1200:

- Activation of the function without additional condition
- Triggering of torque limitation (E2060)
- Triggering of command value limitation (cf. S-0-0091)
- Triggering of command value or torque limitation



While a speed masking window is passed, the function "run-up stop" is deactivated.

**Jerk Limitation**

The velocity command value, the increase and maximum of which are limited, is jerk-limited by means of a 1st order filter.

For jerk limitation, we make the following distinction:

- Cyclic command value input via S-0-0036 or motor potentiometer  
→ Jerk limitation takes effect as set in parameter P-0-1222
- Command value input via memory of fixed command values (P-0-1206)  
→ Jerk limitation can be separately defined for each of the 31 fixed command values by an individual smoothing time constant (P-0-1225)

**Command Value Input via  
S-0-0036 or Motor Potentiometer**

The command value input via "S-0-0036, Velocity command value" or a motor potentiometer is jerk-limited according to the settings in "P-0-1222, Velocity command filter".

**Command Value Input via Memory  
of Fixed Command Values**

With command value input via the memory of fixed command values (P-0-1206), an individual filter time constant (P-0-1225, List of smoothing time constants) can be configured for each of the 31 fixed command values; the filter time constant is selected via the control bits (bits 0...4) of parameter "P-0-1200, Control word 1 velocity control".



The control bits in parameter P-0-1200 are also used to select the fixed command values (P-0-1206) and the corresponding ramp pitches (P-0-1223 and P-0-1224)!

The assignment of bits 0...4 of parameter P-0-1200 depends on bit 8 of parameter "P-0-1214, Control word 2 velocity control" (see "Activating the Fixed Command Values" in section "Command Value Generation via Memory of Fixed Command Values").

## Command Value Limitation

The effective velocity command value (sum of values from S-0-0036 and S-0-0037) is limited to the value indicated in parameter "S-0-0091, Bipolar velocity limit value" resp. in the parameters "S-0-0038, Positive velocity limit value" or "S-0-0039, Negative velocity limit value".

See also "Velocity Limitation"



When the limitation takes effect, the drive generates the message "E2059 Velocity command value limit active".

## Fine Interpolation

The limited command value available at the output of command value processing can be adjusted, by means of linear fine interpolation, for further processing in the velocity loop. To do this, a command value input in the position loop clock is fine interpolated in the velocity loop clock.

This function has to be activated via bit 0 of parameter "P-0-0556, Config word of axis controller".

## 7.3.3 Velocity Control Loop

### Velocity Loop

The velocity loop is a typical PI loop and can be set via the following parameters:

- S-0-0100, Velocity loop proportional gain
- S-0-0101, Velocity loop integral action time

See also "Control Loop Structure"

### Control Loop Performance and Cycle Times

The minimum possible control loop cycle time of the velocity loop depends

- on the available control section (CSH, CSB, CDB),
- on the respective firmware variant (MPH, MPB or MPD)

- and -

- in the case of variant MPH, on the parameterized performance (Basic or Advanced; see "P-0-0556, Config word of axis controller").

See "Performance Data"

### Current Loop in Velocity Control Loop

In velocity control, the outer current control loop (cascade structure), that can be set via the following parameters, always takes effect, too:

- S-0-0106, Current loop proportional gain 1
- S-0-0107, Current loop integral action time 1
- P-0-0001, Switching frequency of the power output stage

See also "Torque/Force Control: Current Loop"

Operation Modes

Possibilities of Filtering

To filter noise components possibly present in the actual velocity value or to attenuate resonance frequencies, the following filter settings can be made:

- Via "P-0-0004, Velocity loop smoothing time constant" the low-pass filter that filters the control difference for the velocity loop can be set.
- To filter the control deviation it is possible to configure four filters connected in series as low-pass filters or band-stop filters with "P-0-1120, Velocity control loop filter: filter type".



The "S-0-0081, Additive torque/force command value" is added to the output signal of the velocity loop and the resulting value is transmitted to the current and torque/force limit (see also "Current and Torque/Force Limitation").

7.3.4 Notes on Commissioning

Memory of Fixed Command Values

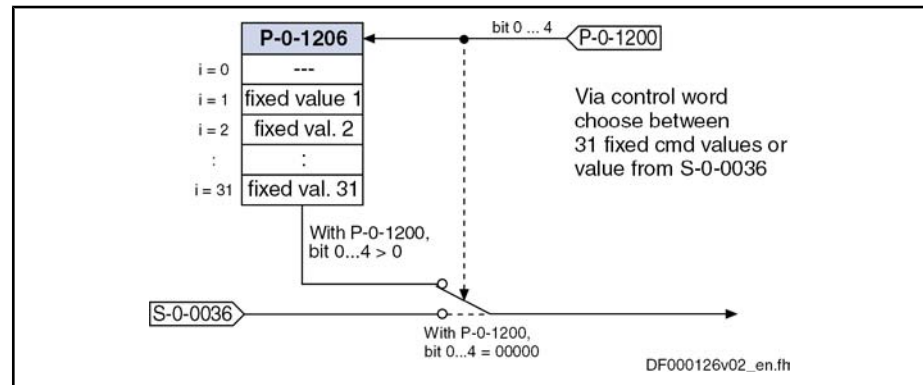
In addition to the cyclic velocity command value (S-0-0036), the drive can be moved with fixed constant velocity command values stored in the drive.

Selecting Fixed Command Values

Selecting preset fixed command values can be effectively used for applications with analog or parallel interface with which the drive is moved with constant velocity steps (e.g. jogging forward/backward, feeding, setting up, washing, ...) that are to be selected via switches/pushbuttons.

Velocity Steps

The velocity steps (max. 31 values) provided for this purpose can be entered in the list parameter P-0-1206 and each of them can be individually activated via the bits 0...4 of the control word P-0-1200 (according to a binary coding). The figure below illustrates the interaction of the parameters:



- S-0-0036 Velocity command value
- P-0-1200 Control word 1 velocity control
- P-0-1206 Memory of velocity command values

Fig.7-9: Selecting the Internally Stored Velocity Command Values

Special Cases

Observe the following special cases for selecting the fixed command values via bit 0...4 of parameter P-0-1200:

- When all 5 bits have been set to "0", the velocity command value (S-0-0036) preset by the master is active.
- If the motor potentiometer was activated via bit 0 of "P-0-1214, Control word 2 velocity control" the selected fixed command values will not take effect.

**Applying the Fixed Command Values** The command values are applied immediately, when the bit pattern is created so that you have to make sure that the bits 0...4 are, as far as possible, simultaneously updated.

If the selection of the fixed command values is switched off via bit 9 of the parameter P-0-1214, the selected fixed command values won't take effect. Instead, the command value of parameter "S-0-0036, Velocity command value".

## Motor Potentiometer

**Activating the Function** After the motor potentiometer has been activated by setting bit 0 of "P-0-1214, Control word 2 velocity control", the motor potentiometer functionality can be used.

**Using and Modifying Command Value Ramps** The command value ramps are used and modified via the two control bits, bit 8 (ramp+) and bit 9 (ramp-) of "P-0-1200, Control word 1 velocity control". These bits can be written in the following ways:

- Via digital inputs  
→ See "Digital Inputs/Outputs"
- Via the control panel (comfort or standard control panel)  
→ See "Control Panels of the IndraDrive Controllers"
- By simple writing of the parameter via the serial interface or the interface of the master communication

**Start or Initial Value for the Command Value Generator** Bits 1 and 2 of "P-0-1214, Control word 2 velocity control" determine the start value after the activation of drive enable (cf. P-0-0115, bit "drive on"); the following settings can be selected:

- **00** → Command value generator starting at command value "0"
- **01** → Command value generator starting with old command value (value is also stored when control voltage switched off!)
- **10** → Command value generator starting with current actual velocity value in S-0-0040
- **11** → Selection not allowed!

**Acceleration of the Ramps** Bit 3 of "P-0-1214, Control word 2 velocity control" determines the acceleration behavior; the following cases are to be distinguished:

- **Bit 3 = 0: Constant acceleration**  
→ Linear adjustment of command velocity  
The velocity command value is influenced with the duty cycle of "ramp+" or "ramp-" and acceleration remains constant:
  - With the control bit "ramp+", the velocity command value is increased up to the positive limit value (= minimum value of S-0-0091 and S-0-0038), with the acceleration entered in "P-0-1215, Motor potentiometer, acceleration".
  - With the control bit "ramp-", the velocity command value is decreased up to the negative limit value (= minimum value of S-0-0091 and S-0-0038), with the deceleration entered in "P-0-1216, Motor potentiometer, deceleration".
- **Bit 3 = 1: Linearly variable acceleration**  
→ Square adjustment of command velocity  
The acceleration is varied in linear form with the duty cycle of "ramp+" or "ramp-":

Operation Modes

- With the control bit "ramp+", the acceleration value within 2s is increased up to the positive limit value ("P-0-1201, Ramp 1 pitch" or "P-0-1203, Ramp 2 pitch"), with the pitch ("P-0-1215, Motor potentiometer, acceleration").
- With the control bit "ramp-", the acceleration value within 2 s is decreased up to the negative limit value ("P-0-1211, Deceleration ramp 1" or "P-0-1213, Deceleration ramp 2"), with the pitch ("P-0-1215, Motor potentiometer, acceleration").



This allows parameterizing different ramps for the acceleration and braking process.

Evaluation Mode of Ramp Inputs

Bit 3 of "P-0-1214, Control word 2 velocity control" determines the evaluation mode of the two control inputs "ramp+" and "ramp-"; the following cases are to be distinguished:

- **Bit 4 = 0: Continuous evaluation**
  - Continuous adjustment of acceleration or velocity via "ramp+" or "ramp-"
    - As long as bit 8 ("ramp+") is set, the command value is increased.
    - As long as bit 9 ("ramp-") is set, the command value is increased.
- **Bit 4 = 1: Edge-controlled evaluation**
  - Stepwise adjustment of the velocity command value with value of parameter "P-0-1217, Motor potentiometer, step size"
    - With a 0-1 edge of "ramp+", the command value is increased by the value of parameter P-0-1217.
    - With a 0-1 edge of "ramp-", the command value is decreased by the value of parameter P-0-1217.



When a control bit "ramp+" or "ramp-" f is set for more than 2 s, the mode automatically changes to continuous adjustment of the command value with the corresponding acceleration/deceleration ramp.

Examples

The figures below show some examples by means of the signal characteristic:

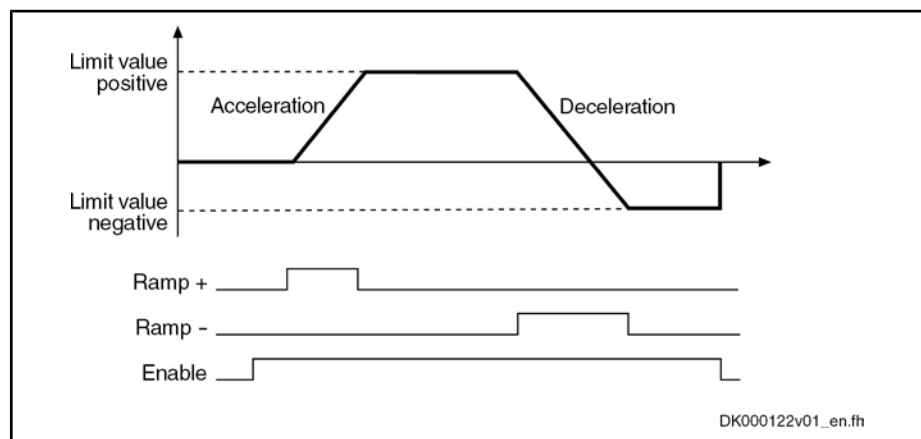


Fig.7-10: Linear Adjustment of Command Velocity With Status-Controlled Evaluation of "Ramp+" and "Ramp-"

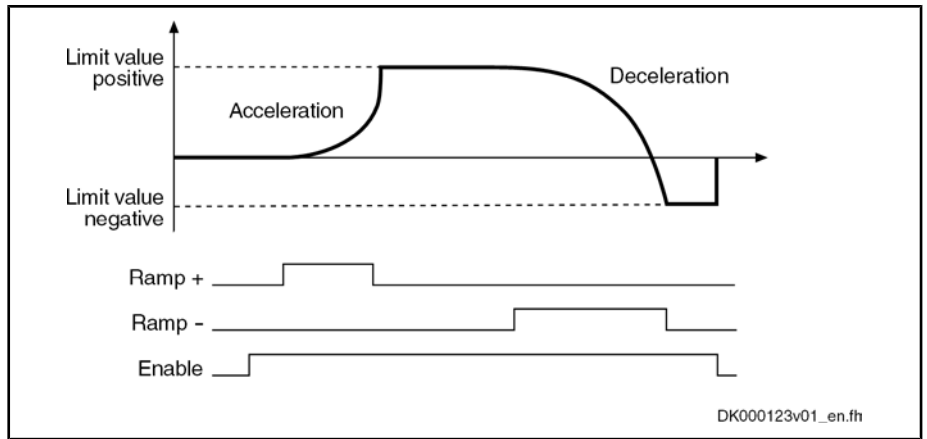


Fig. 7-11: Square Adjustment of Command Velocity With Status-Controlled Evaluation of "Ramp+" and "Ramp-"

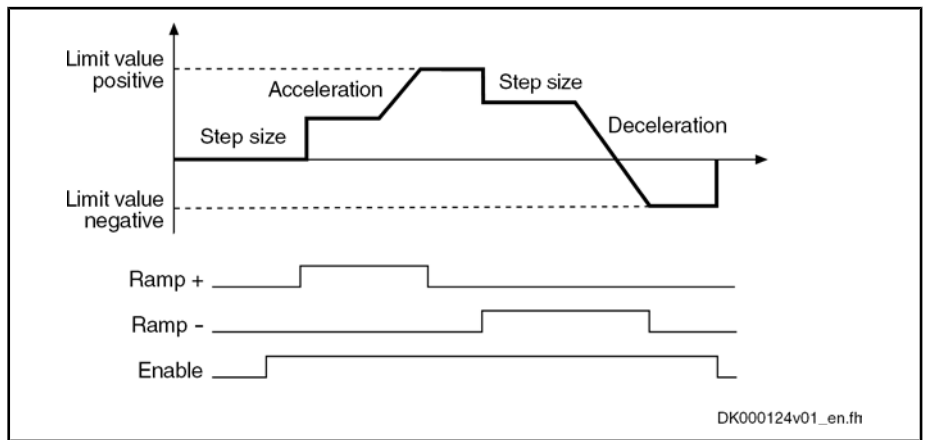


Fig. 7-12: Linear Adjustment of Command Velocity With Edge-Controlled Evaluation of "Ramp+" and "Ramp-"

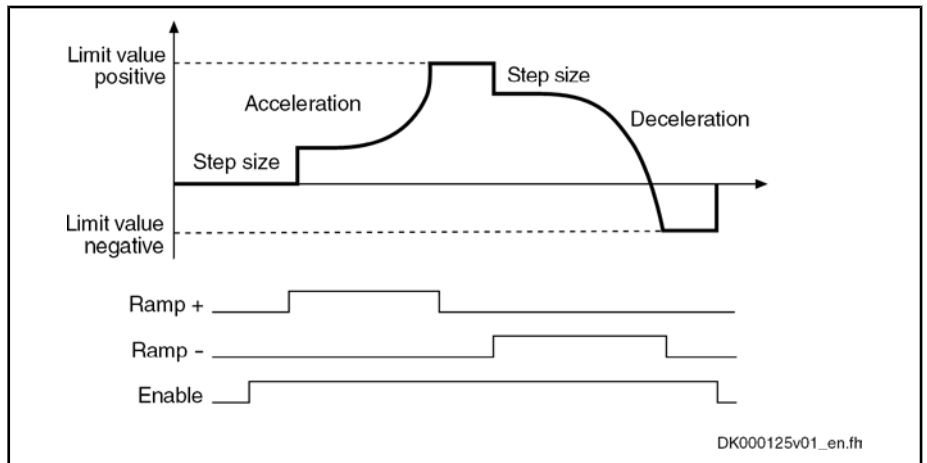


Fig. 7-13: Square Adjustment of Command Velocity With Edge-Controlled Evaluation of "Ramp+" and "Ramp-"

## Velocity Mixing

Via "P-0-1119, Velocity mix factor feedback 1 & 2" it is possible to mix the different actual encoder values in the case of control-related stability problems.

## Operation Modes

## Acceleration Feedforward

To improve the control performance it is possible to add the speed command value, bypassing the velocity controller, to the velocity controller output in a derivative way and scaled via "P-0-1126, Velocity control loop: acceleration feedforward". This differentiated command value can also be smoothed by means of a PT1 filter (cf. P-0-0180).

This kind of feedforward allows achieving sufficiently good and dynamic control performance, even with bad measuring systems or a very high degree of load inertia (or mass).

See also "Control Loop Structure"

## Masking the Velocity Command Value

For each velocity window (cf. P-0-1207, P-0-1208), it is possible to define an individual acceleration factor (cf. P-0-1209) that takes effect, however, both for acceleration and for deceleration.

When parameterizing the velocity windows, the following aspects have to be taken into account:

- The list elements have to contain ascending numeric values (identical values are allowed).
- Inputs that lead to overlapping ranges ( $P-0-1207[n] > P-0-1208[n+1]$ ) are not allowed.
- When identical values are input for lower and upper limit ( $P-0-1207[n] = P-0-1208[n]$ ), the window is deactivated.
- If the element  $P-0-1207[0] = 0$ , the window takes effect symmetrically relative to speed zero. This prevents the velocity command value from falling below a certain minimum value.



The default value of P-0-1207 and P-0-1208 is zero which means that the speed window has not been defined.

## 7.3.5 Diagnostic Messages and Monitoring Functions

### Diagnostic Status Message

**Active Operation Mode** The activated "velocity control" mode is displayed by the following diagnostic message:

- A0101 Velocity control

### Status of Ramp-Function Generator

**Effective Velocity Command Value** The currently effective velocity command value at the output of command value adjustment, that is preset for the velocity loop via the fine interpolation, is mapped to "P-0-0048, Effective velocity command value".

**Status of Ramp-Function Generator (Run-Up Encoder)** "Frequency converter" applications require several status messages that are contained in "P-0-1210, Status word of velocity control mode":

- Bit 0 = 1 → Command value reached  
The output of the ramp-function generator, including the jerk filter, corresponds exactly to the selected command value, i.e. either to the value of S-0-0036 or a selected fixed value from P-0-1205.
- Bit 1 = 1 → Run-up stop active  
The command "run-up stop" prevents the acceleration ramp from being integrated. The jerk filter is not stopped, the current command value for the time set in the jerk filter can change.



- Bit 2 = 1 → Acceleration active  
The absolute value of the present command value is higher than the current command value. Either the acceleration ramp is active or the jerk filter has not yet reached the final value.
- Bit 3 = 1 → Deceleration active  
The absolute value of the present command value is lower than the current command value. Either the deceleration ramp is active or the jerk filter has not yet reached the final value.
- Bit 4 = 1 → Command value within masking window  
The command value is within a masking window defined by the values of P-0-1207 and P-0-1208 and prevents the drive from moving exactly to this command value.
- Bit 5 = 1 → Velocity ramp within masking window  
The ramp-function generator goes through the range of a masking window, the increased acceleration/deceleration according to P-0-1209 is active. In addition to this message bit, either the bit "acceleration active" or "deceleration active".

## Monitoring Functions

	Monitoring functions specific to the operation mode:
<b>Velocity Command Value Limit Active</b>	<ul style="list-style-type: none"> <li>• The effective velocity command value (sum from S-0-0036 and S-0-0037) is limited to the value indicated in "S-0-0091, Bipolar velocity limit value". When the limitation takes effect, the drive generates the message "E2059 Velocity command value limit active".</li> </ul>
<b>Velocity Command Value &gt; Limit Value</b>	<ul style="list-style-type: none"> <li>• The value of the parameter "S-0-0036, Velocity command value" is limited to "S-0-0091, Bipolar velocity limit value". If the value in S-0-0036 is higher than the value in S-0-0091, the warning "E2063 Velocity command value &gt; limit value" is generated.</li> </ul>
<b>Speed Loop Error</b>	<ul style="list-style-type: none"> <li>• The drive monitors the correct function of the velocity loop and in the case of fatal errors disables the drive torque with the error message F8078 "F8078 Speed loop error".</li> </ul>
<b>Velocity Limit Value Exceeded</b>	<ul style="list-style-type: none"> <li>• The value of the parameter "S-0-0040, Velocity feedback value" is monitored, as soon as it is outside the standstill window S-0-0124. If it exceeds the 1.125-Fold Value Parameterized in "S-0-0091, Bipolar velocity limit value", the Error Message "F8079 Velocity limit value exceeded" is Generated.</li> </ul>

## 7.4 Position Control With Cyclic Command Value Input

### 7.4.1 Brief Description



Assignment to functional firmware package, see chapter "Supported Operation Modes".

In the "position control" mode, a cyclic position command value is preset for the drive in NC cycle time. This command value is fine interpolated in the drive and jerk-limited via filters, if necessary, before being transmitted to the position loop. To minimize the lag error, variable acceleration feedforward is available in addition to variable velocity feedforward.

There are different forms of the "position control" mode which result in the corresponding diagnostic messages when the operation mode was activated (see below "Pertinent Diagnostic Messages").

## Operation Modes

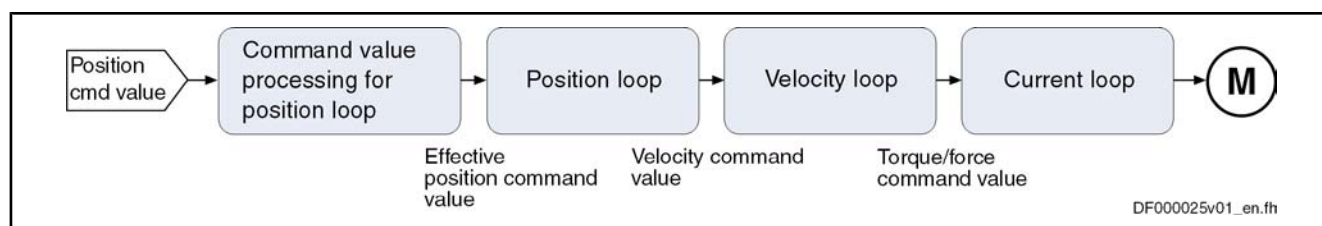


Fig. 7-14: Block Diagram "Position Control With Cyclic Command Value Input"

- Features**
- Position control with regard to the command value preset in "S-0-0047, Position command value"
  - NC-controlled or drive-controlled position control with internal, dynamic synchronization when changing operation modes
  - Timebase for cyclic command value input defined by "S-0-0001, NC cycle time (TNcyc)"
  - Monitoring the position command value difference for exceeding "S-0-0091, Bipolar velocity limit value"
  - Position command values of the control unit smoothed by means of adjustable average value filter; calculation from acceleration and jerk limit values; display in "P-0-0042, Current position command average value filter order"
  - fine interpolation of position command value of the control unit to position controller clock; can be switched by means of parameter "P-0-0187, Position command processing mode"
  - Adjustable deceleration of position command value in position clocks (P-0-0456), maximum 32 clocks.
  - Position control with regard to actual position value encoder 1 (motor encoder) or actual position value encoder 2 [external (load-side) encoder], can be dynamically switched
  - Velocity feedforward through adjustable factor of 0...150 % (default = 100 %)
  - Acceleration monitor for position command value can be switched on (P-0-0556, bit 15)



The condition for this operation mode is synchronous communication between the control unit and the drive, as it is the case with SERCOS interface, for example.

- Pertinent Parameters**
- S-0-0047, Position command value
  - S-0-0091, Bipolar velocity limit value
  - S-0-0138, Bipolar acceleration limit value
  - S-0-0520, Control word of axis controller
  - P-0-0010, Excessive position command value
  - P-0-0011, Last valid position command value
  - P-0-0041, Position command average value filter time constant
  - P-0-0042, Current position command average value filter order
  - P-0-0047, Position command value control
  - P-0-0059, Additive position command value, controller
  - P-0-0099, Position command smoothing time constant
  - P-0-0142, Synchronization acceleration

- P-0-0143, Synchronization velocity
  - P-0-0187, Position command processing mode
  - P-0-0434, Position command value of controller
  - P-0-0456, Position command value delay
  - P-0-0457, Position command value generator
  - P-0-0556, Config word of axis controller
- Pertinent Diagnostic Messages**
- A0102 Position mode, encoder 1
  - A0103 Position mode, encoder 2
  - A0104 Position mode lagless, encoder 1
  - A0105 Position mode lagless, encoder 2
  - A0154 Position mode drive controlled, encoder 1
  - A0155 Position mode drive controlled, encoder 2
  - A0156 Position mode lagless, encoder 1 drive controlled
  - A0157 Position mode lagless, encoder 2 drive controlled
  - F2036 Excessive position feedback difference
  - F2037 Excessive position command difference

## 7.4.2 Command Value Adjustment in Position Control

### NC- or Drive-Controlled Position Control

We distinguish the following characteristics of the operation mode "position control with cyclic command value input":

- **NC-controlled position control** (cf. A0102 to A0105)

The drive generally follows the position command values cyclically input by the master in the NC cycle.

- **Drive-controlled position control** (cf. A0154 to A0157)

In the case of a change of operation mode to cyclic position control, the drive realizes the corresponding synchronization process, i.e. it generates, internally by means of the internal synchronization parameters (P-0-0142, P-0-0143, P-0-0154, P-0-015), a smooth transition of the internal position command value from the current actual position to the new command value characteristic input by the NC. After the synchronization process has been completed, the drive follows the position command values input by the master in the NC cycle.



The command value cyclically transmitted by the control unit is displayed in "P-0-0047, Position command value control".

The internal position command value at the position controller is displayed in "P-0-0434, Position command value of controller". If required, it can also be written via "S-0-0047, Position command value".

---

### Command Value Filtering (Jerk Limitation)

The position command values preset by the control unit can be smoothed via an average value filter that can be set ("P-0-0041, Position command average value filter time constant", moving average filter for a maximum of 64 values). The resulting filter degree is displayed via "P-0-0042, Current position command average value filter order". This filter can be used for jerk limitation.

In the case of drive-controlled position control, a jump of the position command value is traveled by a change of the position command average value filter with synchronization motion in control.

## Operation Modes



The PT1 filter for jerk limitation that can be parameterized via "P-0-0099, Position command smoothing time constant" only takes effect for linear fine interpolation.

---

### Fine Interpolation of the Position Command Value

The position command value cyclically transmitted in the NC cycle time by the control unit can be fine interpolated in the drive, if necessary.

Via "P-0-0187, Position command processing mode", it is possible to switch between:

- Cubic fine interpolator (according to contour),
- Linear fine interpolator or
- Cubic approximator.



See also Parameter Description "P-0-0187, Position command processing mode"

---



It is recommended to use the cubic fine interpolator according to contour (default setting), because it provides clearly higher quality of velocity and acceleration feedforward, particularly with lagless position control.

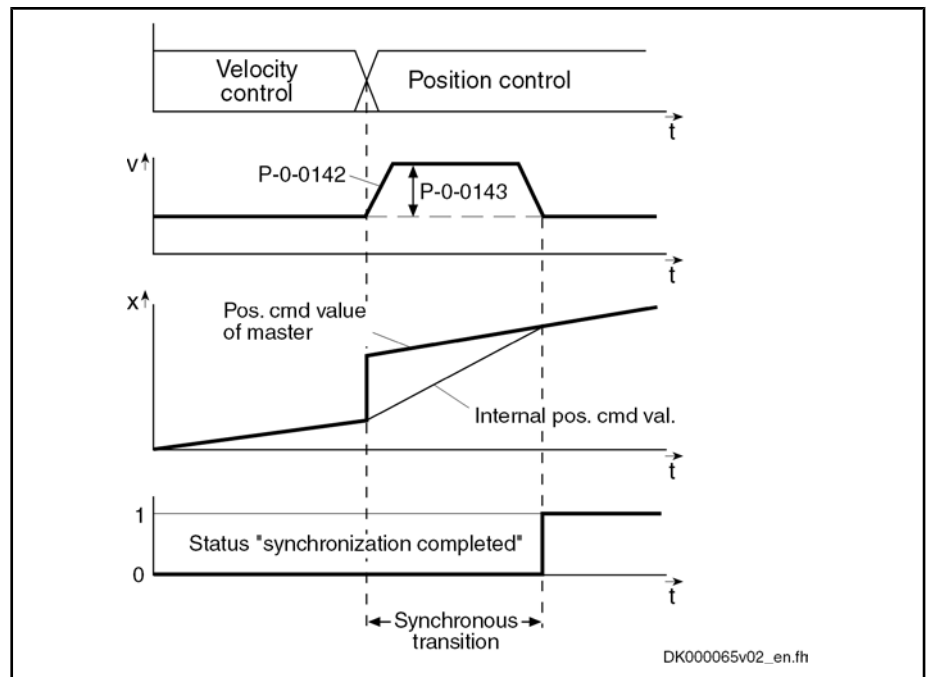
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### Position Command Value Deceleration

The position command value can be delayed by maximum 32 position clocks after the fine interpolator, before it is fed in the position controller. This allows synchronous control of a master axis with the controlled slave axis. The number of position clocks is set with the position command value delay (P-0-0456). The position command value generator without delay (P-0-0457) is entered in a ring buffer and then the position command value with delay is applied in the position command value controller (P-0-0434).

### Drive-Controlled Change of Operation Mode

During drive-controlled change of operation mode, the drive makes sure internally that when the operation mode is changed, the transition is carried out in a synchronized way, even if the command value changes abruptly.



P-0-0142 Synchronization acceleration  
 P-0-0143 Synchronization velocity

Fig.7-15: Chronological Diagram "Drive-Controlled Change of Operation Mode"

See also "Changing the Operation Mode"

**Block Diagram** The figure below illustrates command value processing in the "position control" mode as a block diagram.

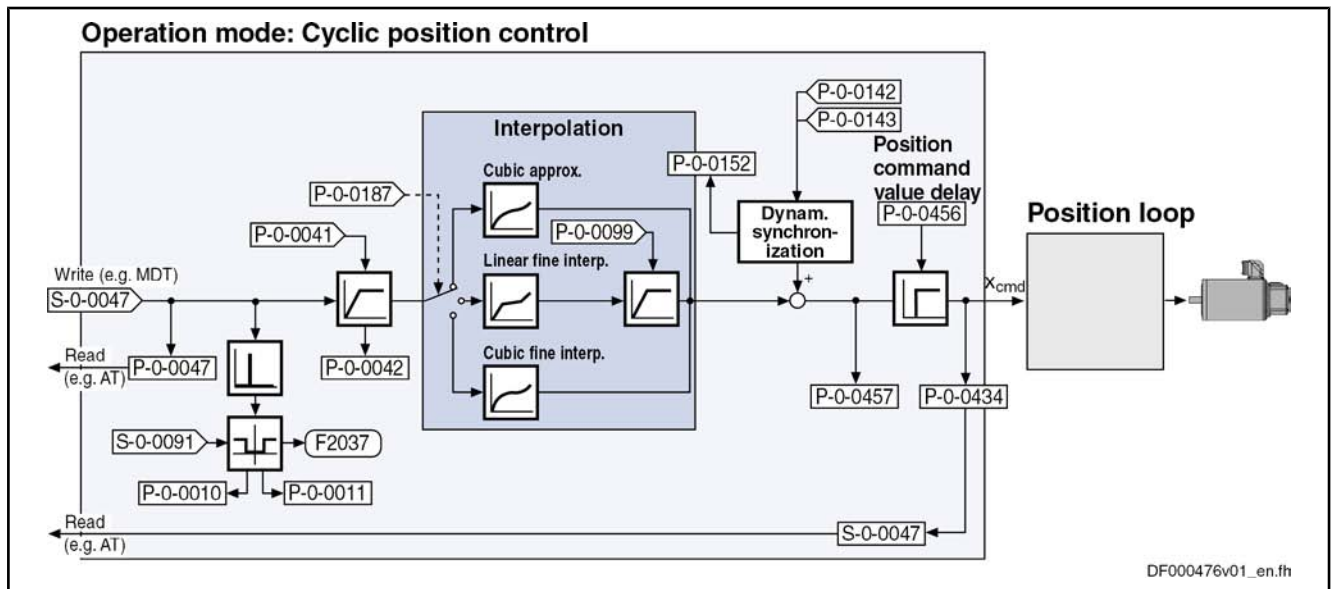


Fig.7-16: Command Value Adjustment in Position Control

See also "Position Loop" in the same section

See also "Velocity Loop" in section "Velocity Control"

See also "Current Loop" in section "Torque/Force Control"

## Operation Modes

### 7.4.3 Position Loop

The position controller is a simple P-controller, its proportional gain can be set with the value of "S-0-0104, Position loop Kv-factor".

See also "Control Loop Structure"

**Control Loop Performance and Cycle Times**

The position control loop is closed according to the available performance design (see "Performance Data").

According to the application it is possible to set via bit 3 of the operation mode parameters (S-0-0032 to S-0-0035):

- Lagless operation (**with** velocity feedforward)
- Operation with lag error (**without** velocity feedforward)

The lag error is the difference between position command value and actual position value. The current value is stored in "S-0-0189, Following distance".

The kind of position control (lagless, with lag error) can be set via "S-0-0520, Control word of axis controller".



If the mechanical system and the application permit it, lagless operation should always be selected.

---

**Possibilities of Feedforward**

In lagless operation variable acceleration feedforward can be activated in addition to variable velocity feedforward ("P-0-0040, Velocity feedforward evaluation").

To do this, the acceleration-proportional feedforward component (additive current command value) is set via parameter "S-0-0348, Acceleration feedforward gain" and the velocity-proportional feedforward component (additive velocity command value) is set via "P-0-0040, Velocity feedforward evaluation".

This allows setting the lag error to a desired percentage value at constant velocity.



In lagless operation and with P-0-0040 = 100%, there is a minimum lag error of "0" at constant velocity.

---



In addition, it is possible to realize feedforward via "P-0-1126, Velocity control loop: acceleration feedforward", but this feedforward is derived from the velocity command value. Therefore, you have to make sure that you didn't activate both feedforward values by mistake!

---

See also "Axis Control: Position Loop (With Respective Feedforward Functions and Actual Value Adjustment)"

### 7.4.4 Diagnostic Messages and Monitoring Functions

**Diagnostic Status Messages**

The activated "position control with cyclic command value input" mode is displayed by one of the following diagnostic messages:

- A0102 Position mode, encoder 1
- A0103 Position mode, encoder 2
- A0104 Position mode lagless, encoder 1
- A0105 Position mode lagless, encoder 2
- A0154 Position mode drive controlled, encoder 1
- A0155 Position mode drive controlled, encoder 2

- A0156 Position mode lagless, encoder 1 drive controlled
- A0157 Position mode lagless, encoder 2 drive controlled

## Monitoring Functions/Diagnostic Messages Specific to Operation Mode

### Monitoring for Single Position Command Value Failure

#### Position Command Value Extrapolation

In the "position control with cyclic command value input" mode, new position command values are transmitted to the drive in every NC cycle. The difference between the current and the last position command value is determined and a validation check is carried out for this difference.

Reasons why the monitoring function triggers:

- Incorrect command value input by control unit
- Command value transmission error



In the case of single command value failure, the position command value is extrapolated.

### Excessive Position Command Difference

When the "position control" mode was activated, the calculated velocity required for reaching the preset position command value (S--0-0047) is compared to "S-0-0091, Bipolar velocity limit value". The NC cycle time (TN<sub>cyc</sub> in S-0-0001) is used as the time base for converting the position command value differences into a velocity.

If the command velocity corresponding to the preset position command value exceeds the value in S--0-0091, the error message "F2037 Excessive position command difference" is generated. In addition, the two involved command values are written to the following parameters:

- P-0-0010, Excessive position command value
- P-0-0011, Last valid position command value

The velocity resulting from the difference of these two values generated the error message.

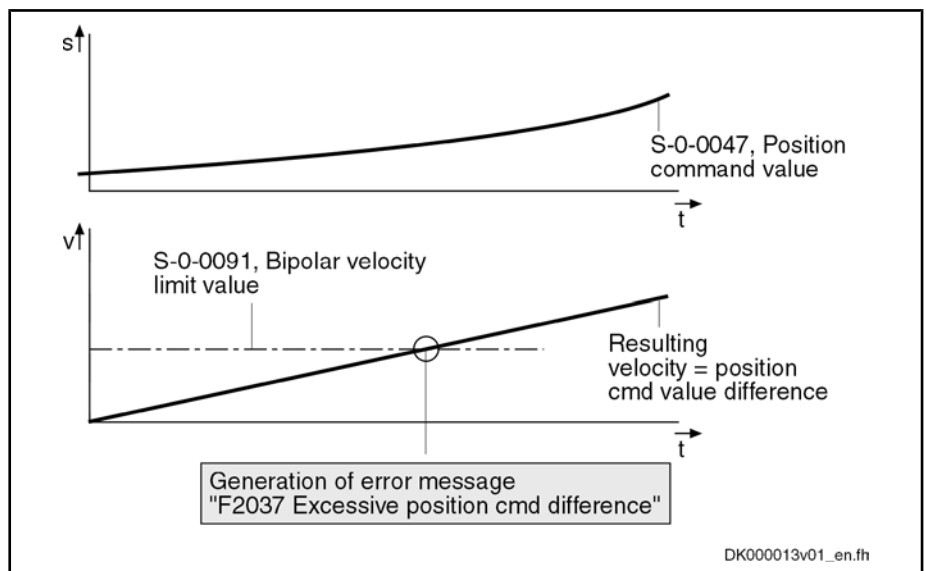


Fig.7-17: Monitoring for Error "F2037 Excessive Position Command Difference"

Operation Modes



The value entered in "S-0-0091, Bipolar velocity limit value" should be approximately 5 to 10% above the intended maximum velocity of the axis.

**Maximum Acceleration Exceeded**

In "P-0-0556, Config word of axis controller" (bit 15), it is possible to set that the command acceleration is monitored for compliance with "S-0-0138, Bipolar acceleration limit value". When the value of S-0-0138 is exceeded, the "F2037 Excessive position command difference" error message is generated.

## 7.5 Drive-Internal Interpolation

### 7.5.1 Brief Description



Assignment to functional firmware package, see chapter "Supported Operation Modes".

The operation modes "drive-internal interpolation" and "drive-controlled positioning" allow time-optimized positioning of a single axis. The "drive-internal interpolation" mode is the basis for the more comprehensive functionality of the "drive-controlled positioning" mode.

In the "drive-internal interpolation" mode, a target position is directly preset for the drive. In the internal positioning generator, a position command value characteristic is generated (interpolated), from the preset value for the target position considering preset positioning data (velocity, acceleration and jerk), as the input value for the position loop.

There are different forms of the "drive-internal interpolation" mode which result in the corresponding diagnostic messages when the operation mode was activated (see below "Pertinent Diagnostic Messages").

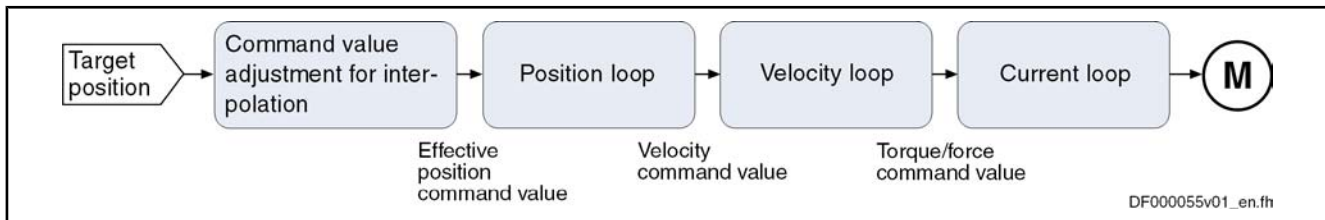


Fig.7-18: Block Diagram "Drive-Internal Interpolation"

- Features**
- Drive-internal generation of a position command value profile to travel to a preset target position (S-0-0258) while maintaining the positioning velocity (S-0-0259) and positioning acceleration (S-0-0260) or positioning deceleration (S-0-0359) that can be set; can be set separately
  - Jerk limitation of the generated position command value via "S-0-0193, Positioning Jerk"
  - Setting of the average value filter (jerk limitation) to fixed filter time with IPO command value average value filter time constant (P-0-0641)
  - Adjustable deceleration of position command value in position clocks (P-0-0456, Position command value delay), maximum 32 clocks.
  - Evaluation of the positioning velocity with "S-0-0108, Feedrate override"
  - Monitoring of the positioning velocity for exceeding "S-0-0091, Bipolar velocity limit value"



- Monitoring of the target position for compliance with the position limit values
- Command value mode can be set (S-0-0393) in modulo format (shortest distance, only positive or only negative direction)
- Position control with regard to "S-0-0051, Position feedback value 1" (motor encoder) or "S-0-0053, Position feedback value 2" [external (load-side) encoder]
- Acceleration and deceleration ramps, can be set separately
- No change in direction of motion when "command value mode in modulo format" equal "shortest distance", if  $v_{act} > S-0-0417$
- "Shortest distance" mode when "command value mode in modulo format" equal "only positive/negative direction of motion" and target position within "S-0-0418, Target position window in modulo mode"



In this operation mode, it is possible to separately parameterize the acceleration and deceleration processes. This allows optimum adjustment to the respective application-specific requirements.

#### Pertinent Parameters

- S-0-0108, Feedrate override
- S-0-0138, Bipolar acceleration limit value
- S-0-0193, Positioning Jerk
- S-0-0258, Target position
- S-0-0259, Positioning velocity
- S-0-0260, Positioning acceleration
- S-0-0342, Status "Target position attained"
- S-0-0343, Status "Interpolator halted"
- S-0-0359, Positioning deceleration
- S-0-0393, Command value mode
- S-0-0417, Positioning velocity threshold in modulo mode
- S-0-0418, Target position window in modulo mode
- S-0-0430, Effective target position
- S-0-0437, Positioning status
- P-0-0059, Additive position command value, controller
- P-0-0434, Position command value of controller
- P-0-0456, Position command value delay
- P-0-0457, Position command value generator
- P-0-0556, Config word of axis controller
- P-0-0641, Interpolation cmd value average value filter time constant

#### Pertinent Diagnostic Messages

- A0106 Drive controlled interpolation, encoder 1
- A0107 Drive controlled interpolation, encoder 2
- A0108 Drive controlled interpolation, lagless, encoder 1
- A0109 Drive controlled interpolation, lagless, encoder 2
- E2049 Positioning velocity  $\geq$  limit value
- E2053 Target position out of travel range
- E2055 Feedrate override S-0-0108 = 0

## Operation Modes

- F2057 Target position out of travel range

## 7.5.2 Command Value Adjustment With Drive-Internal Interpolation

The target position can be cyclically preset via "S-0-0258, Target position".

The drive generates the position command value profile necessary to move to the target position, considering the requirements defined in the following parameters:

- S-0-0108, Feedrate override
- S-0-0193, Positioning Jerk
- S-0-0259, Positioning velocity
- S-0-0260, Positioning acceleration
- S-0-0359, Positioning deceleration



The target position preset by the control master is displayed in "S-0-0430, Effective target position".

The figure below illustrates command value processing in the "drive-internal interpolation" mode as a block diagram.

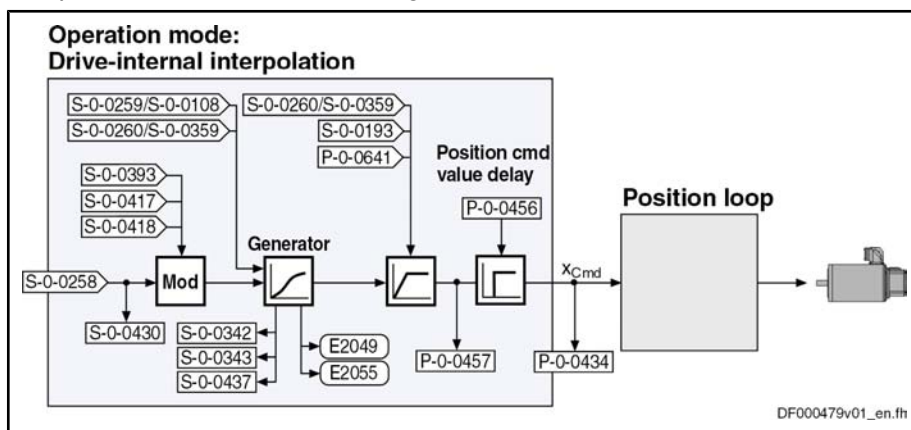


Fig. 7-19: Command Value Adjustment With "Drive-Internal Interpolation"

## 7.5.3 Position Loop With Drive-Internal Interpolation

The position command value generated at the output of the command value generator is displayed in p"P-0-0434, Position command value of controller" and can be output at the analog output.

In this operation mode, the same information as relevant in the "position control with cyclic command value input" mode applies to the position control loop.

See also "Control Loop Structure"

See also "Position Loop" in section "Position Control With Cyclic Command Value Input"

## 7.5.4 Notes on Commissioning

### Effective Positioning Velocity

The drive reaches its maximum velocity after an acceleration phase with the value set in "S-0-0260, Positioning acceleration".

The maximum velocity during a positioning procedure is the result of:

$$v_{\max} = S-0-0259 \times \frac{S-0-0108}{100 \%}$$

S-0-0259 Positioning velocity

S-0-0108 Feedrate override

Fig.7-20: Determining the Maximum Velocity During the Positioning Process

## Effective Acceleration and Deceleration

The maximum deceleration is defined in parameter "S-0-0359, Positioning deceleration".

If the value in parameter S-0-0359 equals zero, the drive uses the parameter value of "S-0-0260, Positioning acceleration" for deceleration, too.

If the value in parameter S-0-0260 equals zero, too, the parameter value of "S-0-0138, Bipolar acceleration limit value" is used. If this value has likewise been set to zero, acceleration is not limited. If possible, the drive sets the positioning velocity immediately.

## Smoothing Filter (or Jerk Filter)

In the "drive-internal interpolation" mode the position command value can be filtered at the output of the positioning generator. We distinguish between two cases for setting of the filter order.

### Case 1: Calculating the filter order from A / R

The filter order of the (moving) average filter available to do this (cf. P-0-0042) is calculated on the basis of the preset positioning acceleration or the positioning jerk.

This means that the parameterized acceleration or deceleration only becomes effective after  $t = P-0-0042 \times T_{A\_position}$ .



In this case,  $T_{A\_position}$  is the cycle time of the position loop or the positioning generator. Therefore, the cycle time to be used is different according to the control performance (Advanced: 250  $\mu$ s, Basic: 500  $\mu$ s).

$$P-0-0042 = \frac{S-0-0260}{S-0-0193} [s] \cdot \frac{10^6}{T_{A\_Lage}}$$

– or –

$$P-0-0042 = \frac{S-0-0359}{S-0-0193} [s] \cdot \frac{10^6}{T_{A\_Lage}}$$

P-0-0042 Current position command average value filter order

S-0-0260 Positioning acceleration

S-0-0193 Positioning jerk

S-0-0359 Positioning deceleration

Fig.7-21: Internally Determining the Value of P-0-0042 for Operation Modes With "Drive-Internal Interpolation"



The setting S-0-0193 = 0 switches the smoothing filter off; i.e. the desired acceleration or deceleration is immediately reached.

## Operation Modes

### Case 2: Constant filter order

The filter order can also be set to a constant value. This is made via parameter "P-0-0641, Interpolation cmd value average value filter time constant". The filter order is calculated from the time constant related to the position clock  $T_{A\_position}$ . In the case of an order  $> 0$  the function "filter order constant" is active and the calculation A/R without effect. A new filter order can only take effect during initialization of the operation mode and during change of blocks. As before, the current filter order is displayed in "P-0-0391, Current position command average value filter order"!

## Position Command Value Deceleration

The position command value can be delayed by maximum 32 position clocks after the jerk filter, before it is fed in the position controller. This allows synchronous control of a master axis with the controlled slave axis. The number of position clocks is set with the position command value delay (P-0-0456). The position command value generator without delay (P-0-0457) is entered in a ring buffer and then the position command value with delay is applied in the position command value controller (P-0-0434).

## Modulo Processing

"S-0-0393, Command value mode" controls the drive behavior in the case of **position processing in modulo format**.

The following definition applies to "S-0-0393, Command value mode":

- Bit 1/0 = 00 → Positive direction of rotation
- Bit 1/0 = 01 → Negative direction of rotation
- Bit 1/0 = 10 → Shortest distance



See also Parameter Description "S-0-0393, Command value mode"

### Special Cases

The following special cases apply to the evaluation of the settings for "S-0-0393, Command value mode":

- If the absolute value of the current actual velocity is greater than the velocity threshold for positioning (S-0-0417, Positioning velocity threshold in modulo mode), the drive always moves in the last active direction of rotation.
- If the target position is within the target position window (S-0-0418), positioning is always carried out according to the "shortest distance" mode.



If the velocity threshold for positioning behavior was parameterized with very low values that are within the noise level of the actual velocity value, this can cause unpredictable behavior.



See also Parameter Description "S-0-0417, Positioning velocity threshold in modulo mode", "S-0-0418, Target position window in modulo mode" and "S-0-0430, Effective target position"

## 7.5.5 Diagnostic Messages and Monitoring Functions

### Diagnostic Status Messages

The activated "drive-internal interpolation" mode is displayed by one of the following diagnostic messages:

- A0106 Drive controlled interpolation, encoder 1

- A0107 Drive controlled interpolation, encoder 2
- A0108 Drive controlled interpolation, lagless, encoder 1
- A0109 Drive controlled interpolation, lagless, encoder 2

## Monitoring Functions

Monitoring functions specific to the operation mode:

### Target Position out of Travel Range

- If position limit value monitoring is activated (bit 4 of "S-0-0055, Position polarities" has been set) and the measuring system used for the operation mode has been homed, the parameter "S-0-0258, Target position" is monitored for compliance with the position limit values (S-0-0049 or S-0-0050). If these values are exceeded, depending on the definition in "P-0-0090, Travel range limit parameter", either the error message F2057 Target position out of travel range or the warning "E2053 Target position out of travel range" is generated. If the warning has been parameterized, positioning to the limit switches takes place.

The preset target position will not be accepted.

### Positioning Velocity >= Limit Value

- If the preset positioning velocity ("S-0-0259, Positioning velocity") exceeds the maximum allowed limit value ("S-0-0091, Bipolar velocity limit value"), the warning "E2049 Positioning velocity >= limit value" is generated.

The drive moves to the new target position with the velocity from parameter "S-0-0091, Bipolar velocity limit value".

### Feedrate Override (S-0-0108) = 0

- If the positioning velocity factor "S-0-0108, Feedrate override" equals zero, the warning "E2055 Feedrate override S-0-0108 = 0" is generated.

## Status Messages

"S-0-0437, Positioning status" contains all important status information for the operation mode "drive-internal interpolation".



See Parameter Description "S-0-0437, Positioning status"

The figures below illustrate the operating principle of the status messages:

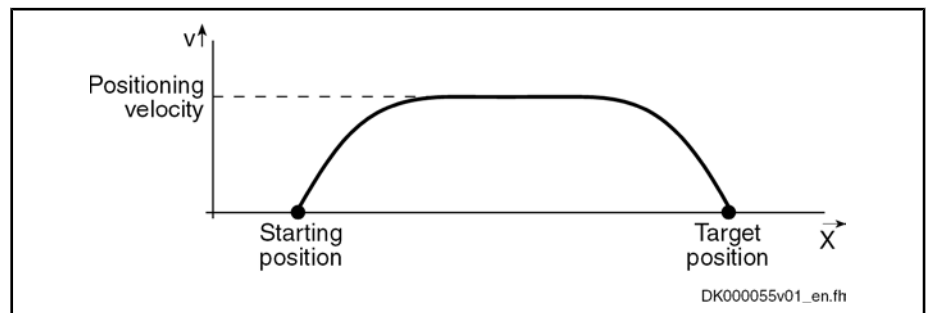


Fig.7-22: Travel Profile to Explain how the Interpolation Status Messages Work

In this example, the drive is at the starting position when the new target position is preset.

The result is the following time diagram:

## Operation Modes

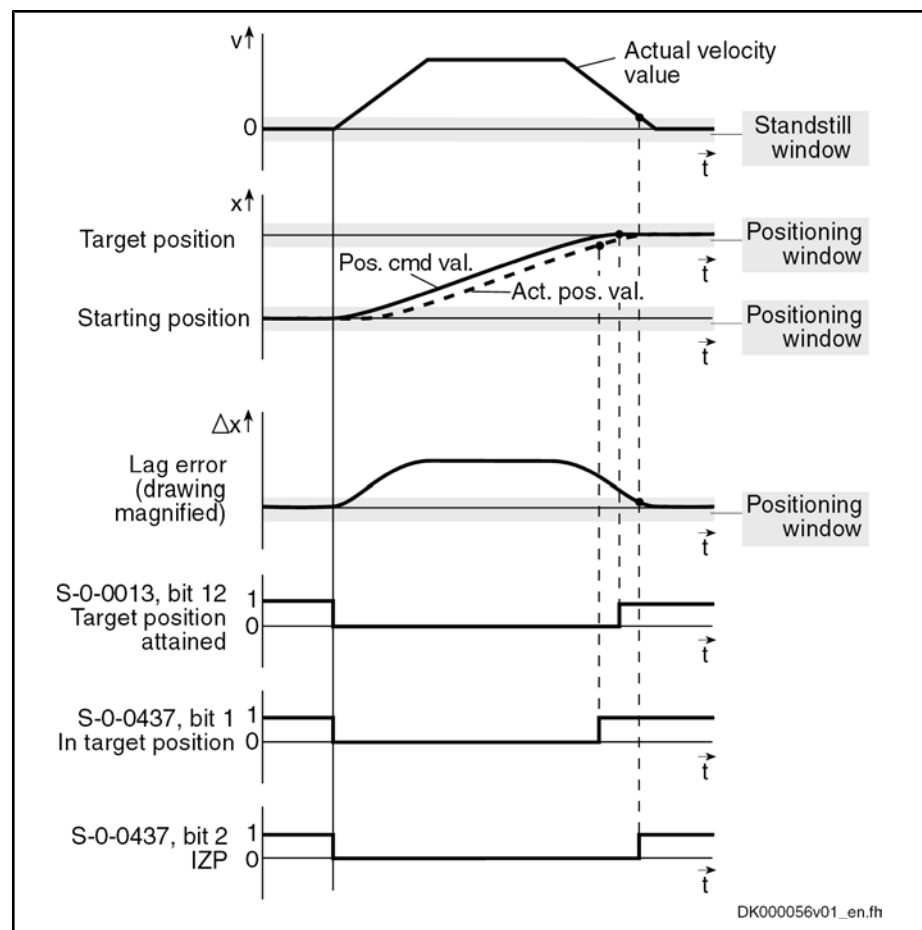


Fig. 7-23: *Generating the Status Bits of the Operation Modes With "Drive-Internal Interpolation"*

## 7.6 Drive-Controlled Positioning

### 7.6.1 Brief Description



Assignment to functional firmware package, see chapter "Supported Operation Modes".

The operation modes "drive-internal interpolation" and "drive-controlled positioning" allow time-optimized positioning of a single axis. The "drive-internal interpolation" mode is the basis for the more comprehensive functionality of the "drive-controlled positioning" mode.

In the "drive-controlled positioning" mode, a positioning command value is preset for the drive. The drive can continue processing this value internally in absolute (position target) or relative (travel distance) form. In the internal interpolator, a position command value characteristic is generated as the input value for the position loop from the preset positioning data (effective target position, velocity, acceleration and jerk).

There are different forms of the "drive-controlled positioning" mode which result in the corresponding diagnostic messages when the operation mode was activated (see below "Pertinent Diagnostic Messages").

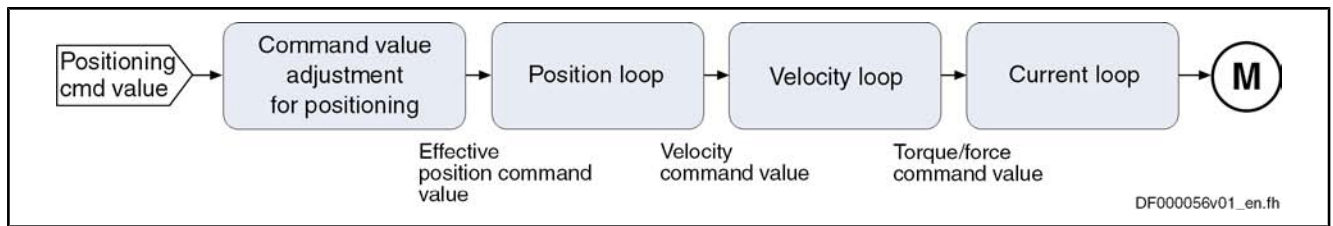


Fig.7-24: Block Diagram "Drive-Controlled Positioning"

#### Features

- Processing of an absolute target position or a relative travel distance
- Drive-internal generation of a position command value profile to travel to the positioning command value (S-0-0282) while maintaining the positioning velocity (S-0-0259) and positioning acceleration (S-0-0260) or positioning deceleration (S-0-0359) that can be set; can be set separately
- Acceptance of the positioning command value via toggle bit (S-0-0346, bit 0)
- Jerk limitation of the generated position command value with "S-0-0193, Positioning Jerk"
- Setting of the average value filter (jerk limitation) to fixed filter time with IPO command value average value filter time constant (P-0-0641)
- Adjustable deceleration of position command value in position clocks (P-0-0456), maximum 32 clocks.
- Evaluation of the positioning velocity with "S-0-0108, Feedrate override"
- Monitoring of the positioning velocity for exceeding the value in "S-0-0091, Bipolar velocity limit value"
- Monitoring of the target position for compliance with the position limit values (see "S-0-0049, Positive position limit value", "S-0-0050, Negative position limit value")
- Command value mode can be set in modulo format in "S-0-0393, Command value mode" (shortest distance, positive only or negative only direction, no reversal of direction of rotation)
- Position control with regard to "S-0-0051, Position feedback value 1" (motor encoder) or "S-0-0053, Position feedback value 2" [external (load-side) encoder]
- Acceleration and deceleration ramps can be set separately ("S-0-0260, Positioning acceleration" or "S-0-0359, Positioning deceleration")
- Position limit values taken into account when accepting target position, positioning velocity and positioning acceleration
- Jog mode ("infinite travel" positive/negative; S-0-0346, bits 1 and 2)
- Residual path processing can be activated
- "On-the-fly acceptance" of the new target position or intermediate stop



In this operation mode, it is possible to separately parameterize the acceleration and deceleration processes in order to achieve optimum adjustment to the respective application-specific requirements.

#### Pertinent Parameters

- S-0-0057, Position window
- S-0-0108, Feedrate override
- S-0-0138, Bipolar acceleration limit value
- S-0-0193, Positioning Jerk

## Operation Modes

- S-0-0259, Positioning velocity
- S-0-0260, Positioning acceleration
- S-0-0282, Positioning command value
- S-0-0342, Status "Target position attained"
- S-0-0343, Status "Interpolator halted"
- S-0-0346, Positioning control word
- S-0-0359, Positioning deceleration
- S-0-0393, Command value mode
- S-0-0417, Positioning velocity threshold in modulo mode
- S-0-0418, Target position window in modulo mode
- S-0-0419, Positioning command acknowledge
- S-0-0430, Effective target position
- S-0-0437, Positioning status
- P-0-0059, Additive position command value, controller
- P-0-0434, Position command value of controller
- P-0-0456, Position command value delay
- P-0-0457, Position command value generator
- P-0-0556, Config word of axis controller
- P-0-0641, Interpolation cmd value average value filter time constant

### Pertinent Diagnostic Messages

- A0150 Drive-controlled positioning, encoder 1
- A0151 Drive-controlled positioning, encoder 1, lagless
- A0152 Drive-controlled positioning, encoder 2
- A0153 Drive-controlled positioning, encoder 2, lagless
- E2049 Positioning velocity  $\geq$  limit value
- E2053 Target position out of travel range
- E2055 Feedrate override S-0-0108 = 0
- E2064 Target position out of num. range
- F2050 Overflow of target position preset memory
- F2057 Target position out of travel range

## 7.6.2 Command Value Adjustment With Drive-Controlled Positioning

### Overview

The figure below illustrates command value processing in the "drive-controlled positioning" mode as a block diagram.



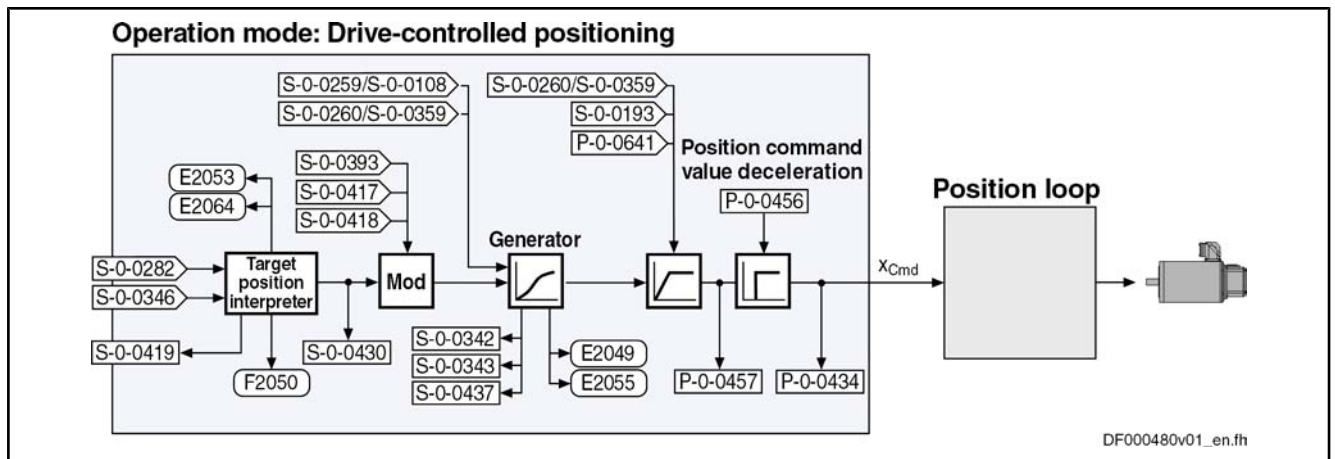


Fig.7-25: Command Value Adjustment With "Drive-Controlled Positioning"

### Position Target Interpreter

#### Accepting and Acknowledging the Command Value

The acceptance and internal processing of "S-0-0282, Positioning command value" to a value entered in "S-0-0430, Effective target position" is controlled via "S-0-0346, Positioning control word".

At every edge of bit 0 (toggle bit) of S-0-0346, the content of "S-0-0282, Positioning command value", depending on bit 3 of S-0-0346, is

- **copied** to S-0-0430  
(when bit 3 = 0 → absolute **target position**)
- or -
- **added** to the value of S-0-0430  
(when bit 3 = 1 → **travel distance**).



If a positioning process is aborted by switching bits 1 and 2 of S-0-0346 from status "00" to "01", "10" or "11", repeated edge reversal has to take place in bit 0 in order to start a new positioning process! A residual path possibly present is cleared, i.e. the status of bit 4 of S-0-0346 is automatically interpreted as "1" during the next positioning process.

Via "S-0-0419, Positioning command acknowledge" (bit 0), the drive acknowledges that it has applied the positioning command value. This allows realizing a data handshake for monitoring the command value acceptance between master and drive.



The active target position is displayed in "S-0-0430, Effective target position".

## Operation Modes

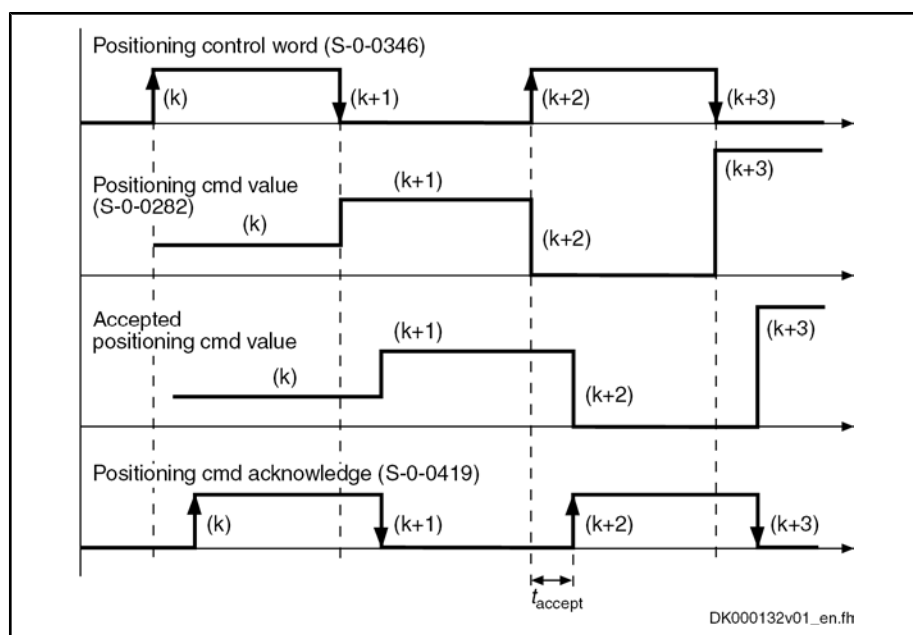


Fig. 7-26: Positioning Command Value Acceptance and Acknowledgment

Time  $t_{\text{accept}}$  (see illustration above) defines the time that passes between status change of the acceptance bit by the control unit and the reception of acknowledgment in the master. The time is made up of the effective transmission time of the command values and actual values and thus depends on the configuration of the interface to the master (e.g. SERCOS/field bus timing parameter).



If the "drive-controlled positioning" mode is not yet active, the acceptance of the new positioning command value is not acknowledged.

If bit 0 of S-0-0346 is unequal bit 0 of S-0-0419 while the operation mode is active, the positioning command value from S-0-0282 is immediately accepted and the drive immediately moves to this command value.

The acknowledgment of acceptance takes place when the new positioning command value is accepted from the intermediate memory to "S-0-0430, Effective target position" and thus to the position command value generator.

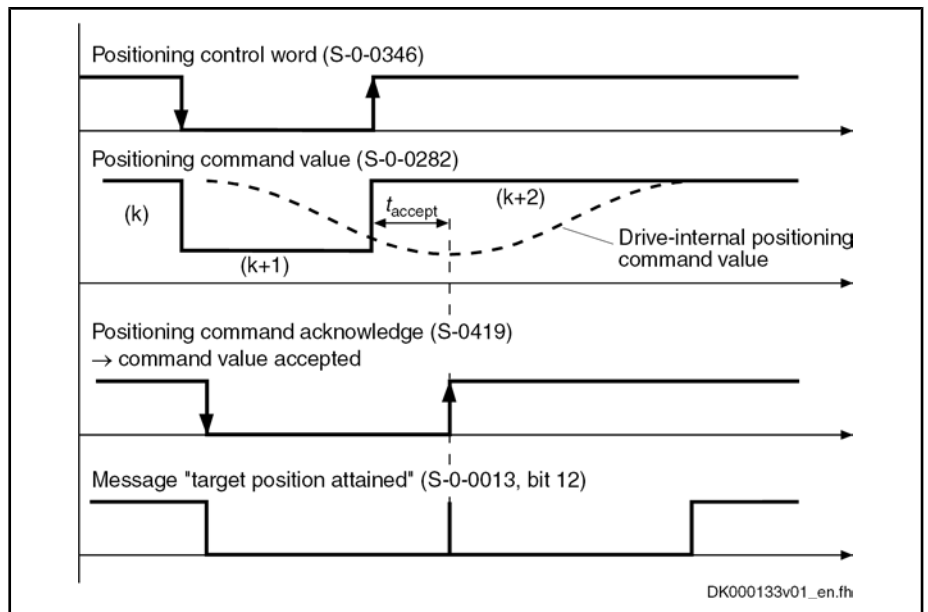


Fig. 7-27: Acknowledgment of Positioning Command Value Acceptance in Mode "Complete Move to Positioning Command Value (k+2)"

**Acknowledgment With Error "Overflow of Target Position Preset Memory"**

When trying, in the "complete move to positioning command value" mode, to preset a new positioning command value by toggling "S-0-0346, Positioning control word", although the previous positioning command value (k+1) was not accepted [because the drive had not yet moved to the previous positioning command value (k)], the error message "F2050 Overflow of target position preset memory" is generated.

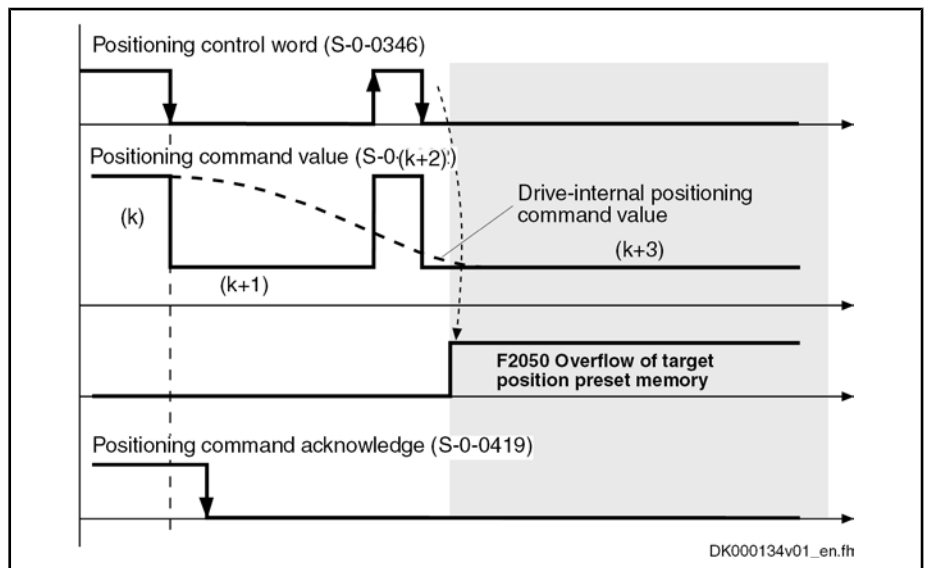


Fig. 7-28: Acknowledgment With Error "Overflow of Target Position Preset Memory"

**Positioning Modes to be Selected**

In addition to bit 0 for mere block acceptance, "S-0-0346, Positioning control word" contains further control bits which are explained below.

Via bit 1 and bit 2 of S-0-0346, you can determine different positioning modes:

- **"Infinite travel"** (jog positive or negative → **Jog mode**) when:
  - Bit 2/1 = 01 → "Infinite travel" positive
  - Bit 2/1 = 10 → "Infinite travel" negative
- **"Stopping"** (with "S-0-0359, Positioning deceleration") when:

## Operation Modes

- Bit 2/1 = 11

## Reference of Active Target Position

Via bit 4 of S-0-0346, it is possible to determine the reference of the active target position.

- **Bit 4 = 0** → Reference for positioning is the "old target position", i.e. a residual path that possibly hasn't been traveled yet is traveled before the drive moves to the new target
  - Incremental dimension is maintained in the case of successive positioning procedures
- **Bit 4 = 1** → Reference for positioning is the current actual position value, a possibly existing residual path is not traveled
  - Incremental dimension reference is maintained



Bit 4 takes effect with every new travel job (edge on bit 0). Residual path processing is only carried out, during the first positioning process after the operation mode was activated, when the position status has been set and bit 2 = 1 in S-0-0393. In this case the residual path, after the operation mode was activated, is traveled without start edge.

## Reaction to New Target Position Input

Via bit 5 of S-0-0346, it is possible to determine the time of the reaction to a new target position input:

- **Bit 5= 0** → The drive travels to the last preset target before positioning at the new target. The target is considered to have been reached when the following applies:
  - Target position – actual position value < positioning window
- **Bit 5=1** → The previous target is rejected and the drive immediately travels to the new target.
  - Immediate block change



See also Parameter Description "S-0-0346, Positioning control word"

## Processing in Modulo Format

"S-0-0393, Command value mode" controls the drive behavior in the case of **position processing in modulo format**. The following definition applies to S-0-0393:

- Bit 1/0 = 00 → Positive direction of rotation
- Bit 1/0 = 01 → Negative direction of rotation
- Bit 1/0 = 10 → Shortest distance



See also Parameter Description "S-0-0393, Command value mode"

## Special Cases

The following special cases apply to the evaluation of the settings for "S-0-0393, Command value mode":

- If the absolute value of the current actual velocity is greater than the velocity threshold for positioning (S-0-0417, Positioning velocity threshold in modulo mode), the drive always moves in the last active direction of rotation.
- If the target position is within the target position window (S-0-0418), positioning is always carried out according to the "shortest distance" mode.



If the velocity threshold for positioning behavior was parameterized with very low values that are within the noise level of the actual velocity value, this can cause unpredictable behavior.



See also Parameter Description "S-0-0417, Positioning velocity threshold in modulo mode" and "S-0-0418, Target position window in modulo mode" and "S-0-0430, Effective target position"

## Positioning Generator

The drive generates the position command value profile necessary to move to the target position, considering the conditions defined in the following parameters:

- S-0-0108, Feedrate override
- S-0-0193, Positioning Jerk
- S-0-0259, Positioning velocity
- S-0-0260, Positioning acceleration
- S-0-0359, Positioning deceleration

### 7.6.3 Position Loop With Drive-Controlled Positioning

The position command value generated at the output of the command value generator is displayed in "P-0-0434, Position command value of controller" and can be output at the analog output.

In this operation mode, the same information as relevant in the "position control with cyclic command value input" mode applies to the position control loop.

See also "Control Loop Structure"

See also "Position Loop" in section "Position Control With Cyclic Command Value Input"

### 7.6.4 Jog Mode With Drive-Controlled Positioning ("Jogging")



The jog mode is part of the positioning mode and not an individual operation mode! This means that there aren't any separate parameters for the jog mode, but you have to use the parameters of the operation mode "drive-controlled positioning".

#### Activating the Jog Mode

To use the jog mode, make the following settings:

- Activate the operation mode "drive-controlled positioning"  
- and -
- Select the positioning mode "infinite travel" (jog positive or negative → jog mode) via bits 1 and 2 of parameter "S-0-0346, Positioning control word"

#### Parameterizing the Jog Mode

When jogging, the following parameters are relevant for operation:

- S-0-0108, Feedrate override  
→ To achieve online, if necessary, the reduction of the jog velocity by means of a "potentiometer"
- S-0-0193, Positioning Jerk
- S-0-0259, Positioning velocity
- S-0-0260, Positioning acceleration
- S-0-0282, Positioning command value
- S-0-0346, Positioning control word  
→ To select the jog direction ("Jog+", "Jog-" and "stopping")
- S-0-0359, Positioning deceleration

## Operation Modes



Bits 1 and 2 of S-0-0346 are parts of the field bus control word and, if required, can be assigned to the digital inputs.

See "Profile Types (With Field Bus Interfaces)"

See "Digital Inputs/Outputs"

## 7.6.5 Notes on Commissioning

### Effective Positioning Velocity

The drive reaches its maximum velocity after an acceleration phase with the value set in "S-0-0260, Positioning acceleration".

The maximum velocity during a positioning procedure is the result of:

$$v_{\max} = S-0-0259 \times \frac{S-0-0108}{100 \%}$$

S-0-0259      Positioning velocity

S-0-0108      Feedrate override

*Fig. 7-29: Determining the Maximum Velocity During the Positioning Process*

### Effective Acceleration and Deceleration

The maximum deceleration is defined in "S-0-0259, Positioning velocity".

If the value in parameter S-0-0359 equals zero, the drive uses the parameter value of "S-0-0260, Positioning acceleration" for deceleration, too.

If the value in parameter S-0-0260 equals zero, too, the parameter value of "S-0-0138, Bipolar acceleration limit value" is used. If this value has likewise been set to zero, acceleration is not limited. If possible, the drive sets the positioning velocity immediately.

### Smoothing Filter (or Jerk Filter)

In the "drive-controlled interpolation" mode, the position command value can be filtered at the output of the positioning generator. We distinguish between two cases for setting of the filter order.

#### Case 1: Calculating the filter order from A / R

The filter order of the (moving) average filter available to do this (cf. P-0-0042) is calculated on the basis of the preset positioning acceleration or the positioning jerk.

Because of the filter the parameterized acceleration or deceleration only becomes effective after  $t = P-0-0042 \times T_{A\_position}$ .



In this case,  $T_{A\_position}$  is the cycle time of the position loop or the positioning generator. Therefore, the cycle time to be used is different according to the control performance (Advanced: 250  $\mu$ s, Basic: 500  $\mu$ s).

$$P-0-0042 = \frac{S-0-0260}{S-0-0193} [s] * \frac{10^6}{T_{A\_Lage}}$$

– or –

$$P-0-0042 = \frac{S-0-0359}{S-0-0193} [s] * \frac{10^6}{T_{A\_Lage}}$$

P-0-0042	Current position command average value filter order
S-0-0260	Positioning acceleration
S-0-0193	Positioning jerk
S-0-0359	Positioning deceleration

Fig. 7-30: Internally Determining the Value of P-0-0042 for Operation Modes With Drive-Internal Interpolation



The setting S-0-0193 = 0 switches the smoothing filter off; i.e. the desired acceleration or deceleration is immediately reached.

### Case 2: Constant filter order

The filter order can also be set to a constant value. This is made via parameter "P-0-0641, Interpolation cmd value average value filter time constant". The filter order is calculated from the time constant related to the position clock  $T_{A\_position}$ . In the case of an order > 0 the function "filter order constant" is active and the calculation A/R without effect. A new filter order can only take effect during initialization of the operation mode and during change of blocks. As before, the current filter order is displayed in "P-0-0042, Current position command average value filter order".

## Position Command Value Deceleration

The position command value can be delayed by maximum 32 position clocks after the jerk filter, before it is fed in the position controller. This allows synchronous control of a master axis with the controlled slave axis. The number of position clocks is set with the position command value delay (P-0-0456). The position command value generator without delay (P-0-0457) is entered in a ring buffer and then the position command value with delay is applied in the position command value controller (P-0-0434).

## Command Value Mode in Modulo Format

### Positive/Negative Direction of Motion

If modulo format was selected for displaying position data (infinitely turning axes) and positive or negative direction of motion was set in parameter "S-0-0393, Command value mode", the drive moves to the preset target position in the programmed direction.

Via parameter "S-0-0418, Target position window in modulo mode", it is possible to set the distance between actual position value and target position from which on it is the "shortest distance" that is traveled.

### "Positive Direction" and Position Target Outside of Target Position Window

The examples below show the behavior of the drive for 3 different start velocities in the "positive direction" mode and target position outside of the target position window (S-0-0418).

- **Case 1:**

Current velocity positive and braking distance greater than the distance between starting point and next target point

## Operation Modes

→ Drive moves to next possible target position

- **Case 2:**

Current velocity positive and braking distance smaller than the distance between starting position and next target position

→ Drive moves to next possible target position

- **Case 3:**

Current velocity negative (< S-0-0417)

→ Drive brakes to velocity = 0 and positions at next target in positive direction

**"Positive Direction" and Position  
Target Inside of Target Position  
Window**

The examples below show the behavior of the drive for 4 different start velocities in the "positive direction" mode and target position inside of the target position window (S-0-0418).

- **Case 4:**

Current velocity positive and braking distance greater than the distance between starting point and next target point

→ Drive moves to next possible target position in positive direction

Braking and moving back would lead to a movement in negative direction greater than the programmed target position window!

**The following applies to the braking procedure:**

Starting position + braking distance – target position > S-0-0418

→ Positioning in negative direction not allowed; i.e. drive must move to target in positive direction

- **Case 5:**

Current velocity = 0

→ Drive moves to target position in negative direction

**The following applies to the braking procedure:**

Starting position + braking distance – target position < S-0-0418

→ Positioning in negative direction allowed; i.e. drive must move to target in negative direction

- **Case 6:**

Current velocity negative and braking distance smaller than the difference between starting position and next target position

→ Drive directly moves to target position in negative direction

**The following applies to the braking procedure:**

Starting position + braking distance (negative) – target position < S-0-0418

→ Positioning in negative direction directly at target position

- **Case 7:**

Current velocity negative (< S-0-0417) and braking distance greater than the difference between starting position and next target position

→ Drive brakes to zero and positions at next target position in positive direction

**The following applies to the braking procedure:**

Starting position + braking distance (negative) – target position > S-0-0418

→ Drive brakes to zero and positions positively at next target position





As a matter of principle, the braking distance is calculated before starting the positioning movement; the result of the calculation influences the subsequent positioning procedure.

**Shortest Distance**

In the "shortest distance" mode, the drive positions at the effective target position (cf. S-0-0430) over the shortest possible distance.



Depending on "S-0-0417, Positioning velocity threshold in modulo mode", the drive moves with or without reversal of direction.

**"Shortest Distance" With Different Velocities**

The following examples show the behavior of the drive in the "shortest distance" mode with different velocities.

- **Case 8:**

Current velocity positive and  $> S-0-0417$ ; braking distance greater than the distance between starting position and next target position

→ Drive moves to target position that can be reached without reversal of direction, in positive direction

**The following applies to the braking procedure:**

Starting position + braking distance – target position  $> S-0-0418$

→ Positioning in negative direction not allowed; i.e. drive must move to target in positive direction

- **Case 9:**

Current velocity (positive)  $< S-0-0417$ ; braking distance smaller than distance between starting position and next target position

→ Drive moves to next target position

**The following applies to the braking procedure:**

Starting position + braking distance – target position  $< S-0-0418$

→ Positioning in negative direction allowed; i.e. drive must move to target in negative direction

- **Case 10:**

Current velocity (negative)  $< S-0-0417$

Braking distance smaller than distance between starting position and next target position

→ Drive moves to next target position

**The following applies to the braking procedure:**

Starting position + braking distance (negative!) – target position  $< S-0-0418$

→ Positioning in negative direction directly at target position

- **Case 11:**

Current velocity negative and braking distance greater than the difference between starting position and next target position

→ Drive positions at next target position in negative direction

**The following applies to the braking procedure:**

Starting position + braking distance (now negative) – target position  $> S-0-0418$

→ Drive positions negatively at next target position

## Operation Modes



As a matter of principle, the braking distance is calculated before starting the positioning movement; the result of the calculation influences the subsequent positioning procedure.

- **Case 12:**  
Current velocity (positive) < **S-0-0417**; braking distance greater than distance between starting position and next target position  
→ Drive brakes to zero and changes direction in order to move to the next target position
- **Case 13:**  
Current velocity (negative) < **S-0-0417**; braking distance greater than distance between starting position and next target position  
→ Drive brakes to zero and changes direction in order to move to the next target position

## 7.6.6 Diagnostic Messages and Monitoring Functions

### Diagnostic Status Messages

The activated "drive-controlled positioning" mode is displayed by one of the following diagnostic messages:

- A0150 Drive-controlled positioning, encoder 1
- A0151 Drive-controlled positioning, encoder 1, lagless, lagless
- A0152 Drive-controlled positioning, encoder 2
- A0153 Drive-controlled positioning, encoder 2, lagless, lagless

### Monitoring Functions

Monitoring functions specific to the operation mode:

- **Target Position out of Travel Range**  
If position limit value monitoring is activated (bit 4 of "S-0-0055, Position polarities" has been set) and the measuring system used for the operation mode has been homed, the parameter "S-0-0258, Target position" is monitored for compliance with the position limit values (S-0-0049 or S-0-0050). If these values are exceeded, depending on the definition in "P-0-0090, Travel range limit parameter", either the error message "F2057 Target position out of travel range" or the warning "E2053 Target position out of travel range" is generated. If the warning has been parameterized, positioning to the limit switches takes place.  
The preset target position will not be accepted.
- **Positioning Velocity >= Limit Value**  
If the preset positioning velocity (S-0-0259, Positioning velocity) exceeds the maximum allowed limit value (S-0-0091, Bipolar velocity limit value), the warning "E2049 Positioning velocity >= limit value" is generated.  
The drive moves to the new target position with the velocity from parameter "S-0-0091, Bipolar velocity limit value".
- **Feedrate Override (S-0-0108) = 0**  
If the positioning velocity factor "S-0-0108, Feedrate override" equals zero, the warning "E2055 Feedrate override S-0-0108 = 0" is generated.

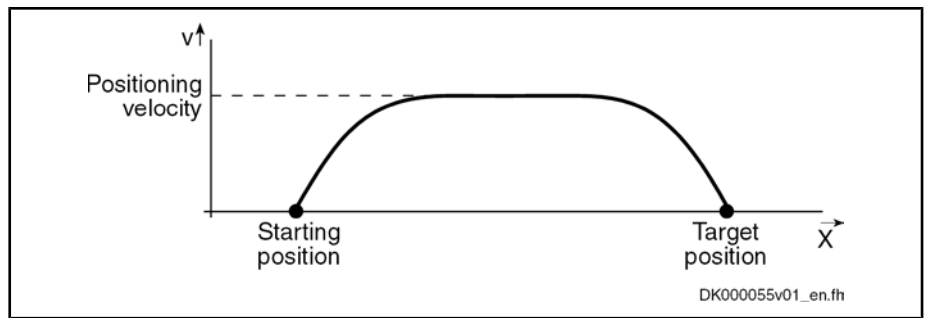
### Status Messages

"S-0-0437, Positioning status" contains all important status information for the operation mode "drive-internal interpolation".



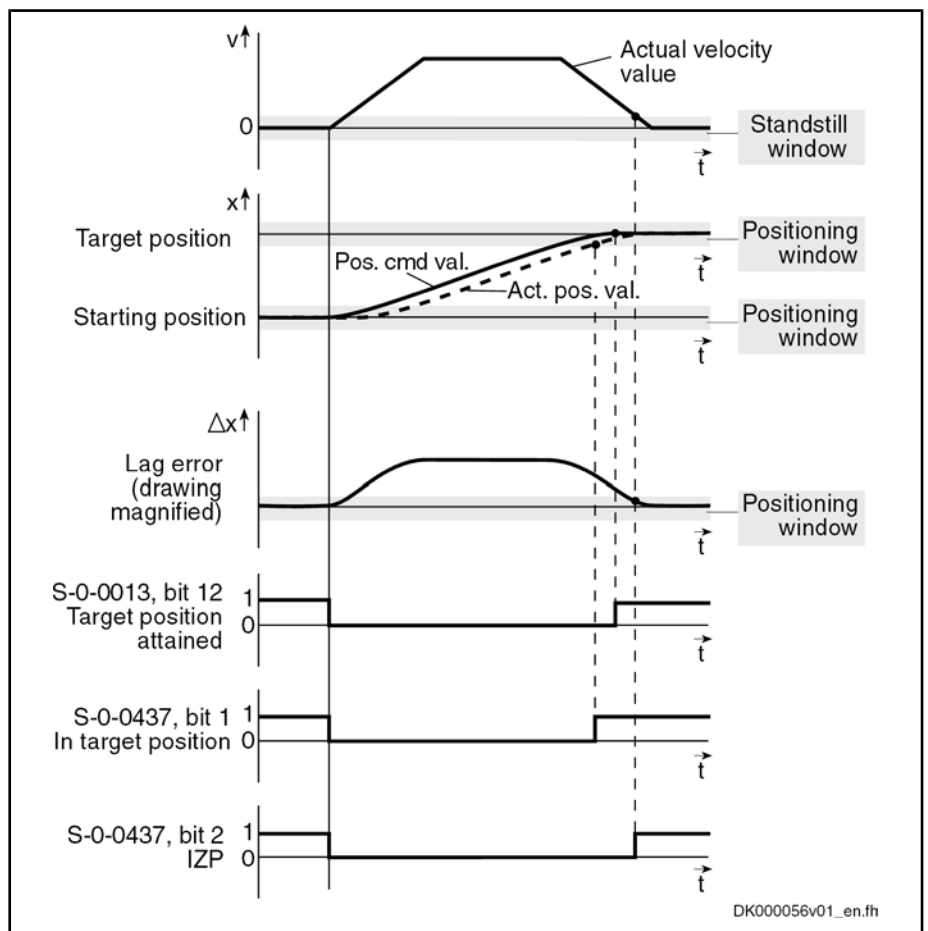
See Parameter Description "S-0-0437, Positioning status"

The figures below illustrate the operating principle of the status messages:



**Fig.7-31:** Travel Profile to Explain How the Interpolation Status Messages Work  
In this example, the drive is at the starting position when the new target position is preset.

The result is the following time diagram:



**Fig.7-32:** Generating the Status Bits of the Operation Modes With Drive-Internal Interpolation

## 7.7 Positioning Block Mode

### 7.7.1 Brief Description



Assignment to functional firmware package, see chapter "Supported Operation Modes".

## Operation Modes

In the "positioning block mode" it is possible to run up to 64 programmed positioning blocks. The drive moves to the target position in position control, while maintaining velocity, acceleration, deceleration and jerk limits as defined in the respective positioning block.

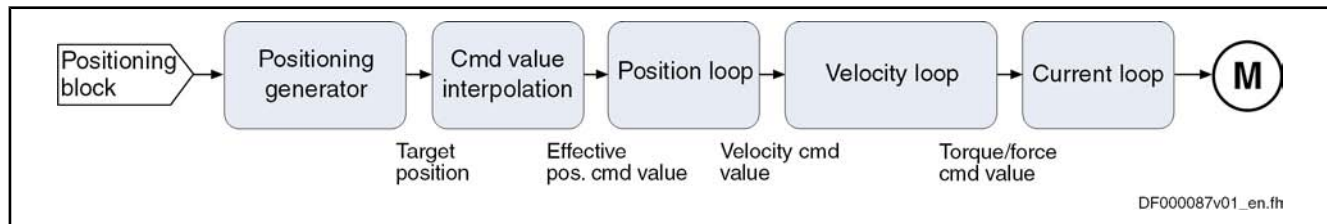


Fig.7-33: Block Diagram "Positioning Block Mode":

**Features**

- Parameterization of up to 64 positioning blocks; each with target position/ travel distance, velocity, acceleration, deceleration and jerk
- Jerk limitation of the generated position command value via "P-0-4009, Positioning block jerk"
- Setting of the average value filter (jerk limitation) to fixed filter time with IPO command value average value filter time constant (P-0-0641)
- Adjustable deceleration of position command value in position clocks (P-0-0456, Position command value delay), maximum 32 clocks.
- Defined block acceptance by toggling bit 0 in "S-0-0346, Positioning control word" with reaction time  $t_{R\_strobe} = t_{position}$

**Note:** With field bus drives, the I/O mode and control via the parallel interface are exceptions. In these cases, acceptance takes place by a 0-1 edge of bit 0 in P-0-4060.

→ Block selection and acknowledgment via separate parameters (handshake principle)

- Positioning modes to be freely parameterized:
  - Relative positioning
  - Absolute positioning
  - Infinite travel (positive or negative)
- Single-block or sequential block mode with different conditions for advance:
  - Block advance with switch cams
  - Block advance at defined position value
  - Block transition with "old" or "new" positioning velocity
- Positioning block transition with freely definable delay time (P-0-4018)
- Positioning while taking command value mode into account (shortest distance, positive direction, ...)
- Residual path processing can be activated (→ no loss of incremental dimension)
- "Slow travel" mode can be activated
- Velocity override to be set

**Fields of Application**

Sequential block processing allows executing several positioning blocks in direct sequence without having to give a new start signal each time. Typical fields of application are:

- There is none or only a very simple higher-level control unit available and control is realized via digital I/Os only or a field bus control word (I/O mode with field bus interface).
- There are quick reaction times or block advances required. The required motion profiles can be represented in the drive by the maximum possible 64 positioning blocks.
- There are positioning processes required which cover long distances at high speeds (rapid traverse) and then position at the end position at low speed without any intermediate stops; for example:
  - Taking up or putting down transport goods in handling robots
  - Execution of joining processes in assembly facilities

**Pertinent Parameters**

- S-0-0138, Bipolar acceleration limit value
- S-0-0259, Positioning velocity
- S-0-0346, Positioning control word
- S-0-0393, Command value mode
- S-0-0419, Positioning command acknowledge
- S-0-0430, Effective target position
- S-0-0437, Positioning status
- P-0-0059, Additive position command value, controller
- P-0-0434, Position command value of controller
- P-0-0456, Position command value delay
- P-0-0457, Position command value generator
- P-0-0556, Config word of axis controller
- P-0-0641, Interpolation cmd value average value filter time constant
- P-0-4006, Positioning block target position
- P-0-4007, Positioning block velocity
- P-0-4008, Positioning block acceleration
- P-0-4009, Positioning block jerk
- P-0-4018, Positioning block delay time
- P-0-4019, Positioning block mode
- P-0-4026, Positioning block selection
- P-0-4051, Positioning block acknowledgment
- P-0-4052, Positioning block, last accepted
- P-0-4053, Positioning block, last active
- P-0-4057, Positioning block, input linked blocks
- P-0-4060, Positioning block control word
- P-0-4061, Positioning block status word
- P-0-4063, Positioning block deceleration



S-0-0259 is used in positioning block mode to reduce positioning velocity (see also "P-0-4060, Positioning block control word").

---

**Pertinent Diagnostic Messages**

- A0162 Positioning block mode
- A0206 Positioning block mode, encoder 1
- A0207 Positioning block mode lagless, encoder 1

Operation Modes

- A0210 Positioning block mode, encoder 2
- A0211 Positioning block mode lagless, encoder 2
- E2049 Positioning velocity >= limit value
- E2053 Target position out of travel range
- E2054 Not homed
- E2055 Feedrate override S-0-0108 = 0
- E2058 Selected positioning block has not been programmed
- E2064 Target position out of num. range
- F2028 Excessive deviation

### 7.7.2 Command Value Adjustment With Positioning Block Mode

The figure below illustrates command value processing in the "positioning block mode" mode as a block diagram.

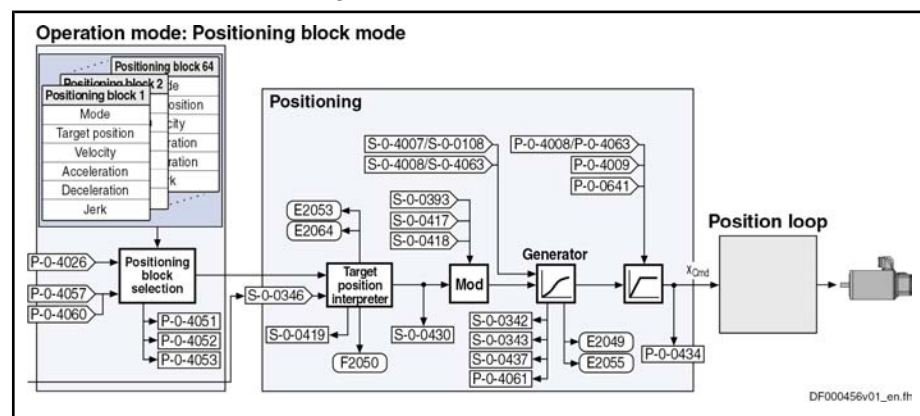


Fig.7-34: Command Value Adjustment With Positioning Block Mode

### 7.7.3 Single-Block Processing

#### Description of Basic Function

##### General Information

##### Positioning Block Elements

A positioning block is defined by the values of the following list parameters:

- P-0-4006, Positioning block target position
- P-0-4007, Positioning block velocity
- P-0-4008, Positioning block acceleration
- P-0-4009, Positioning block jerk
- P-0-4018, Positioning block delay time
- P-0-4019, Positioning block mode
- P-0-4063, Positioning block deceleration



Each parameter contains 64 elements, elements of the same number generate the travel profile of the respective positioning block.

The drive reaches the relevant positioning block velocity after an acceleration phase with the corresponding positioning block acceleration (P-0-4008).

##### Effective Positioning Velocity

The effective velocity during a positioning process is calculated as follows:

$$v_{\max} = P-0-4007 \times \frac{S-0-0108}{100 \%}$$

$v_{\max}$  Velocity  
 P-0-4007 Positioning block velocity  
 S-0-0108 Feedrate override

Fig.7-35: Effective Velocity During a Positioning Process

**Effective Acceleration and Deceleration**

The maximum delay is specified by "P-0-4063, Positioning block deceleration".



**CAUTION**

**Property damage!**

If the acceleration or deceleration values are equal to zero, the drive can no longer brake. The specified target is never reached or overrun.

⇒ Set acceleration value > 0!



Further limitation takes place by the value of "S-0-0138, Bipolar acceleration limit value" because this limit value takes effect in all operation modes with position control.

**Jerk Limitation by Jerk Filter**

In the "drive-internal interpolation" mode the position command value can be filtered at the output of the positioning generator. We distinguish between two cases for setting of the filter order.

**Case 1: Calculating the filter order from A / R**

This means that the parameterized acceleration or deceleration only becomes effective after  $t = P-0-0042 \times T_{A\_position}$ .



In this case,  $T_{A\_position}$  is the cycle time of the position loop or the positioning generator. Therefore, the cycle time to be used is different according to the control performance (Advanced: 250 µs, Basic: 500 µs).

$$P-0-0042 = \frac{P-0-4008}{P-0-4009}$$

- or -

$$P-0-0042 = \frac{P-0-4063}{P-0-4009}$$

P-0-0042 Current position command average value filter order  
 P-0-4008 Positioning block acceleration  
 P-0-4063 Positioning block deceleration  
 P-0-4009 Positioning block jerk

Fig.7-36: Internally Determining the Value of P-0-0042 for Positioning Block Mode



The setting P-0-4009 = 0 switches the smoothing filter off; i.e. the desired acceleration or deceleration is immediately reached.

**Case 2: Constant filter order**

The filter order can also be set to a constant value. This is made via parameter "P-0-0641, Interpolation cmd value average value filter time constant". The filter

## Operation Modes

order is calculated from the time constant related to the position clock  $T_{A\_position}$ . In the case of an order  $> 0$  the function "filter order constant" is active and the calculation A/R without effect. A new filter order can only take effect during initialization of the operation mode and during change of blocks. As before, the current filter order is displayed in "P-0-0391, Current position command average value filter order"!

**Position Command Value Deceleration**

The position command value can be delayed by maximum 32 position clocks after the jerk filter, before it is fed in the position controller. This allows synchronous control of a master axis with the controlled slave axis. The number of position clocks is set with the position command value delay (P-0-0456). The position command value generator without delay (P-0-0457) is entered in a ring buffer and then the position command value with delay is applied in the position command value controller (P-0-0434).

**Positioning Block Control Word**

With parameter "P-0-4060, Positioning block control word" (bit 1), the positioning velocity can be limited to the value defined in "S-0-0259, Positioning velocity".

**Position Feedback**

When a positioning block is completed, bit 4 (end position reached) is set in "P-0-4061, Positioning block status word".

→  $|S-0-0430 - S-0-0051/53| < S-0-0057$  && no sequential block

**Interrupting a Positioning Block**

The positioning block mode can be interrupted by:

- Removing drive enable
- Activating "Drive HALT"
- Changing the operation mode
- Jogging
- Positioning stop or operational stop (S-0-0346, bit 1 and bit 2 = 1)
- A drive error occurring

**Positioning Block Modes**

"P-0-4019, Positioning block mode" determines how the target position is processed in "P-0-4006, Positioning block target position". There are the following options:

- Absolute positioning
- Relative positioning
- Relative positioning with residual path storage
- Infinite Travel in Positive/Negative Direction
- Sequential block processing



See Parameter Description "P-0-4019, Positioning block mode"



It is possible to define an individual positioning mode for each positioning block.

**Command Value Mode (S-0-0393)**

"S-0-0393, Command value mode" controls the drive behavior in case "modulo format" was set as processing format of the position data.



See also Parameter Description "S-0-0393, Command value mode"

The following modes are distinguished:

- Shortest distance
- Positive direction
- Negative direction



The following limiting conditions have to be taken into account:

- If the absolute value of the current actual velocity is greater than the velocity threshold for positioning in modulo format (S-0-0417), the drive always moves in the last active direction of rotation.
- If the target position is within the target position window in modulo format (S-0-0418), positioning is always carried out according to the "shortest distance" mode.



If the velocity threshold for positioning in modulo format was parameterized with very low values that are within the noise level of the actual velocity value, this can cause unpredictable behavior.

---



See Parameter Description "S-0-0417, Positioning velocity threshold in modulo mode"



See Parameter Description "S-0-0418, Target position window in modulo mode"

### Activating Positioning Blocks

#### Requirements

"Positioning block mode" must have been entered as the primary mode of operation.



This is done by the respective selection of the active operation mode in the status word, by activating drive enable and by setting "Drive Halt" = 1.

---

#### Command Value Acceptance

Depending on the master communication, a positioning block is started by:

- Toggling bit 0 in "S-0-0346, Positioning control word"
- or -
- 0-1 edge of bit 0 in "P-0-4060, Positioning block control word", with **parallel interface or field bus interface in I/O mode**

The positioning command value is thereby copied to the effective target position S-0-0430 (absolute target position) or added (relative position target, travel distance).



The block acceptance is confirmed by updating "P-0-4051, Positioning block acknowledgment" and "S-0-0419, Positioning command acknowledge". In addition, bit 0 of S-0-0346 is toggled internally, too, in the case of a 0-1 edge of bit 0 of P-0-4060.

---

According to master communication and profile type, the block acceptance requires different configurations in the cyclic command value channel:

- **SERCOS interface**
  - "S-0-0346, Positioning control word" has to be configured in the cyclic data channel (MDT)
- **Field bus interface**
  - In the freely configurable mode (profile type P-0-4084 = 0xFFFE), bit 0 of P-0-4077 is mapped to bit 0 of S-0-0346.
  - In the "I/O mode positioning" (profile type P-0-4084 = 0xFF82), bit 3 of P-0-4068 is mapped to bit 0 of "P-0-4060, Positioning block control word".

## Operation Modes

As an alternative, the start in the I/O mode can also take place by setting the start signal (P-0-4068, bit 1).

- **Parallel interface**
  - Bit 0 of P-0-4060 has to be configured on a digital input (see also "Digital Inputs/Outputs")

See also "Command Value Acceptance and Acknowledgment" in section "General Information on the Operation Modes"



If bit 0 is different in S-0-0346 and in S-0-0419 when the operation mode is activated, the selected positioning block is immediately accepted and executed.

### Block Selection

In the positioning block mode, block selection is always carried out via the content of "P-0-4026, Positioning block selection".

Depending on the master communication, P-0-4026 can be written in different ways:

Configuration of P-0-4026	Master communication		
	SERCOS interface	Field bus interface	Parallel interface
Via cyclic data channel	■	■	--
Via digital inputs	■	■	■
Via serial interface	■	■	■
Via field bus control word	--	■	--

Fig. 7-37: Possibilities of Writing Parameter P-0-4026 Depending on the Master Communication



The assignment of P-0-4026 to digital inputs requires, among other things, "S-0-0144, Signal status word" and "S-0-0145, Signal control word".

## Absolute Positioning

### Parameter Setting

"P-0-4019, Positioning block mode" = 0000 0000 0000 000X

### Function

In an absolute positioning block, the target position is a fixed (absolute) position within the machine coordinate system.

For absolute positioning the drive must have been homed.

### Requirements

Requirements for executing absolute positioning blocks are:

- The drive must have been homed.
- The travel range can be limited with position limit values. Absolute positioning blocks are only executed, if the target position is within the allowed travel range.

### Example:

Absolute positioning with target position = 700 (current position = 200)

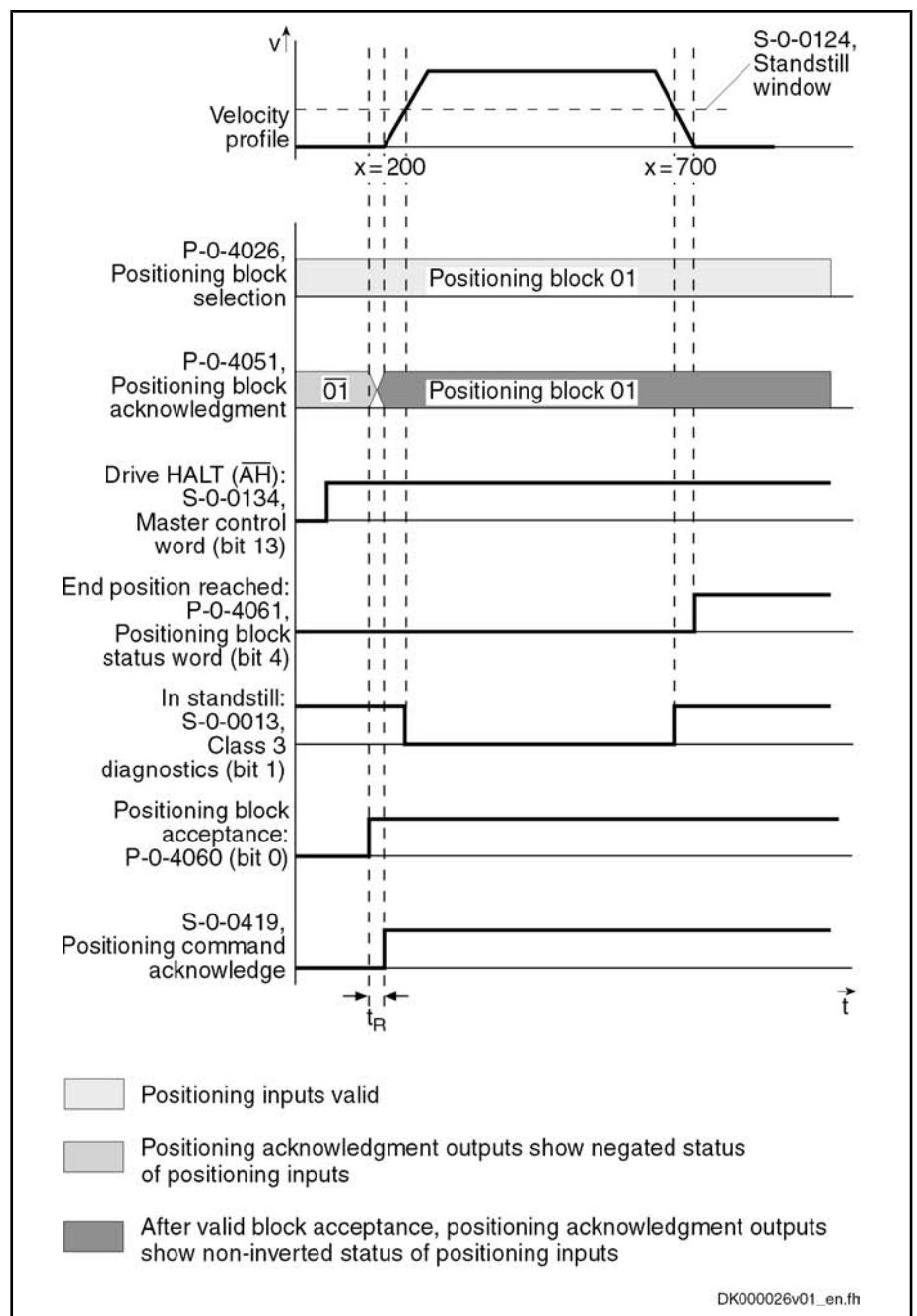


Fig.7-38: Absolute Positioning Block



According to master communication, positioning block acceptance takes place by toggling bit 0 in S-0-0346 or by a 0-1 edge of bit 0 in P-0-4060.

### Relative Positioning Without Residual Path Storage

**Parameter Setting** "P-0-4019, Positioning block mode" = 0000 0000 0000 001X

**Dedicated Position** In the case of relative positioning blocks without residual path storage, the target position contained in the positioning block is added to the current position. Relative positioning blocks are also executed, if the drive has not been homed.

## Operation Modes

**Incremental Dimension Reference** By sequencing relative positioning blocks it is possible to position with incremental dimension. If a relative positioning block without residual path storage is interrupted, the incremental dimension reference gets lost.

If the positioning block is completed (i.e. the drive reaches target position and message "end position reached" is active), positioning is possible without losing the incremental dimension reference.



If infinite positioning in either a forward or backward direction is achieved by sequencing relative positioning blocks (transport belt), the position data must be scaled in modulo format (modulo value = length of transport belt or modulo value =  $2 \times$  maximum travel distance).

---

### **Example:**

Relative positioning without residual path storage with travel distance = 700  
(current position = 200; target position = 900)

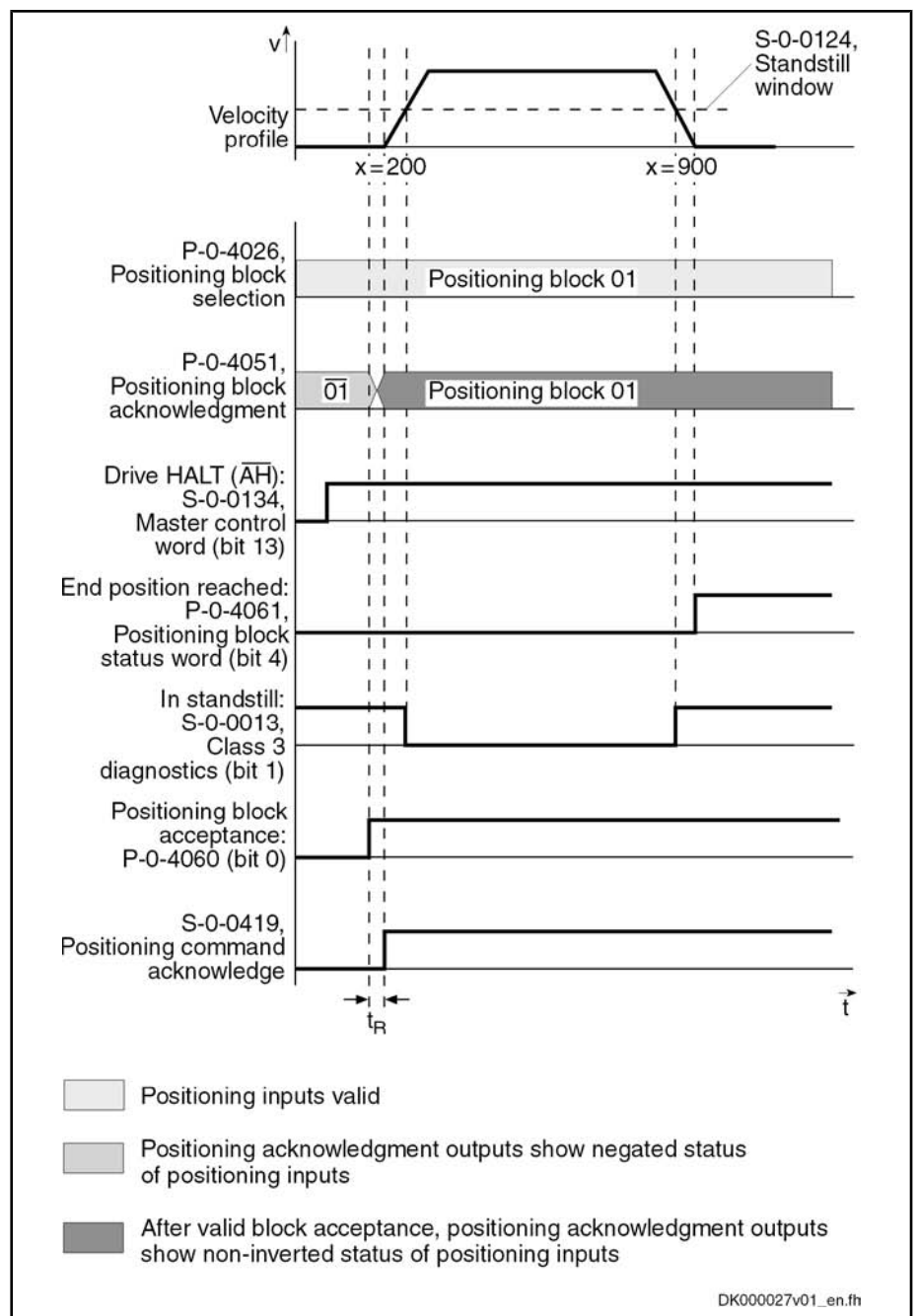


Fig.7-39: Relative Positioning Block Without Residual Path Storage



According to master communication, positioning block acceptance takes place by toggling bit 0 in S-0-0346 or by a 0-1 edge of bit 0 in P-0-4060.

**Example:**

Relative positioning without residual path storage with target position = 700 (current position = 200); interrupting and restarting a relative positioning block without residual path storage

Operation Modes

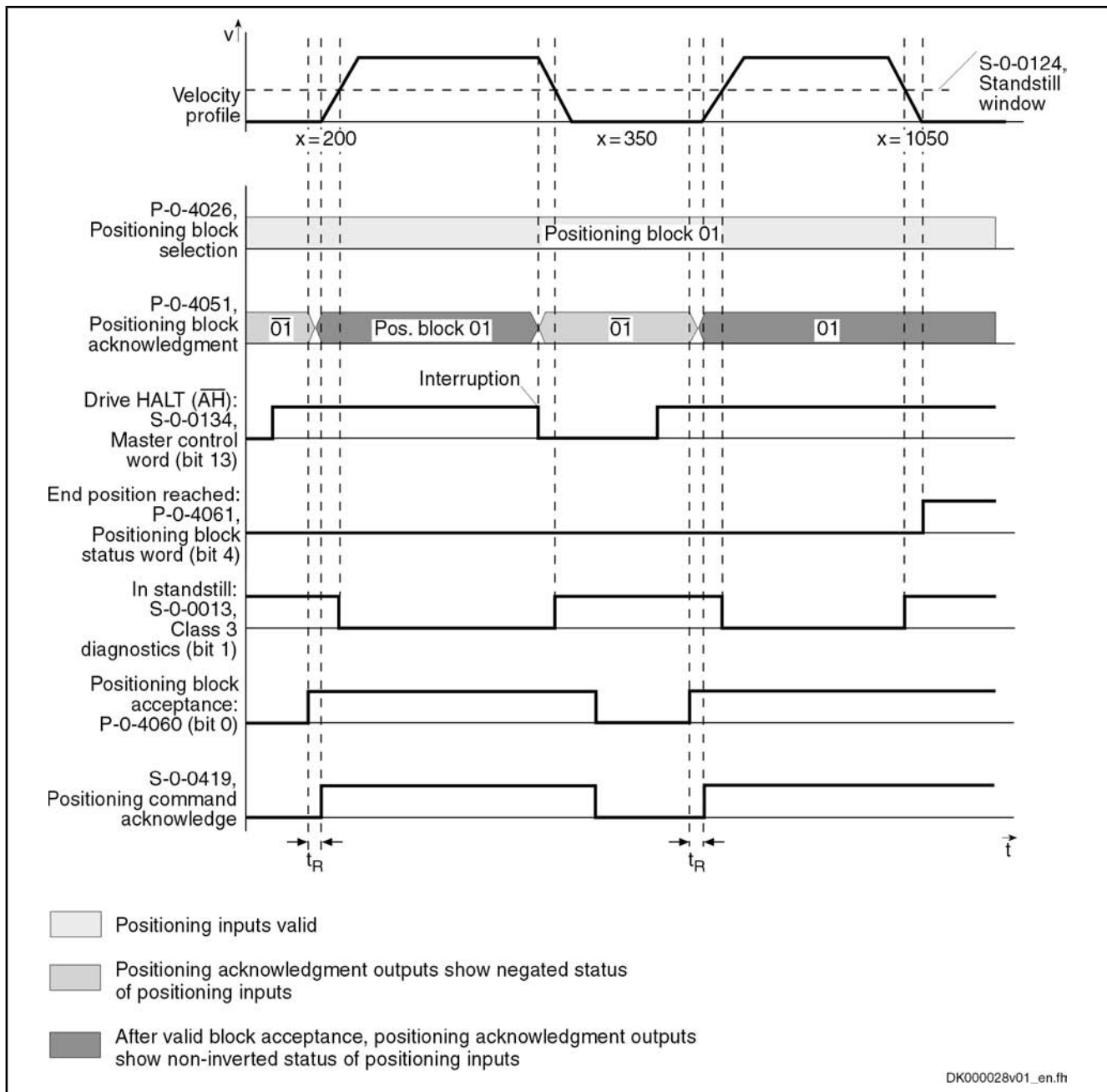


Fig.7-40: Interrupting a Relative Positioning Block Without Residual Path Storage



According to master communication, positioning block acceptance takes place by toggling bit 0 in S-0-0346 or by a 0-1 edge of bit 0 in P-0-4060.

Relative Positioning With Residual Path Storage

Basic Function

Parameter Setting "P-0-4019, Positioning block mode" = 0000 0001 0000 001X

Residual Path If positioning blocks are interrupted, a distance still to be traveled up to the target position remains. This remaining distance is the residual path.

**Incremental Dimension Reference**

In a relative positioning block with residual path storage, the target position is a relative distance that relates to the target position at which the message "end position reached" was last active.

Relative positioning blocks with residual path storage are also executed, if the drive has not been homed.

By sequencing relative positioning blocks it is possible to position with incremental dimension. If a relative positioning block with residual path storage is interrupted, the incremental dimension reference is retained.



If another positioning block is started while such a positioning block is being executed, the residual path is rejected. If this new block is also a relative positioning block with residual path storage, the target position is related **to the current actual position** as a relative distance.

---

**Example:**

- Relative positioning with residual path storage with travel distance = 700 (plus residual path = 20 of positioning block n-1)
- Without interruption
- Current position = 180; new target position = 900

**Dedicated Position**

The last valid target position is used as dedicated position (in the example, position = 200 of positioning block n-1).

Operation Modes

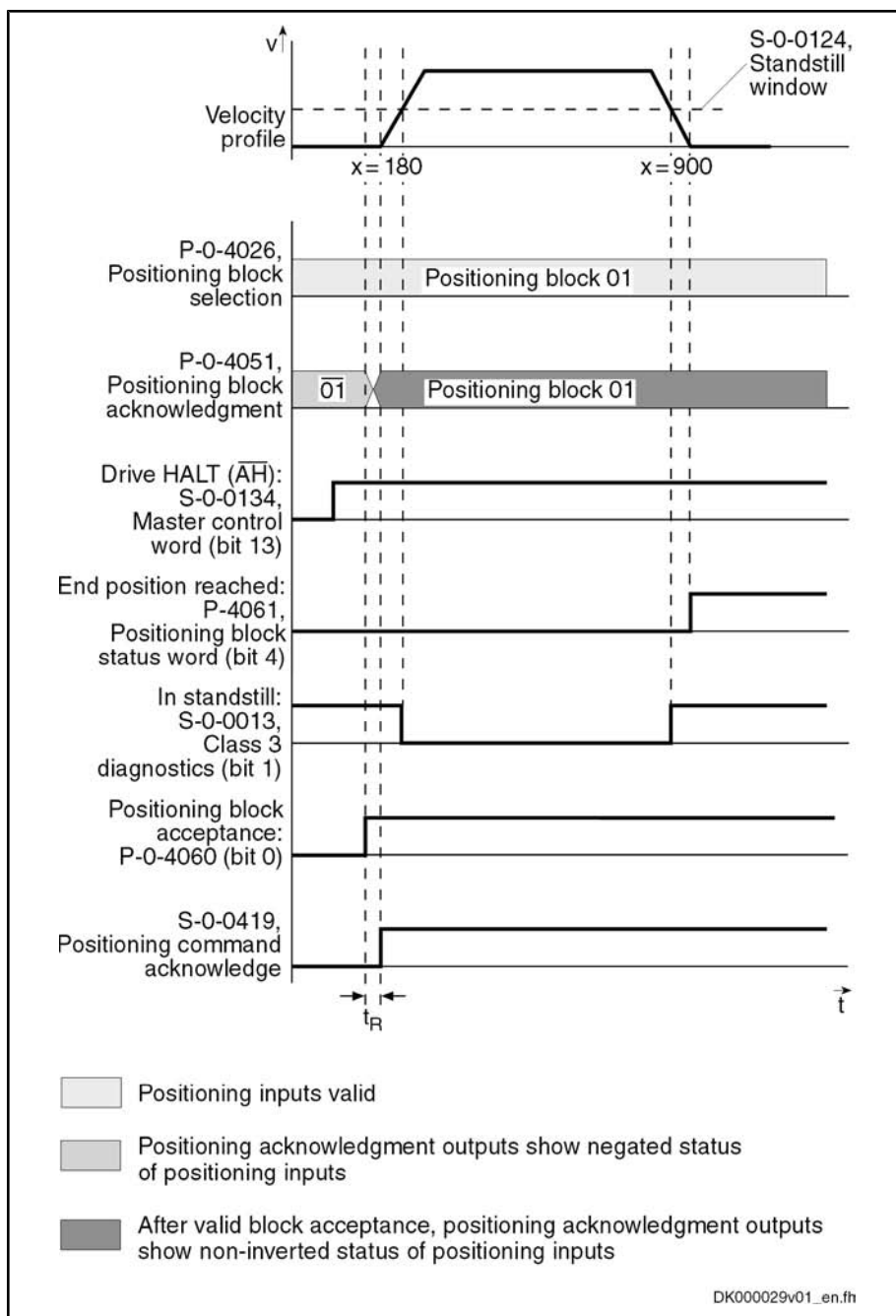


Fig.7-41: Relative Positioning Block With Residual Path Storage



According to master communication, positioning block acceptance takes place by toggling bit 0 in S-0-0346 or by a 0-1 edge of bit 0 in P-0-4060.


**Relative Positioning Block With Residual Path Storage After Activating Drive Enable**

**Example:**

Interrupted relative positioning block with residual path storage after activation of drive enable with travel distance = 400 (current position = 200; target position = 800).



**Dedicated Position** The position command value at the last "end position reached" (position = 200) message is used as the reference position.

 The incremental dimension reference is ensured.

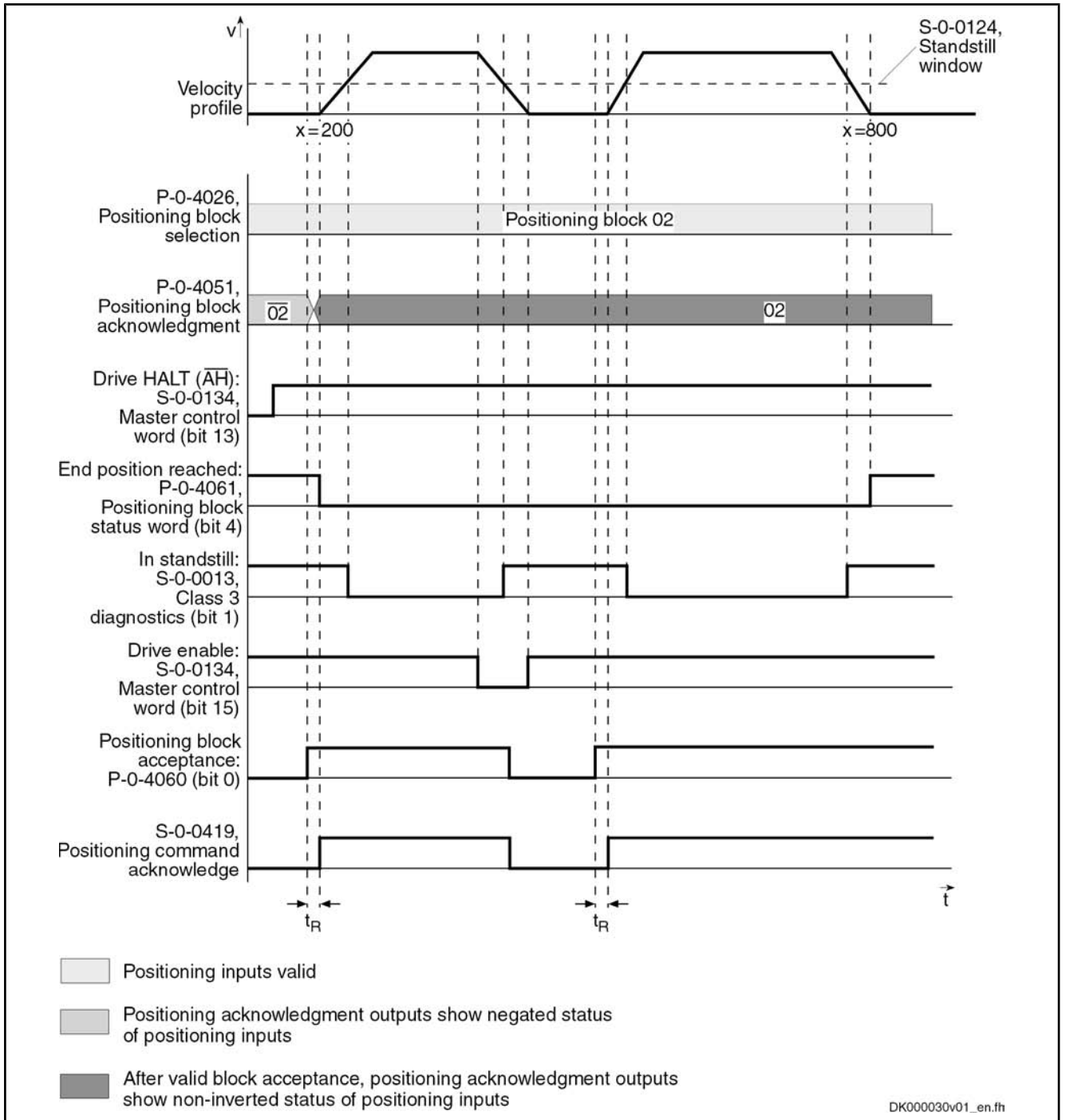



Fig.7-42: Relative Positioning Block With Residual Path Storage After Activating Drive Enable

 According to master communication, positioning block acceptance takes place by toggling bit 0 in S-0-0346 or by a 0-1 edge of bit 0 in P-0-4060.

Operation Modes

**Relative Positioning Block With Residual Path Storage After Interrupting With Jog Mode**

**Example** Interrupted relative positioning block **with residual path storage** after jog mode with target position = 600 **without overrunning the target position** while jogging

**Dedicated Position** Positioning is always continued at the current actual position value.

**Behavior** An interruption by means of jogging or positioning stop clears the residual path memory.



The incremental dimension reference is no longer ensured!

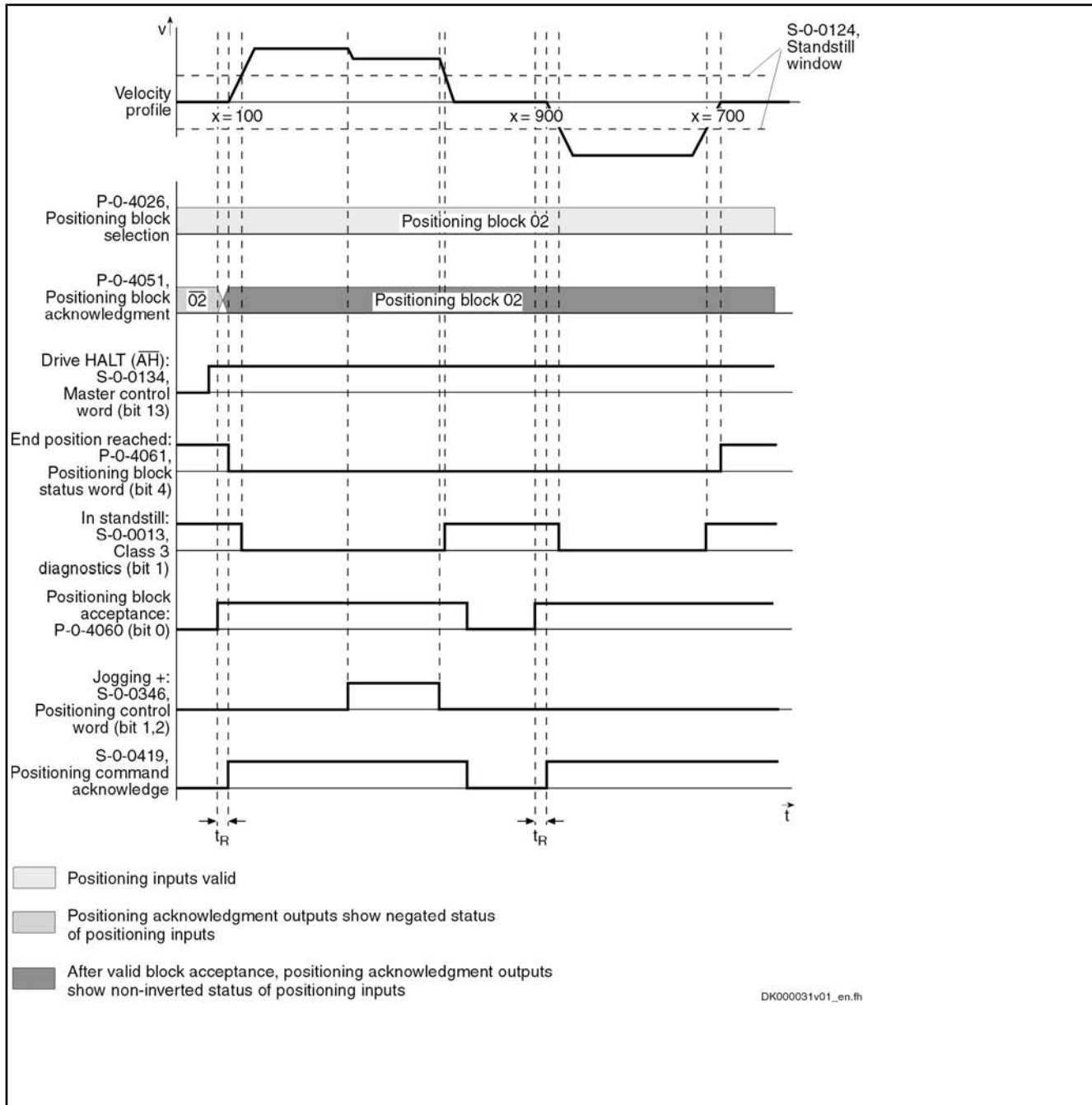


Fig.7-43: Relative Positioning Block With Residual Path Storage After Jog Mode



According to master communication, positioning block acceptance takes place by toggling bit 0 in S-0-0346 or by a 0-1 edge of bit 0 in P-0-4060.

### Relative Positioning Block With Residual Path Storage After Switching Drive Controller Control Voltage Off and On

If an absolute encoder is used, the incremental dimension reference can be retained after switching control voltage off and on. The previously calculated target position is stored at power shutdown. The rest of the distance is traveled after the interrupted relative positioning block with residual path storage is activated.

If a single-turn encoder is used, the residual path is rejected and positioning continues at the actual position.

#### Dedicated Position

The position command value at the last "end position reached" (position = 100) message is used as the reference position.



If a positioning block is not accepted, the drive behaves as if the positioning block had not been started.

## Infinite Travel in Positive/Negative Direction

If an axis is to be moved with defined velocity, acceleration and jerk without a specific target position, the travel block mode "Travelling in positive direction" or "Travelling in negative direction" must be specified. The drive moves in the indicated direction until the start signal is reset or one of the position limit values or the travel range limit switch is reached.

The target position which was set is irrelevant in this positioning mode.

#### Parameter Setting

- "P-0-4019, Positioning block mode" = 0000 0000 0000 010X  
→ Travel in positive direction
- "P-0-4019, Positioning block mode" = 0000 0000 0000 100X  
→ Travel in negative direction

Operation Modes

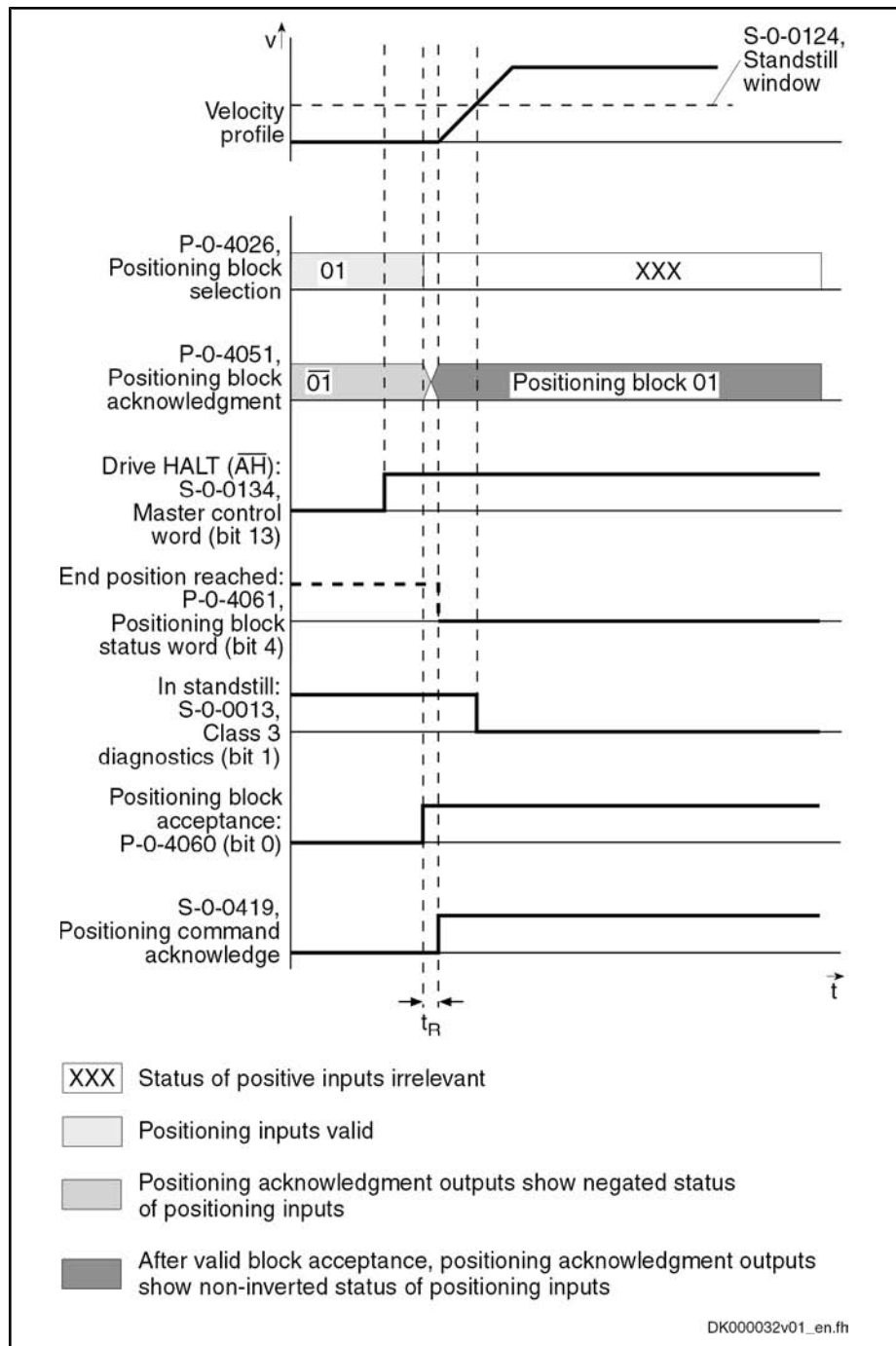


Fig.7-44: Example: Infinite Travel in Positive/Negative Direction



According to master communication, positioning block acceptance takes place by toggling bit 0 in S-0-0346 or by a 0-1 edge of bit 0 in P-0-4060.

## 7.7.4 Sequential Block Processing

### Basic Function



For sequential block processing, it is first of all the same basic rules as for single-block processing which apply (see that section). In addition to mere positioning block functions with defined positioning blocks and block acceptance, there also is a defined block transition to be parameterized.

#### Selecting and Activating a Sequential Block

A positioning block with sequential block is selected and activated in the usual way, only the first block of the sequential block chain being selected. The sequential block is the block with the next higher block number. A sequential block can also have a sequential block so that after a start block up to 63 sequential blocks can be set.



The potential sequential block of the last valid block is block 0.

#### Conditions to Advance in Sequential Block Mode

There are two basically different modes for block advance; these modes can be subdivided:

- **Position-Dependent Block Advance**
  - Block transition with old positioning velocity
  - Block transition with new positioning velocity
  - Block transition with intermediate stop and defined delay time (see P-0-4018)
- **Switch-Signal-Dependent Block Advance**

### Position-Dependent Block Advance

#### General Information

With position-dependent block advance, switching to the sequential block is carried out at the target position of the start block.

There are three different types of block transition:

- Block Transition With Old Positioning Velocity (Mode 1)
- Block Transition With New Positioning Velocity (Mode 2)
- Block Transition With Intermediate Stop and Defined Delay Time

#### Block Transition With Old Positioning Velocity (Mode 1)

##### Parameter Setting

- "P-0-4019, Positioning block mode" = 0000 0000 0001 000X  
→ Absolute block with sequential block
- "P-0-4019, Positioning block mode" = 0000 0000 0001 001X  
→ Relative block with sequential block
- "P-0-4019, Positioning block mode" = 0000 0000 0001 010X  
→ Infinite block in positive direction with sequential block
- "P-0-4019, Positioning block mode" = 0000 0000 0001 100X  
→ Infinite block in negative direction with sequential block

##### Function

In this mode, the target position of the start block is run through at the velocity of the start block. Then the positioning velocity is switched to that of the sequential block.

Operation Modes

With relative and absolute positioning blocks with block advance, the drive moves in the direction of the target position. As soon as the target position is passed, the drive switches to the next travel block n+1.

With infinite positioning blocks, the drive moves in positive or negative direction. As soon as the target position is passed, the drive switches to next positioning block n+1, the block n representing the positioning block currently in process.



If the target position is not in the selected travel direction, the drive moves in the direction of the target position. Thus the drive always reaches the switching position.

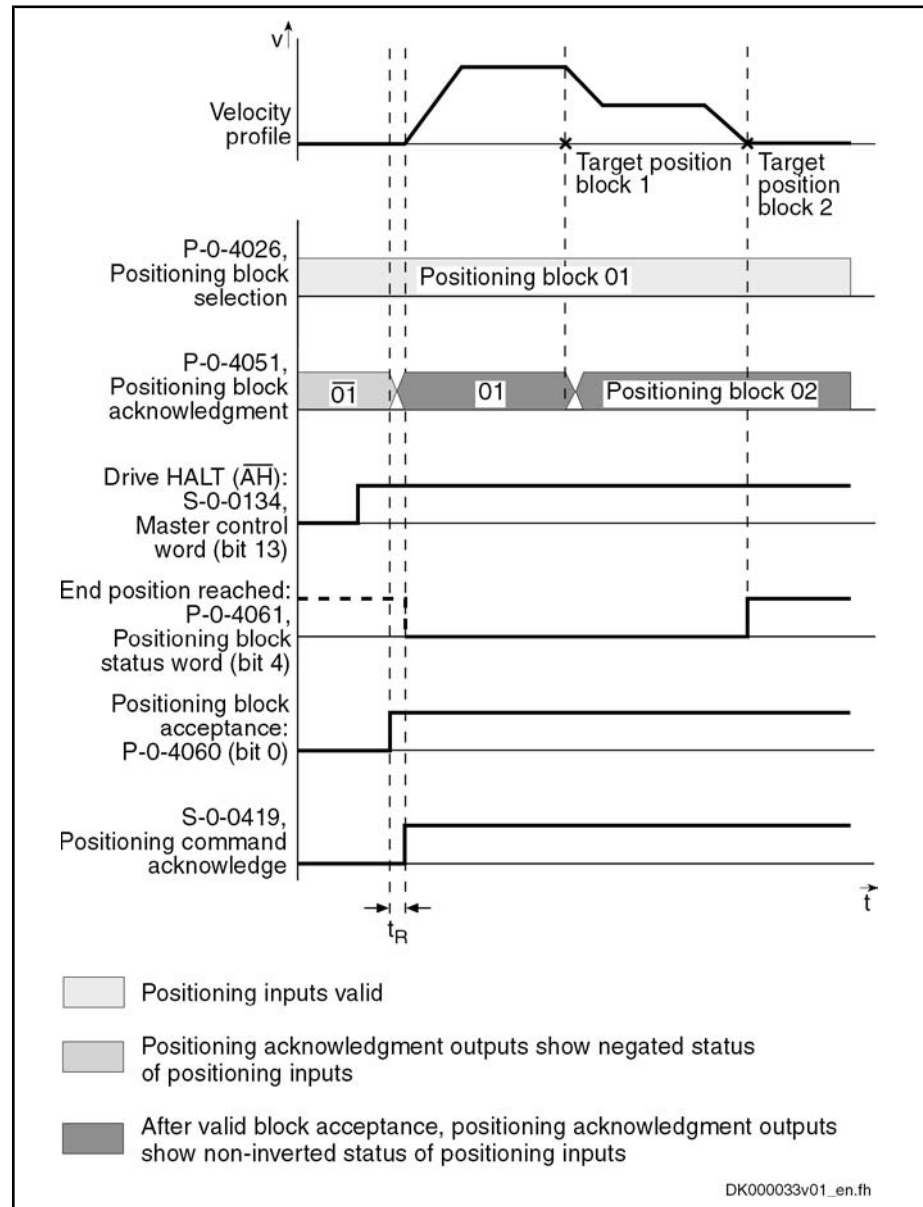


Fig. 7-45: Example: Position-Dependent Block Advance (Mode 1)



According to master communication, positioning block acceptance takes place by toggling bit 0 in S-0-0346 or by a 0-1 edge of bit 0 in P-0-4060.

**Block Transition With New Positioning Velocity (Mode 2)**

- Parameter Setting**
- "P-0-4019, Positioning block mode" = 0000 0000 0010 000X  
→ Absolute block with sequential block
  - "P-0-4019, Positioning block mode" = 0000 0000 0010 001X  
→ Relative block with sequential block
  - "P-0-4019, Positioning block mode" = 0000 0000 0010 010X  
→ Infinite block in positive direction with sequential block
  - "P-0-4019, Positioning block mode" = 0000 0000 0010 100X  
→ Infinite block in negative direction with sequential block

**Function** In this mode, the target position of the start block is run through at the positioning velocity of the sequential block. The deceleration or acceleration processes required to adjust the velocity are already carried out in the start block.

The drive moves in the direction of the target position  $x_n$  (with infinite blocks in the preset direction) set in current positioning block  $n$ . In due time before that, the acceleration is used to accelerate or decelerate to the next positioning velocity  $v_{n+1}$  so that the velocity  $v_{n+1}$  is reached at the target position  $x_n$ .

But switching to the next positioning block does not occur until the target position is overrun.

Operation Modes

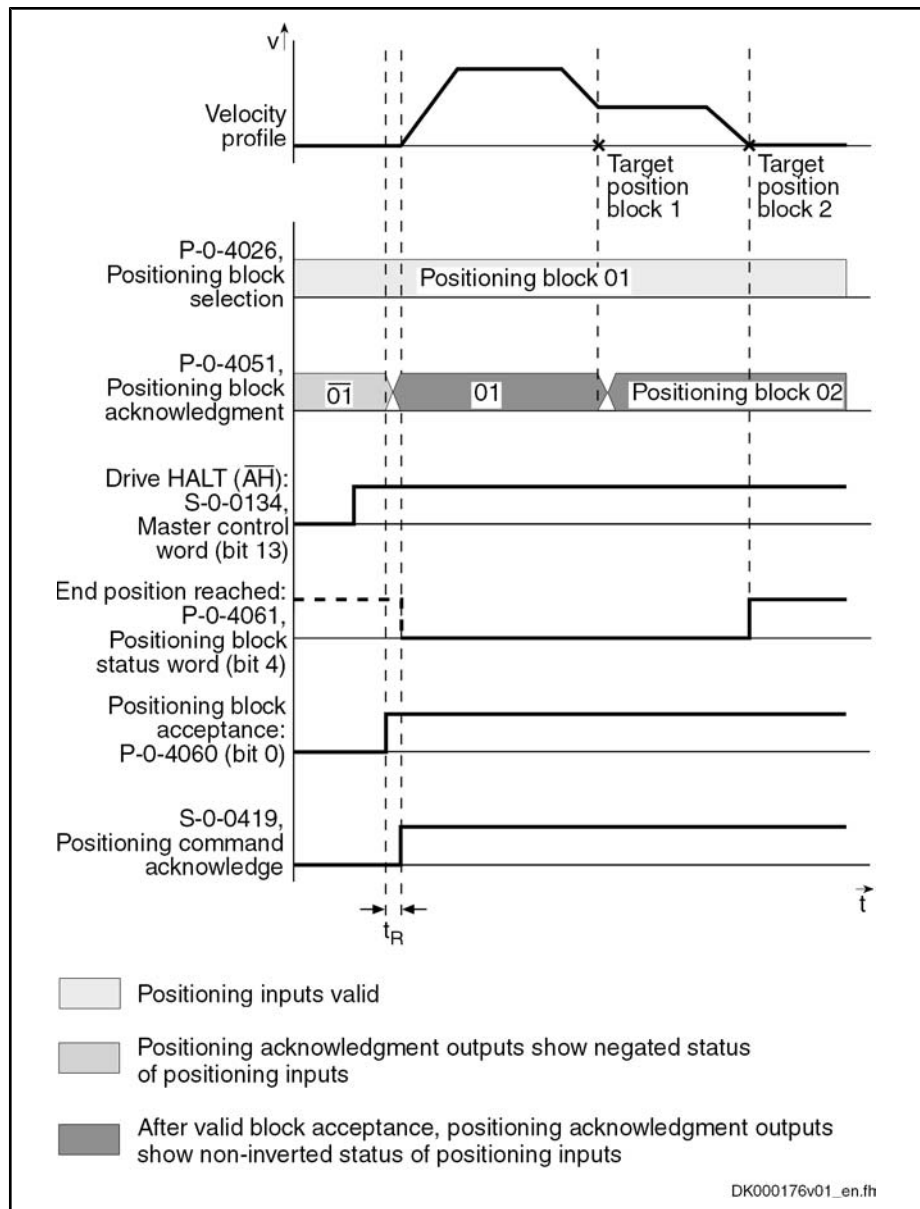


Fig. 7-46: Example: Position-Dependent Block Advance (Mode 2)



According to master communication, positioning block acceptance takes place by toggling bit 0 in S-0-0346 or by a 0-1 edge of bit 0 in P-0-4060.

**Block Transition With Intermediate Stop and Defined Delay Time**

**Parameter Setting**

- "P-0-4019, Positioning block mode" = 0000 0000 0100 000X  
→ Absolute block with sequential block
- "P-0-4019, Positioning block mode" = 0000 0000 0100 001X  
→ Relative block with sequential block

**Function**

In this mode, the drive positions at the target position of the start block. Once the position command value is at the target position, the sequential block is automatically started without a new start signal having been given externally.



If a delay time (P-0-4018) was parameterized for the positioning block, the sequential block is only started when the delay time is over.

Another operating mode is switching when overrunning the target position with intermediate stop.

In this case, the drive is decelerated to speed "0" at the target position and then accelerated to the new positioning velocity.



Advance takes place when the internal command value generator has reached the target position and a possibly parameterized delay time (P-0-4018) has passed. With very low jerk values, the resulting dwell time is relatively long.

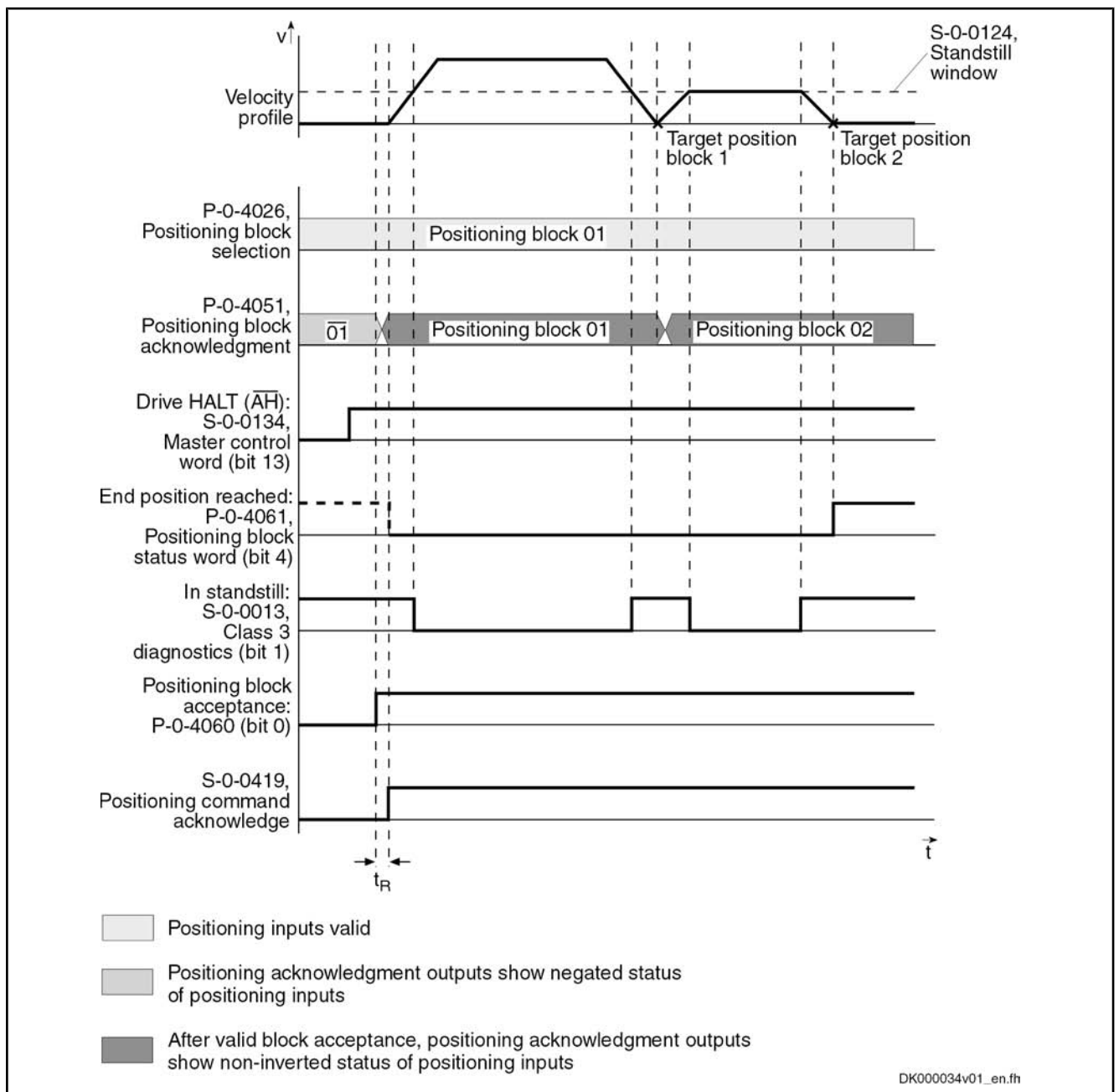


Fig.7-47: Example: Sequential Block Advance for Target Position With Intermediate Stop

## Operation Modes



According to master communication, positioning block acceptance takes place by toggling bit 0 in S-0-0346 or by a 0-1 edge of bit 0 in P-0-4060.



This mode should be used if there is a change in direction in the case of two consecutive sequential blocks within one sequential block chain. Otherwise, the position at which the direction is changed will be inevitably overrun.

## Switch-Signal-Dependent Block Advance

For switch-signal-dependent block advance, there are the following positioning modes:

- "P-0-4019, Positioning block mode" = 0000 0000 1000 000X  
→ Absolute block with sequential block
- "P-0-4019, Positioning block mode" = 0000 0000 1000 001X  
→ Relative block with sequential block
- "P-0-4019, Positioning block mode" = 0000 0000 1000 010X  
→ Infinite block in positive direction with sequential block
- "P-0-4019, Positioning block mode" = 0000 0000 1000 100X  
→ Infinite block in negative direction with sequential block



Advance to the block with the next higher block number is triggered by an externally applied switch signal.

## Switching With Cams

The switch-signal-dependent block advance allows transition to a sequential block, triggered by an external switch signal. As input for this switch signal, there are two sequential block inputs/probe inputs available.

The status of the hardware signals is displayed in "P-0-4057, Positioning block, input linked blocks".

## Function

The drive switches to the **next travel block n+1**, as soon as the input for the **sequential block cam 1** changes from "0" to "1". If the target position is not reached, switching to the new positioning block is carried out while traveling.

The drive switches to the **next travel block n+1**, as soon as the input for the **sequential block cam 2** changes from "0" to "1". If a sequential block cam is activated during this travel, the drive switches to the positioning block after the next.

## Dedicated Position

A following relative positioning block refers to the position at which the sequential block cam was switched.



The sequential block cams are sampled in the position loop clock (see "Performance Data"). The precision of position detection therefore strongly depends on the velocity during overrun.

Assignment Table for Cams

Cam 2	Cam 1	Drive reaction
0	0	Drive moves to target position of block n
x	0 → 1	Block n+1 is started
0 → 1	x	Block n+2 is started

n Positioning block preselected via the parallel inputs or "P-0-4026, Positioning block selection"

x Not relevant

*Fig.7-48: Drive Reaction With Different Switch Signal Sequences*

Operation Modes

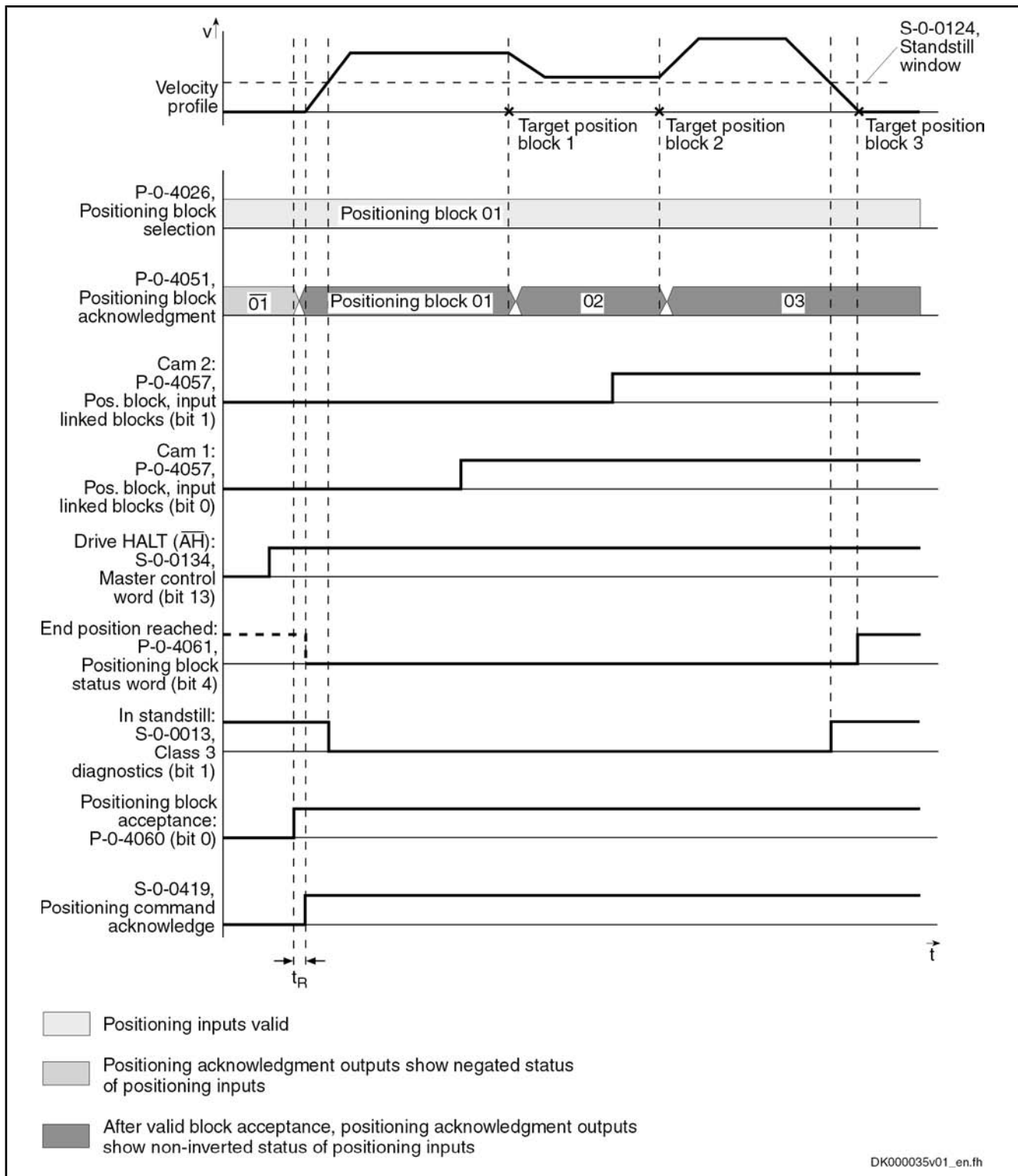


Fig. 7-49: Example: Switch-Signal-Dependent Block Advance



According to master communication, positioning block acceptance takes place by toggling bit 0 in S-0-0346 or by a 0-1 edge of bit 0 in P-0-4060.

**Failure of Switch Signal for Block Advance**

If the start block of a switch-signal-dependent sequential block is an absolute or relative positioning block, the drive positions at target position, if the switch signal for block advance is not received. The drive thus only generates the message "end position reached" after the sequential block chain is completed. If a switch signal is then applied, the drive will carry out the sequential block.

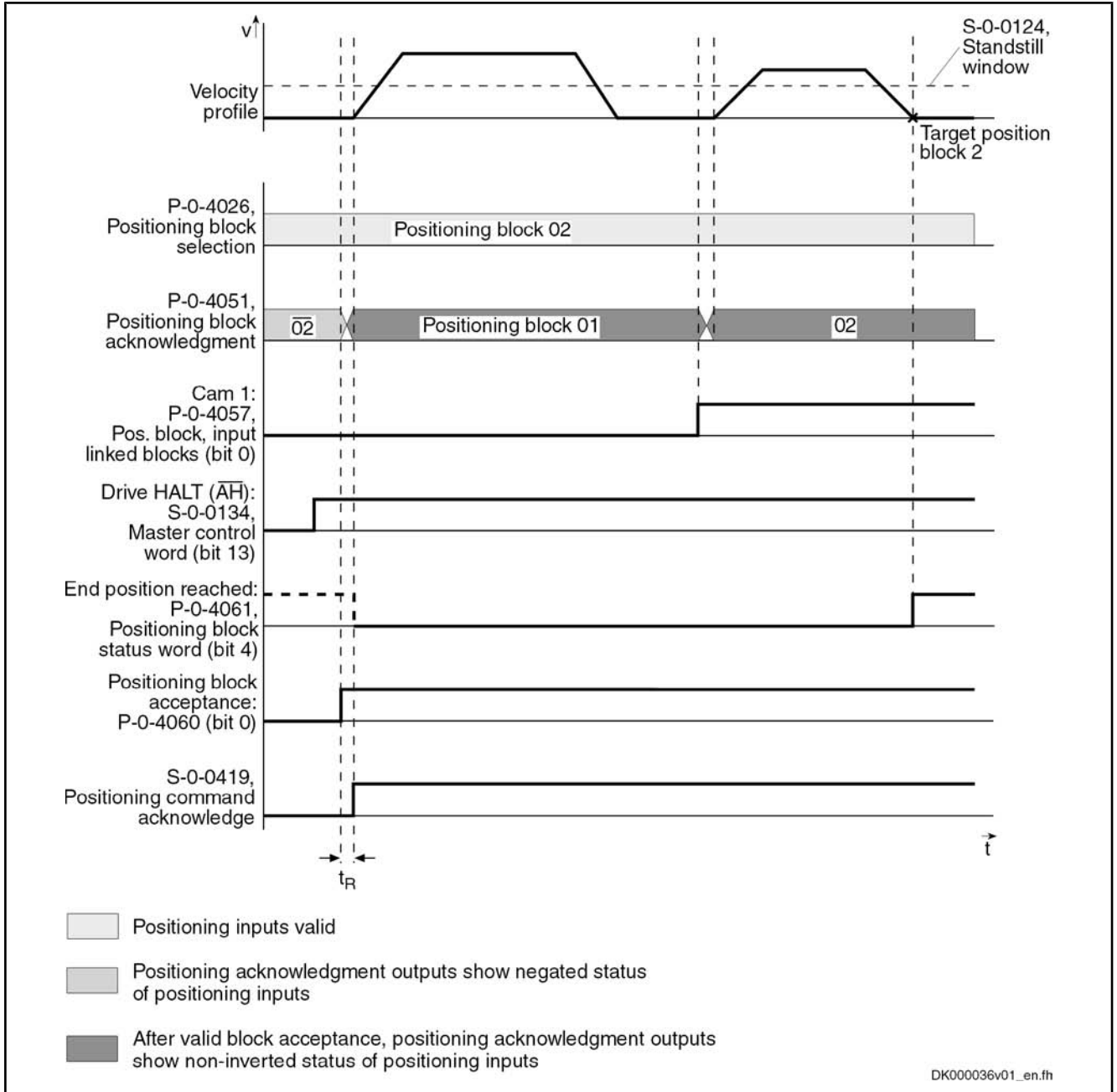


Fig.7-50: Example: Switch-Signal-Dependent Block Advance (Behavior With Failure of Switch Signal)



According to master communication, positioning block acceptance takes place by toggling bit 0 in S-0-0346 or by a 0-1 edge of bit 0 in P-0-4060.

## Operation Modes



All conditions for advance are constantly queried and evaluated to be able to switch to the correct sequential block, even after the sequential block chain was interrupted. Only the first condition for advance occurring during an interruption is recognized, however. All other conditions are not taken into account!

---

**Interrupting a Sequential Block Chain**

There are two basically different behaviors when a sequential block chain is interrupted:

- **Residual path is rejected** when interruption by:
  - Positioning stop (S-0-0346, bit 1 and bit 2 = 1)
  - Jogging +/-
  - Control voltage "Off"

After interruption with "positioning stop" and "jogging +/-" positioning always continues at the current actual position. The sequential block chain interrupted before is not completed, but the currently selected block is executed. Thereby the incremental dimension reference gets lost!

- **Residual path is maintained** when interruption by:
  - Removing drive enable
  - Removing the "drive start" signal
  - Changing the operation mode

Depending on the block type of the sequential block chain that was interrupted and the events occurring during this interruption, the sequential block chain is processed differently after a restart.



In sequential block mode, relative positioning blocks **without residual path storage** are **not allowed**, as otherwise the incremental dimension reference would get lost in the case of interruption.

---

**Dedicated Position**

Given an interruption, a restart will end the sequential block chain.

The dedicated position is the original start position of the sequential block chain.



The incremental dimension reference is retained, as only absolute and relative positioning blocks with residual path storage are used in sequential block mode!

---

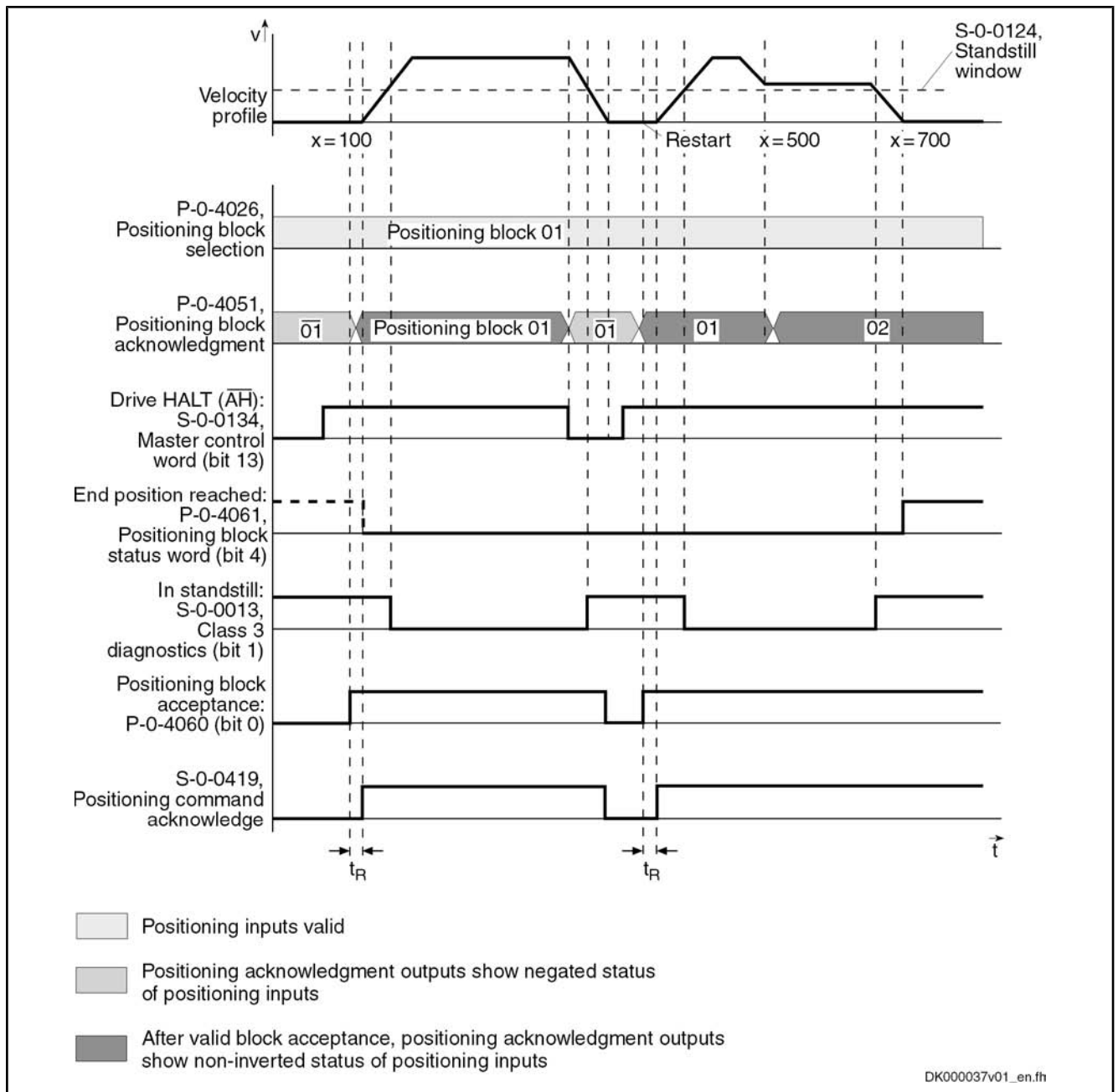


Fig.7-51: Example: Sequential Block Interruption With Same Block Selected



According to master communication, positioning block acceptance takes place by toggling bit 0 in S-0-0346 or by a 0-1 edge of bit 0 in P-0-4060.

**Changing to Different Operation Mode**

When changing the operation mode during an interruption, the sequential block chain interrupted before is completed at the restart, if there hadn't been any new block selected.

Given a sequential block with advance due to target position, only the overrun of the target position of the current positioning block will be detected. The processing of the sequential block is completed from this position.



The advance condition due to switch signals is always detected.

## Operation Modes

### Interrupting a Sequential Block Chain With Selection of New Positioning Block

If a new positioning block is selected during an interruption (e.g. with "Drive HALT"), the previously interrupted sequential block chain is not completed after a restart, but the currently selected block is executed.

#### Dedicated Position

The dedicated position is the current actual position value.



The incremental dimension reference gets lost, if the sequential block is interrupted.

The conditions for the interruption of sequential blocks also apply after the control voltage is switched off, if an absolute encoder is used.

### Interrupting a Sequential Block Chain With Absolute Sequential Blocks

An interruption with absolute positioning blocks does not represent any problem, as the position data reference is always guaranteed.

When a **new block number** is selected in the case of an interruption, the sequential block interrupted before is not completed when toggling bit 0 in "S-0-0346, Positioning control word" or with a 0-1 edge of bit 0 in "P-0-4060, Positioning block control word", but the currently selected block is executed.

When **no new block number** is selected in the case of an interruption, the sequential block interrupted before is completed when toggling bit 0 in "S-0-0346, Positioning control word" or with a 0-1 edge of bit 0 in "P-0-4060, Positioning block control word".

## 7.7.5 Notes on Commissioning and Parameterization

### Limit Values of the Drive

When parameterizing sequential blocks, the maximum values of the drive must be taken into account. These values are:

- Maximum acceleration capability
- Maximum speed (independent of mains voltage)

If blocks are parameterized for which the drive would have to generate values greater than the maximum values, this will cause an excessive lag error. With the error message "F2028 Excessive deviation" the drive will then signal that it cannot follow the position command value.

### Minimum Values for Acceleration and Jerk

If the acceleration values are too low, this can cause problems. Therefore, guide values according to the formula below are to be preferred when determining positioning blocks:

$$\text{Acceleration} > \frac{(\text{velocity difference})^2}{2 \times \text{target position difference}} \times \frac{(v_{n+1} - v_n)^2}{2 \times (x_{n+1} - x_n)}$$

$v_n$	Velocity of block n
$v_{n+1}$	Velocity of block n+1
$x_n$	Target position of block n
$x_{n+1}$	Target position of block n+1

Fig.7-52: Minimum Acceleration Value With Sequential Block Mode (Linear)





The above relationship applies to an infinitely large jerk which corresponds to a jerk filter that has been switched off (= 0). If a jerk filter is used, the calculated values have to be doubled in first approximation. The distance to be run with a block and the respective velocity are generally fixed by the process. If the minimum acceleration value calculated with the above guide value formula already causes the maximum value, mentioned in the previous section, to be exceeded, a lower positioning block velocity must be selected.

---

**Minimum Jerk Value**

If the acceleration values parameterized are too low, this can cause the parameterized velocity not to be reached. In this case, the so-called "triangular mode" is used.

**Directional Change Within a Sequential Block Chain**

If a directional change takes place when changing from block n to block n+1 of a sequential block, the mode "switching at target position with halt" should be used for block n to reverse the direction without overshoot.

---

**Explanation of the Figure Below**

Block n with intermediate stop follows block n-1 with mode 1 (block transition with old positioning velocity), because a change in direction occurs when changing from block n to block n+1. At change in direction there is a change of sign of the velocity at target position n. If the acceleration parameterized in block n is too low to decelerate within the path difference  $x_n - x_{n-1}$  from velocity  $v_{n-1}$  to the value "0" the parameterized target position  $x_n$  will be overrun.

This may cause software or hardware limit switches to trigger.

Operation Modes

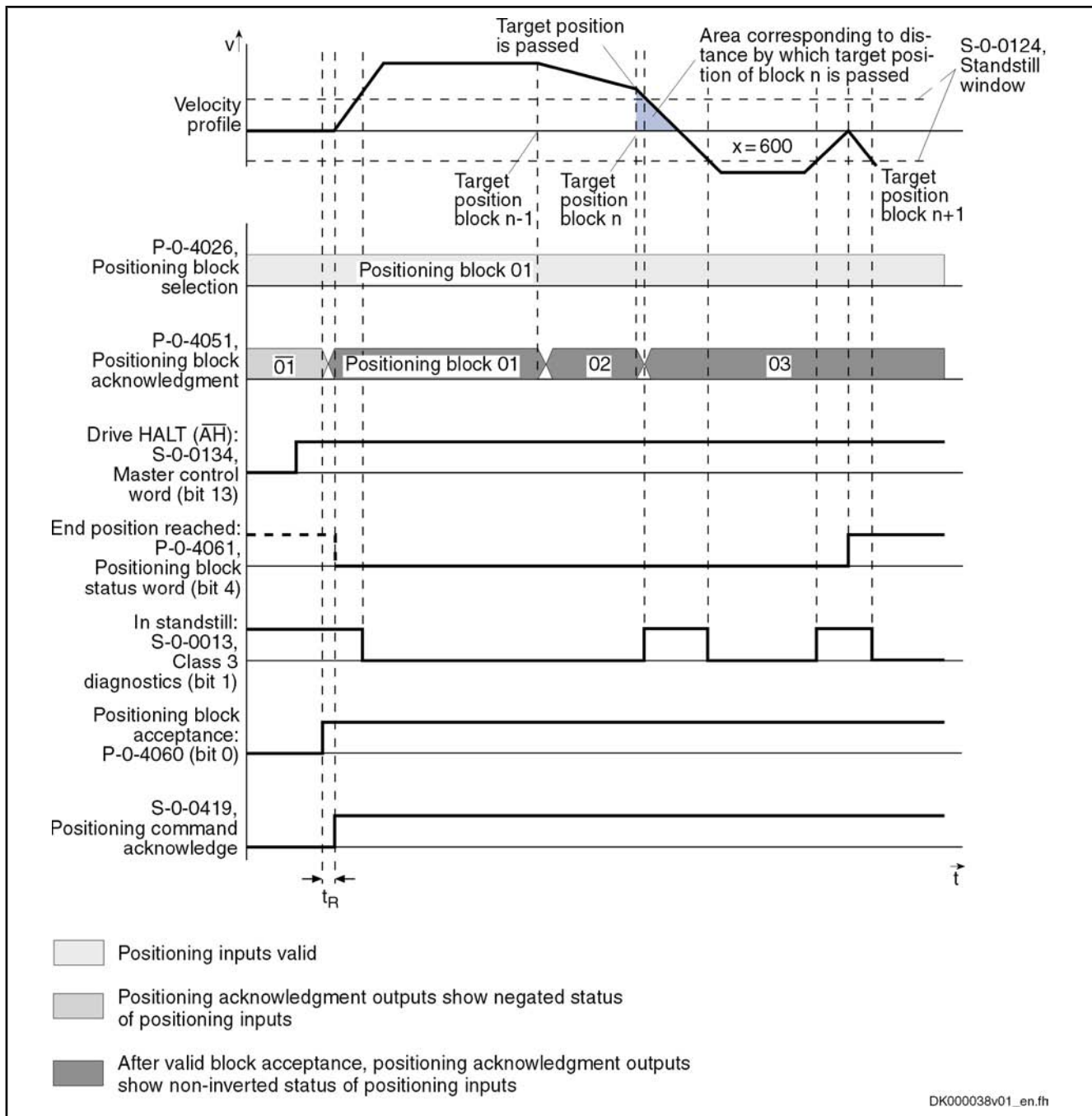


Fig. 7-53: Parameterizing a Sequential Block With Directional Change



According to master communication, positioning block acceptance takes place by toggling bit 0 in S-0-0346 or by a 0-1 edge of bit 0 in P-0-4060.



In the case of a sequential block with directional change, it is necessary to take values according to the above formula for the minimum acceleration value into account in order to avoid overshooting of position!

## 7.7.6 Diagnostic and Status Messages, Acknowledgment

### Positioning Block Acknowledgment

The positioning block acknowledgment is used for feedback of the execution of the active positioning block.

#### Acknowledgment With Active Operation Mode

After the positioning block mode has been activated, the complement of the block number of the selected positioning block is acknowledged, until a start signal (toggling of bit 0 in "S-0-0346, Positioning control word" or 0-1 edge of bit 0 in "P-0-4060, Positioning block control word") is set. As of the first start signal and if operation is trouble-free, the block number of the positioning block that was started is output. If an error is detected at the start of a positioning block, the faulty positioning block is acknowledged with the complement of the block number. The drive generates a warning and stops.

#### Acknowledge With "Drive HALT"

If "Drive HALT" is active, the complement of the block number of the selected positioning block is output in "P-0-4051, Positioning block acknowledgment".

#### Acknowledgment With Secondary Operation Modes

The acknowledgment is not affected by secondary operation modes, error reaction and command inputs, i.e. "P-0-4051, Positioning block acknowledgment" retains the value.

#### Acknowledgment With Drive Enable Switched Off

After switching off drive enable, the last accepted positioning block is output at the acknowledge outputs. If the drive is at the target position of the last accepted positioning block, the message "end position reached" is additionally output.

The example below shows the same absolute positioning block being started once again.

Operation Modes

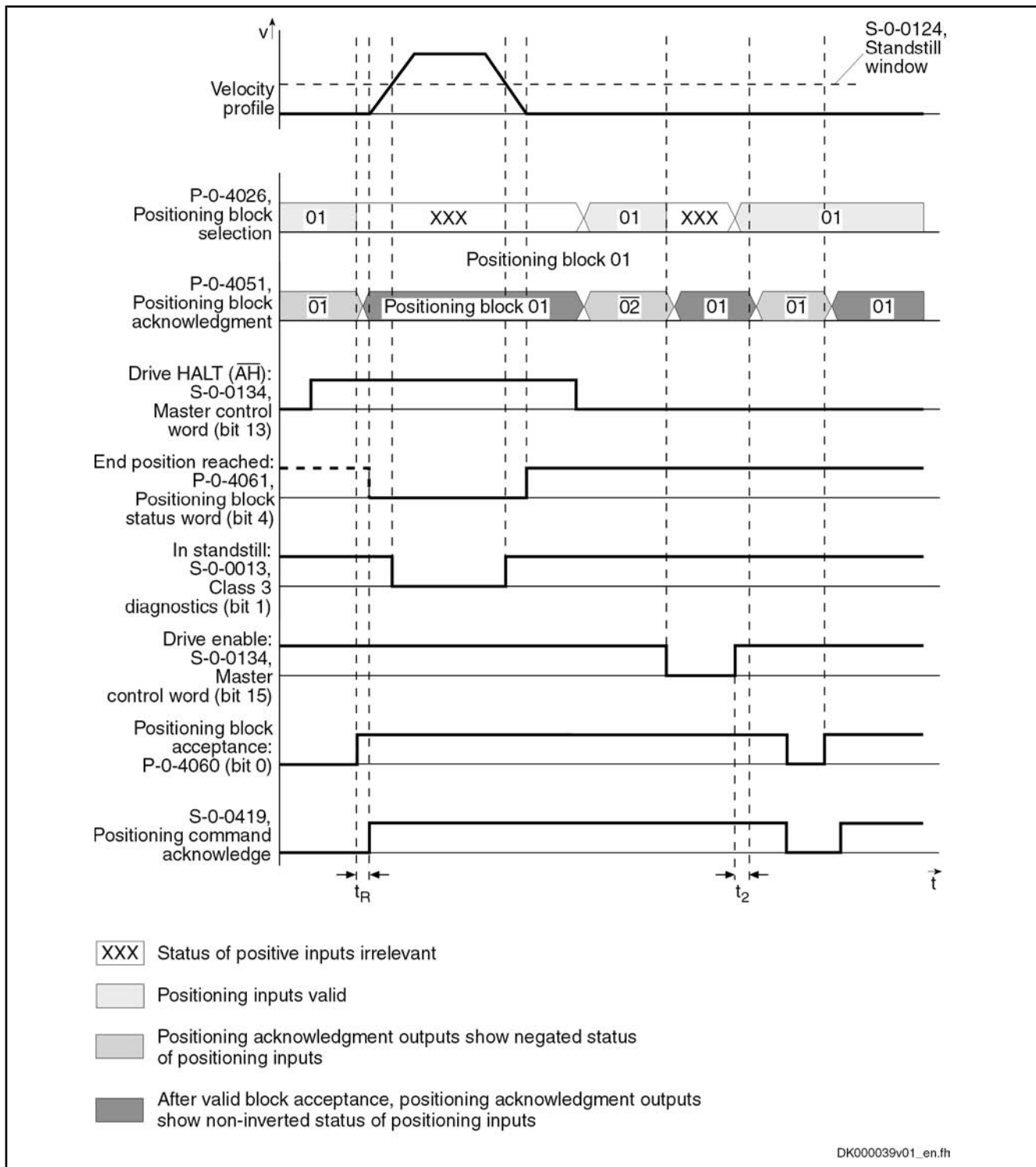


Fig.7-54: Acknowledge and Message "End Position Reached" After Drive Enable Switched Off



According to master communication, positioning block acceptance takes place by toggling bit 0 in S-0-0346 or by a 0-1 edge of bit 0 in P-0-4060.

<b>Acknowledgment With Control Voltage Interrupted</b>	If the control voltage is switched off, the last accepted positioning block is stored in "P-0-4052, Positioning block, last accepted" so that after switching control voltage on, it is always the last accepted positioning block that is output.
<b>With Absolute Value Encoder</b>	If an <b>absolute encoder</b> is used, it is possible to decide, after the control voltage is switched off and on, whether the drive still is at the target position of the last accepted positioning block (end position reached).  The "end position reached" message is generated as soon as the drive is ready for operation again (bb contact closed).
<b>With Single-Turn Encoder</b>	If a <b>single-turn encoder</b> is used, the "end position reached" message is not clearly defined after a voltage interrupt until the first target position has been run to or homed.



The "end position reached" message is only retained if the axis has not been moved during the interruption. If the axis is moved into the positioning window during the interruption, the "end position reached" message will also be generated! After activating drive enable, positioning block acknowledge changes as described under "Acknowledgment with drive enable switched off".

---

## Status Messages

**Status Bits** In addition to the status messages during the "drive-internal interpolation" mode, the "end position reached" status message is generated in the "positioning block mode" (bit 4 = 1 in "P-0-4061, Positioning block status word"), if the following applies:

- |S-0-0430 – S-0-0051/S-0-0053| < S-0-0057 (In Position)  
- and -
- No sequential block has been selected.

See also section "Status Message" for Operation Mode "Drive-Internal Interpolation"



See also Parameter Description "P-0-4061, Positioning block status word"

**Status Parameters** The following parameters provide further diagnostic possibilities:

- P-0-4051, Positioning block acknowledgment  
→ Acknowledgment of the currently accepted and active positioning block  
**Note:** At "Drive HALT" the selected positioning block is returned in negated form (complementary to positioning block selection).
- P-0-4052, Positioning block, last accepted  
→ Contains the last accepted positioning block (stored in non-volatile form)  
**Note:** For sequential block chains, this is always the first block of the sequential block chain!
- P-0-4053, Positioning block, last active  
→ Contains the last active positioning block (stored in non-volatile form)  
**Note:** For sequential block chains, this is the last active block of the sequential block chain. or single blocks (no sequential block processing), the contents of P-0-4052 and P-0-4053 are always equal!
- P-0-4057, Positioning block, input linked blocks  
→ Contains an image of the digital sequential block inputs (switch cam inputs)

Operation Modes

## Diagnostic Messages

### Diagnostic status messages:

- A0162 Positioning block mode
- A0206 Positioning block mode, encoder 1
- A0207 Positioning block mode lagless, encoder 1
- A0210 Positioning block mode, encoder 2
- A0211 Positioning block mode lagless, encoder 2

### Warnings:

- E2049 Positioning velocity  $\geq$  limit value
- E2053 Target position out of travel range
- E2054 Not homed
- E2055 Feedrate override S-0-0108 = 0
- E2058 Selected positioning block has not been programmed
- E2064 Target position out of num. range

### Error messages:

- F2028 Excessive deviation

## 7.8 Synchronization Modes

### 7.8.1 Basic Functions of the Synchronization Modes

#### Overview

#### General Information on Synchronization Modes

The synchronization modes allow the drive to run synchronously with regard to a real or virtual master axis. The synchronization modes are basically divided into the following groups:

- **Velocity synchronization** with real/virtual master axis
- **Synchronous position control modes:**
  - Phase Synchronization With Real/Virtual Master Axis
  - Electronic Cam With Real/Virtual Master Axis
  - MotionProfile With Real/Virtual Master Axis

The figure below illustrates how the synchronization modes are integrated in the control loop structure.

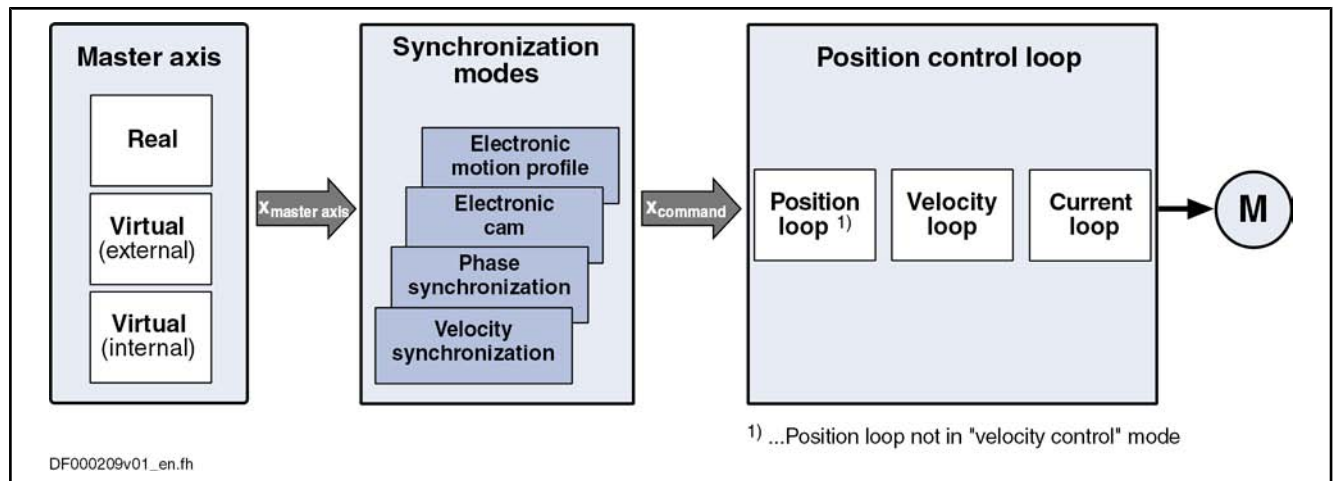


Fig.7-55: General Block Diagram of the Synchronization Modes

All synchronization modes have the following identical or similar basic functions which are comprehensively described in this section:

- Adjustment of master axis, consisting of
  - Generation of master axis
  - Master axis offset and modulo limitation
  - Electronic gear with fine adjustment
- Drive-controlled dynamic synchronization



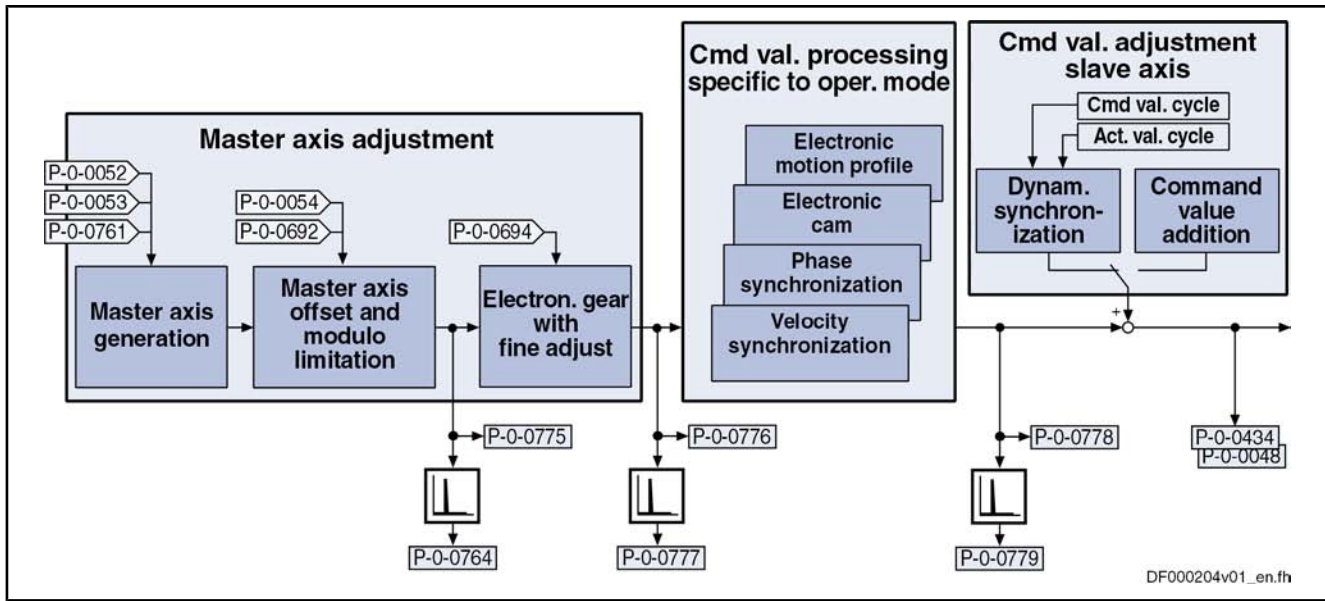
The individual synchronization modes basically differ in the following function blocks:

- Command value processing specific to operation mode
- Command value addition for slave axis

These function blocks are described specific to operation mode in the individual sections on the respective synchronization modes.

The figure below illustrates the interaction of the individual basic functions (function blocks) of the synchronization modes.

Operation Modes



- P-0-0048 Effective velocity command value
- P-0-0052 Actual position value of measuring encoder
- P-0-0053 Master axis position
- P-0-0054 Additive master axis position
- P-0-0434 Position command value of controller
- P-0-0692 Additive position command value, process loop
- P-0-0694 Gear ratio fine adjustment, process loop
- P-0-0761 Master axis position for slave axis
- P-0-0764 Master Axis Speed
- P-0-0775 Resulting Master Axis Position
- P-0-0776 Effective master axis position
- P-0-0777 Effective master axis velocity
- P-0-0778 Synchronous position command value
- P-0-0779 Synchronous velocity

Fig.7-56: Function Blocks of the Synchronization Modes

**Explanation of Terms**

**Master axis:**

The drive which makes available the master axis position for generating the synchronous position command value for the slave axis is called master axis.

**Slave axis:**

The drive which in position control follows a synchronous position command value internally derived from the master axis is called slave axis.

**Actual value cycle:**

The modulo range within which the actual position values of the slave axis are to be found is called actual value cycle. It can also be used to limit the travel range during synchronization.

The modulo range of the actual value cycle corresponds to the integral multiple of the synchronization range.

**Command value cycle:**

The modulo range within which the synchronous position command values of the slave axis are to be found is called command value cycle. If necessary (depending on P-0-0155), it can be used to limit the actual position value in the actual value cycle (cf. P-0-0753).



## Configuring and Controlling the Synchronization Modes

The synchronization modes are configured and controlled by means of the following synchronization parameters:

### Pertinent Parameters (Synchronization Parameters)

- S-0-0520, Control word of axis controller
- S-0-0521, Status word of position loop
- P-0-0086, Configuration word synchronous operation modes
- P-0-0088, Control word synchronization modes
- P-0-0089, Status word synchronization modes

After having selected the required synchronization mode, you can make, among other things, the following settings via these parameters:

- Position control with lag error or lagless
- Use of encoder 1 or encoder 2

See also "Operation Mode Handling"

## Command Value Addition

This section contains an overview of the basic possibilities of adding command values. The characteristics and details specific to operation mode are described in the section of the respective synchronization mode.

### Pertinent Parameters

- S-0-0037, Additive velocity command value
- S-0-0048, Additive position command value
- P-0-0048, Effective velocity command value
- P-0-0054, Additive master axis position
- P-0-0060, Filter time constant additive position cmd value
- P-0-0434, Position command value of controller
- P-0-0686, Additive position command value, positioning velocity
- P-0-0687, Additive position command value, positioning acceleration
- P-0-0688, Additive master axis position, positioning velocity
- P-0-0689, Additive master axis position, positioning acceleration
- P-0-0690, Additive velocity command value, process loop
- P-0-0691, Additive position command value, process loop
- P-0-0692, Additive master axis position, process loop
- P-0-0693, Filter time constant, add. master axis pos., process loop

The figure below contains a rough overview of the command values which can act on the master and slave axis and of how they can be influenced.

## Operation Modes

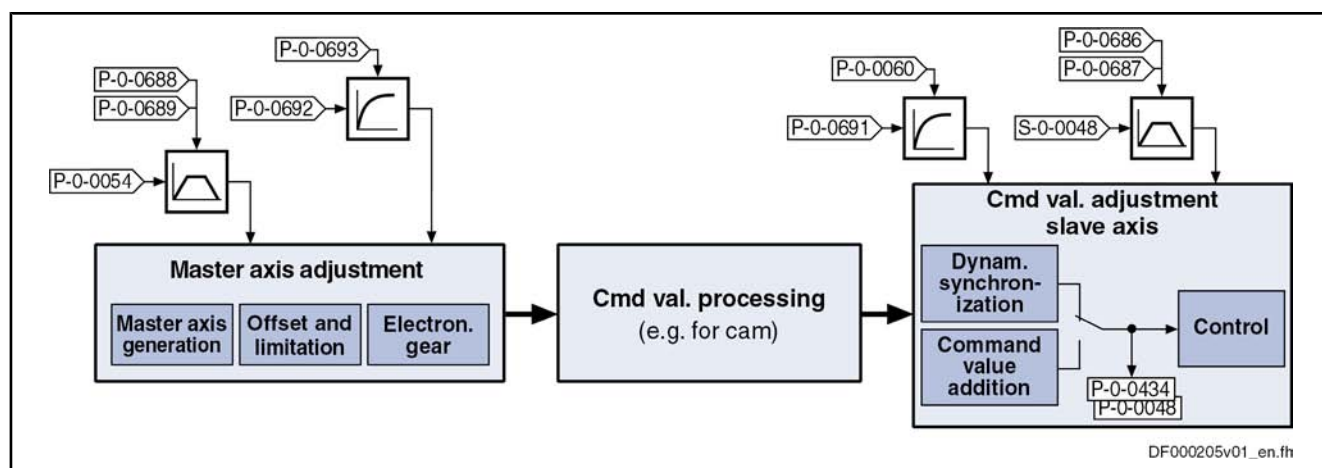


Fig.7-57: Possibilities of Command Value Addition for Master and Slave Axis

## Master Axis Adjustment

## Brief Description

## Master Axis Generation

Possible signal sources for the effective master axis of the synchronization modes:

- Real master axis
- Virtual master axis, external
- Virtual master axis, internal

## Master Axis Offset and Modulo Limitation

For internal adjustment or processing of the master axis information, there are the following options:

- Addition of components (= offset) to the incoming master axis angle:
  - via "P-0-0054, Additive master axis position"
  - via "P-0-0692, Additive master axis position, process loop"
- Limitation to modulo range of master axis

## Electronic Gear Function

By means of factors to be set (e.g. input revolutions, output revolutions, polarity), the electronic gear function can influence the master axis position relevant to the operation mode as compared to the master axis position preset by master axis evaluation.

## Pertinent Parameters

The following parameters are used in conjunction with master axis adjustment:

- P-0-0052, Actual position value of measuring encoder
- P-0-0053, Master axis position
- P-0-0054, Additive master axis position
- P-0-0084, Number of bits per master axis revolution
- P-0-0688, Additive master axis position, positioning velocity
- P-0-0689, Additive master axis position, positioning acceleration
- P-0-0692, Additive master axis position, process loop
- P-0-0693, Filter time constant, add. master axis pos., process loop
- P-0-0750, Master axis revolutions per master axis cycle
- P-0-0761, Master axis position for slave axis
- P-0-0764, Master axis speed
- P-0-0765, Modulo factor measuring encoder
- P-0-0775, Resulting master axis position

The following parameters are used in conjunction with the electronic gear with fine adjustment:

- P-0-0083, Gear ratio fine adjustment
- P-0-0108, Master drive polarity
- P-0-0156, Master drive gear input revolutions
- P-0-0157, Master drive gear output revolutions
- P-0-0694, Gear ratio fine adjustment, process loop
- P-0-0776, Effective master axis position
- P-0-0777, Effective master axis velocity

### Master Axis Generation

The synchronization modes allow the drive to run synchronously with regard to a real or virtual master axis. Command value input in the synchronization modes takes place depending on the kind of master axis.

The firmware supports the following possibilities of input of the master axis position:

- **Real master axis**

For real master axes, the master axis position is input by evaluating the signals of a master axis encoder (measuring encoder) via "P-0-0052, Actual position value of measuring encoder".

See also "Measuring Encoder"

- **Virtual master axis, external**

For external virtual master axes, the master (e.g. MLD) cyclically inputs command values in the NC clock via the master communication in "P-0-0053, Master axis position".

- **Virtual master axis, internal**

For internal virtual master axes, the master axis position is generated by the master axis generator contained in the drive and is input in the position loop clock via "P-0-0761, Master axis position for slave axis".

See also "Virtual Master Axis Generator"

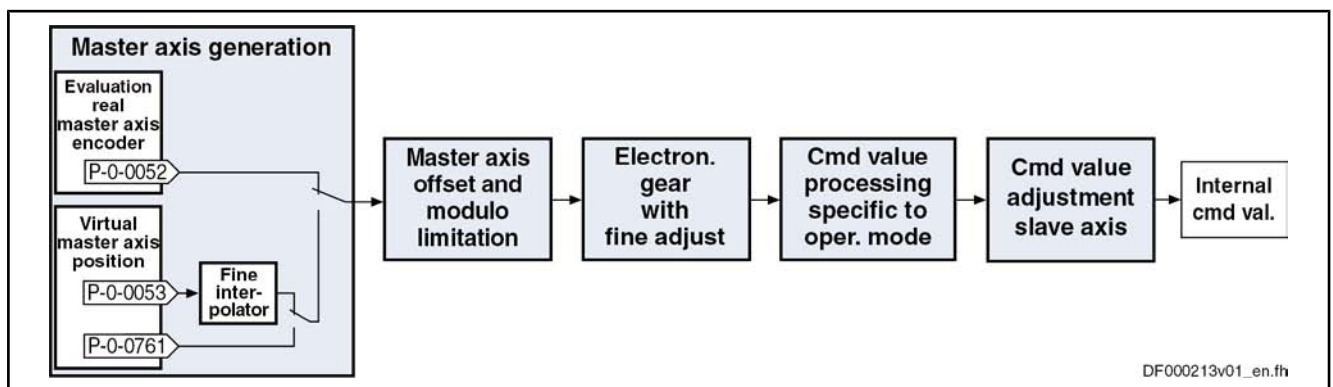


Fig.7-58: Function Block "Master Axis Generation" for Real/Virtual Master Axis

For the generation of the master axis (real or virtual) the following requirements must be taken into consideration (with N = value from "P-0-0084, Number of bits per master axis revolution"):

- The master axis position can only be processed in a binary format (1 master axis revolution =  $2^N$  increments).

Operation Modes

- The minimum/maximum value of "P-0-0054, Additive master axis position" at maximum corresponds to the master axis cycle ( $P-0-0750 \times 2^N$ ).

**Note:** When "P-0-0750, Master axis revolutions per master axis cycle" equals zero, the resulting maximum value for parameter P-0-0054 is  $(2^{31} - 1)$  increments and the minimum value is  $-2^{31}$  increments.

**Master Axis Offset and Modulo Limitation**

In conjunction with master axis adjustment, it is possible to add an offset and limit the preset master axis values.

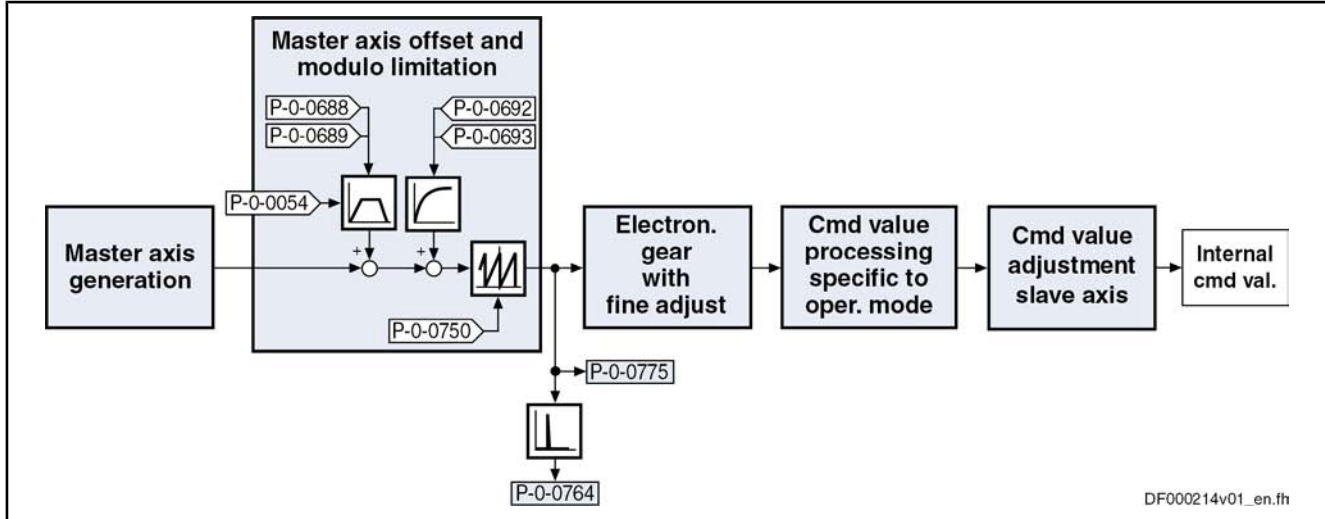


Fig. 7-59: Function Block "Master Axis Offset and Modulo Limitation" for Real/Virtual Master Axis

**Additive Master Axis Position**

If required, the preset master axis can be influenced via additive master axis values (offset):

- For all master axes (real or virtual), the master axis position can be changed by an additive component (= offset) via "P-0-0054, Additive master axis position". Any change in the value of P-0-0054 is traveled with a 2nd order interpolator, taking "P-0-0688, Additive master axis position, positioning velocity" and "P-0-0689, Additive master axis position, positioning acceleration" into account.
- Another master axis offset can be set via "P-0-0692, Additive master axis position, process loop". "P-0-0693, Filter time constant, add. master axis pos., process loop" determines the time constant of a 1st order filter by means of which the value of P-0-0692 is smoothed.

**Resulting Master Axis Position**

The resulting master axis position (P-0-0775) is generated from the preset master axis (P-0-0052, P-0-0053 or P-0-0761) and the additive components (P-0-0054 and, if required, P-0-0692).

**Limiting the Master Axis Position**

The resulting master axis position is limited to the modulo range of the master axis with "P-0-0750, Master axis revolutions per master axis cycle".

With  $N =$  value from "P-0-0084, Number of bits per master axis revolution" the following applies:

→ Modulo value master axis =  $P-0-0750 \times 2^N$

Observe the following aspects:

- The master axis range is set as an integral multiple of a master axis revolution (=  $2^N$  increments) with "P-0-0750, Master axis revolutions per master axis cycle".
- The sum from P-0-0052/P-0-0053, P-0-0054 and P-0-0765 mustn't exceed the double master axis range (P-0-0750 ×  $2^N$ )!

**Master Axis Speed**

The master axis speed is generated by differentiating the master axis position and displayed in "P-0-0764, Master axis speed". The component of an external virtual master axis is generated in the NC clock.

**Electronic Gear Function With Fine Adjustment**

The input value for the electronic gear is the resulting master axis position (P-0-0775).

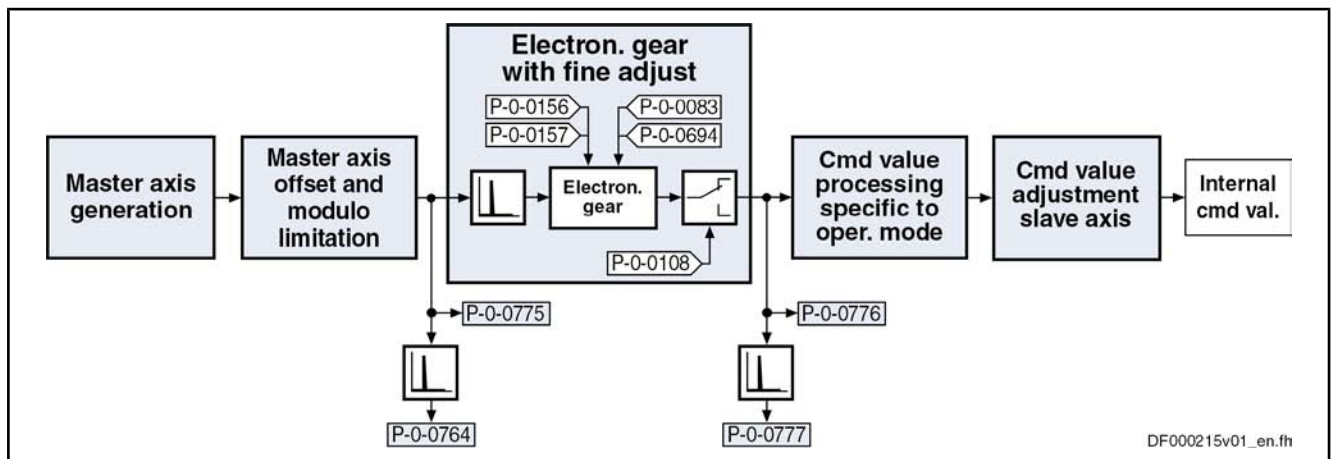


Fig.7-60: Function Block "Electronic Gear With Fine Adjustment"

**Functional Principle**

The function block "electronic gear with fine adjustment" is divided into the following subfunctions:

• **Electronic master axis gear with fine adjustment**

The master axis position or master axis velocity is first multiplied with the factor from P-0-0157/P-0-0156 (output/input revolutions).

The fine adjustment is carried out by multiplication of the resulting master axis position or master axis velocity with the sum of 1 + P-0-0083 (gear ratio fine adjustment) and the subsequent multiplication with the sum of 1 + P-0-0694 (gear ratio fine adjustment, process loop).

• **Polarity reversal of master axis position**

Via "P-0-0108, Master drive polarity", it is possible to invert the polarity of the master axis position or master axis velocity.

**Input Value of Electronic Gear**

The input value for the electronic gear is the resulting master axis position (P-0-0775).

**Output Value of Electronic Gear**

The currently effective master axis position and master axis velocity after the function block "electronic gear with fine adjustment" are generated in the position loop clock (see "Performance Data") and displayed in the following parameters:

- P-0-0776, Effective master axis position
- P-0-0777, Effective master axis velocity

**Command Value Processing for Slave Axis Depending on Operation Mode**

When the output value of the electronic gear is processed, there are different operations carried out, according to the synchronization mode, for generating the position or velocity command value for the subsequent control loop (slave

## Operation Modes

axis). This "command value processing depending on operation mode" is described in the sections on the respective operation mode:

- See "Velocity Synchronization"
- See "Phase Synchronization"
- See "Electronic Cam"
- See "MotionProfile"

## Dynamic Synchronization of the Slave Axis

## Brief Description

## Synchronization With Velocity Synchronization

Features of synchronization in the "velocity synchronization" mode:

- Synchronization takes place as velocity adjustment
- generation of status message "synchronization completed" (P-0-0152; bit 0)
- Generation of status message "synchronous mode in synchronization" (P-0-0089; bit 8)

## Synchronization in Synchronous Position Control Modes

Features of synchronization for synchronous position control modes:

- Sequence of synchronization is **single-step or double-step or double-step optimized**
- Synchronization **absolute** (position and velocity adjustment) or **relative** (only velocity adjustment)
- **Modulo ranges** to be set for synchronization:
  - Modulo value (S-0-0103)
  - Command value cycle slave axis (P-0-0754)
  - Division for command value cycle (setting in P-0-0751)
- Direction for synchronization to be set for position adjustment of modulo axes, shortest distance, positive or negative direction in "P-0-0154, Synchronization direction"; setting the tolerance window with only positive or negative direction via "P-0-0151, Synchronization window for modulo format"
- display of the difference between actual position value in the actual value cycle and the synchronous position command value generated from the master axis position in "P-0-0034, Position command additional actual value"
- Generation of status message "synchronization completed" (P-0-0152; bit 0)
- **Mode "standard" or "register controller"** for command value addition for the slave axis
- Generation of status message "synchronous mode in synchronization" ("P-0-0089, Status word synchronization modes", bit 8)

## Pertinent Parameters

The following parameters are used in conjunction with dynamic synchronization:

- S-0-0048, Additive position command value
- S-0-0183, Velocity synchronization window
- S-0-0228, Position synchronization window
- P-0-0043, Torque-generating current, actual value
- P-0-0060, Filter time constant additive position cmd value
- P-0-0071, C3100 Command Recalculate actual value cycle

- P-0-0142, Synchronization acceleration
- P-0-0143, Synchronization velocity
- P-0-0151, Synchronization window for modulo format
- P-0-0152, Synchronization completed
- P-0-0154, Synchronization direction
- P-0-0155, Synchronization mode
- P-0-0686, Additive position command value, positioning velocity
- P-0-0687, Additive position command value, positioning acceleration
- P-0-0691, Additive position command value, process loop
- P-0-0697, Synchronization, master axis synchronous position
- P-0-0698, Synchronization, master axis synchronization range
- P-0-0751, Synchronization divisions per command cycle slave axis
- P-0-0752, Load revolutions per actual value cycle slave axis
- P-0-0753, Position actual value in actual value cycle
- P-0-0754, Command value cycle
- P-0-0786, Modulo value actual value cycle

### General Information on Synchronization

The synchronization process is a drive-controlled motion with the objective of achieving absolute or relative synchronization between master axis and slave axis. Depending on the synchronization mode, we distinguish the following characteristics of dynamic synchronization:

- Synchronization with velocity synchronization (velocity adjustment)
- Synchronization in synchronous position control modes (velocity and position adjustment)

#### Synchronization Mode

The basic settings for carrying out synchronization are made in "P-0-0155, Synchronization mode"; these settings comprise, for example:

- Mode for command value addition
- Synchronization "absolute" or "relative"
- Range of synchronization
- Reaction to other command value changes after absolute synchronization had been reached for the first time



See Parameter Description "P-0-0155, Synchronization mode"

The figure below contains an overview of the different possible settings for carrying out synchronization and for adding command values in the synchronization modes:

## Operation Modes

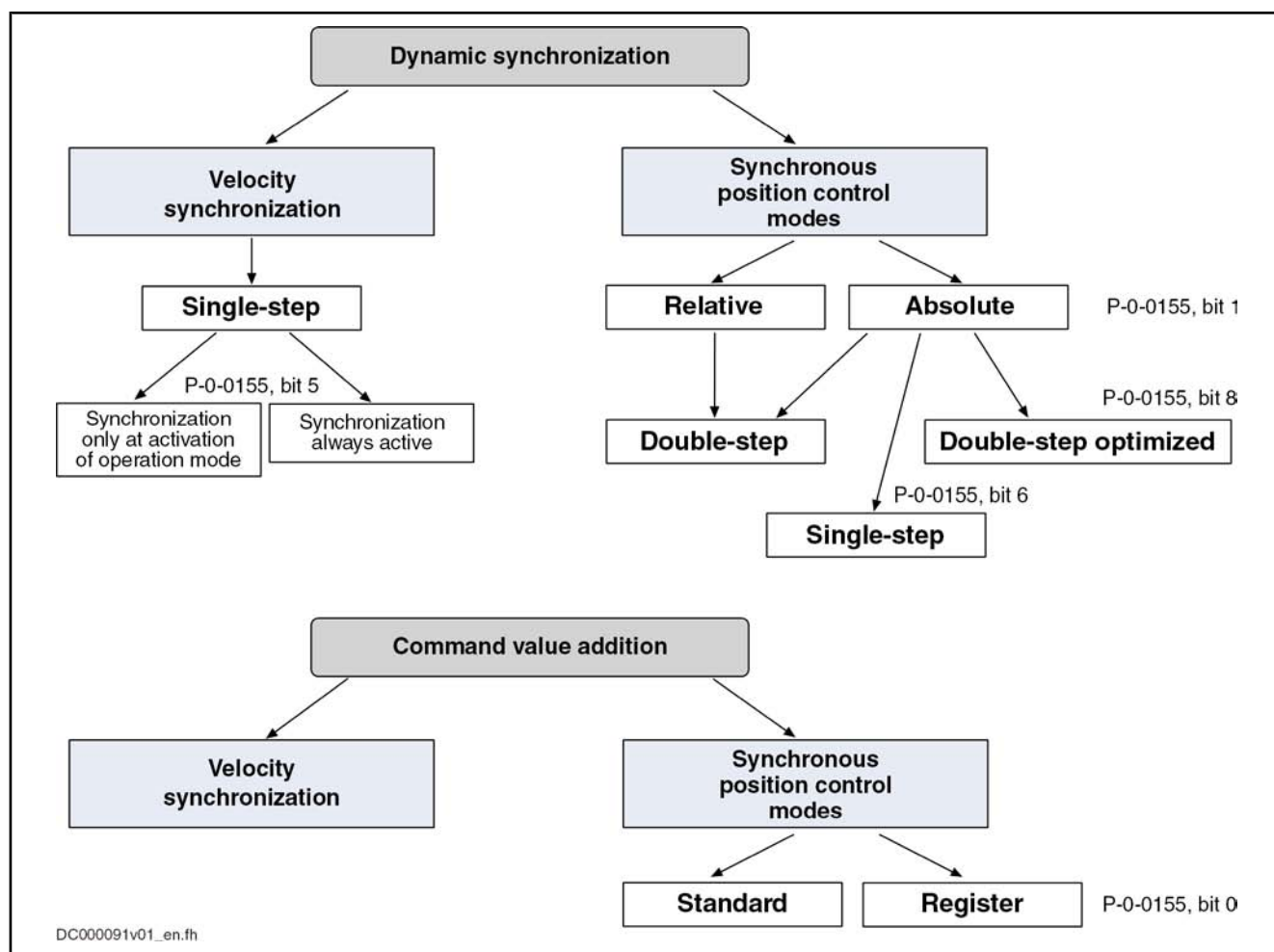


Fig.7-61: Overview of Methods to be Selected for Synchronization and for Command Value Addition



In the default setting of parameter P-0-0155 all bits are at value "0"!

### Synchronization With Velocity Synchronization

Drive-controlled dynamic synchronization in the "velocity synchronization" mode is carried out depending on bit 5 of parameter "P-0-0155, Synchronization mode".

- Bit 5 = 0 → Synchronization only when operation mode is activated
- Bit 5 = 1 → Synchronization is always active

By generating velocity command values, the drive accelerates or decelerates during synchronization until the synchronous velocity has been reached. The velocity command values are generated taking the preset synchronization acceleration (P-0-0142) into account.



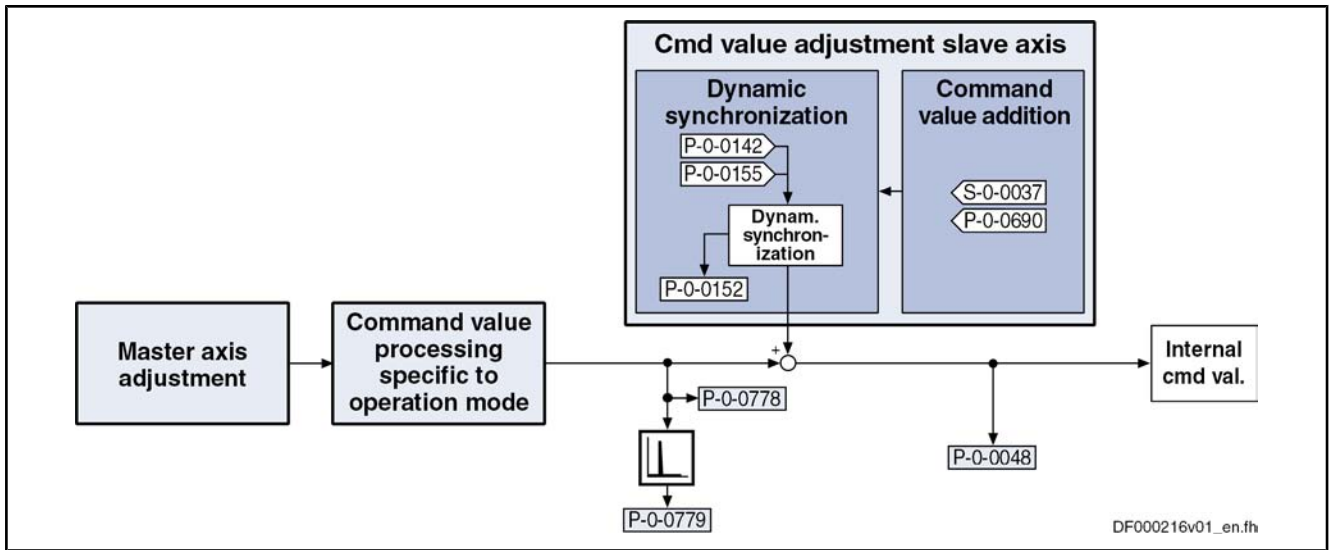


Fig.7-62: Function Block "Dynamic Synchronization" With Velocity Synchronization

**Synchronization in Synchronous Position Control Modes**

In the synchronous position control modes (phase synchronization, cam shaft and motion profile), drive-controlled dynamic synchronization is carried out when a synchronous position control mode is activated.

In the case of double-step synchronization, the values of the "P-0-0142, Synchronization acceleration" and "P-0-0143, Synchronization velocity" are used for generating an additive command value for compensating the slave axis which is not velocity- and position-synchronous.

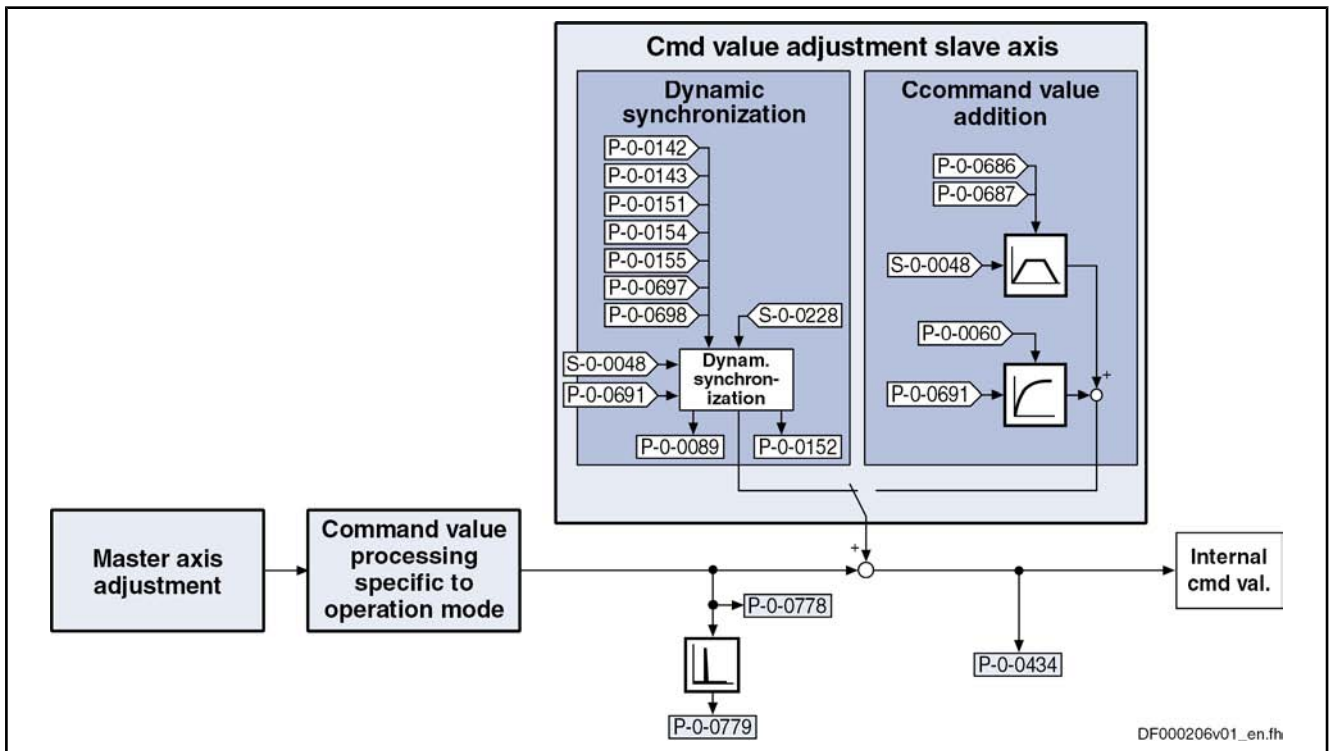


Fig.7-63: Function Block "Dynamic Synchronization" With Synchronous Position Control Modes



All settings relevant for synchronization have to be made in "P-0-0155, Synchronization mode".

## Operation Modes

The drive is absolutely synchronous when the following condition has been fulfilled:

$$S-0-0228 \geq \left\| \% \text{modulo} \left[ (P-0-0753) - \left( (S-0-0048) + (P-0-0691) + P-0-0778 \right) \right] \right\|$$

S-0-0228	Position synchronization window
P-0-0753	Position actual value in actual value cycle
S-0-0048	Additive position command value
P-0-0691	Additive position command value, process loop
P-0-0778	Synchronous position command value

*Fig. 7-64: Condition of Synchronism for Synchronous Position Control Modes*

The **modulo range** can be set depending on the mode of synchronization and the command value addition:

- Modulo value (S-0-0103)
- Command value cycle slave axis (P-0-0754)
- Division for command value cycle (setting in P-0-0751)



In the case of absolute scaling, there is no modulo limitation!

### Single-Step/Double-Step Synchronization

Depending on the synchronization mode, there are the following options:

- In the "velocity synchronization" mode, only single-step synchronization is possible (braking or accelerating with the value from "P-0-0142, Synchronization acceleration").
- In synchronous position control modes you can select either single-step, double-step and optimized double-step synchronization.

#### Single-Step Synchronization

Single-step synchronization is a master-axis-synchronous synchronization that is added to the synchronous movement. The processing of the slave axis synchronization distance is carried out while the master axis is going through the master axis synchronization range.

As a slave axis synchronization distance can only be calculated with absolute synchronization (bit 1 = 0 in "P-0-0155, Synchronization mode") single-step synchronization is only possible with absolute synchronization, as well.

Selecting is carried out via bit 6 of the parameter P-0-0155.

In this case, the corresponding parameters take effect:

- P-0-0697, Synchronization, master axis synchronous position
- P-0-0698, Synchronization, master axis synchronization range



P-0-0697 and P-0-0698 refer to the output of the electronic gear.

By means of bit 7 = 1 in P-0-0155 a relative master-axis-synchronous synchronization is set. As a consequence, synchronizing is immediately started at activation of the synchronization mode. The parameter for the master axis synchronous position (P-0-0697) does not take effect. Starting the synchronizing process for inactive master axis, this will produce a velocity command value of zero. This effect must be prevented for active slave axis.

With bit 7 = 0, you can set that the master-axis-synchronous synchronization motion only starts when the master axis start position is passed (absolutely master-axis-synchronous). This position results from subtraction of master axis synchronous position and master axis synchronization range. Until the master axis start position is passed, the axis decelerates or accelerates, based on the

current actual velocity, with the parameterized synchronization acceleration (P-0-0142) in the direction of the synchronous velocity.

For single-step synchronization, observe the following notes on utilization:

- Single-step synchronization is only active when the operation mode is activated. This means that, after the synchronous operation mode was activated, synchronization starts the next time the master axis start position is passed.

The master axis position used for the comparison with the master axis start position is defined:

- **In phase synchronization** by "P-0-0776, Effective master axis position"
- **In cam shaft mode** by "P-0-0227, Cam table, access angle"
- The profile for synchronization is determined by a 5th order polynomial.
- The synchronous position command values, generated from the master axis positions, take immediate effect when the master axis start position is passed or at the beginning of the master axis synchronization range.
- The velocity of the master axis should be constant when passing through the master axis synchronization range.
- The values set in "P-0-0142, Synchronization acceleration" and "P-0-0143, Synchronization velocity" are not taken into account for the synchronization process.
- Apart from by the other conditions of the synchronization mode, the resulting characteristics of velocity and acceleration can only be influenced by the master axis synchronization range.
- For modulo axes, the polarity of the slave axis synchronization distance can be set by "P-0-0154, Synchronization direction". However, this only applies if the absolute value of the shortest synchronization distance is greater than the value of "P-0-0151, Synchronization window for modulo format".
- Synchronization is completed when the master axis position has gone through the master axis synchronization range. Bit 0 of "P-0-0155, Synchronization mode" then defines how subsequent changes of "S-0-0048, Additive position command value" are processed (see below section "Command Value Addition for Slave Axis").

#### To be noticed for single-step synchronization

With single-step synchronization, a profile "velocity in rest" (standard profile "G-R" according to VDI 2143) is added to the synchronous position command values:

- The distance traveled with the added profile is determined by the difference of synchronous position command value (+ "S-0-0048, Additive position command value" + "P-0-0691, Additive position command value, process loop") and actual position value at the starting point of time.
- When modulo scaling has been set, the distance is limited to the synchronization range set in "P-0-0155, Synchronization mode".
- "P-0-0154, Synchronization direction" is evaluated in the case of modulo scaling. The preferred direction set is taken into account, if the determined synchronization distance is greater than the "P-0-0151, Synchronization window for modulo format".
- The initial velocity of the profile is determined by the difference of actual velocity and synchronous velocity at the starting point of time.

Operation Modes

- We assume that the acceleration of the slave axis at the starting point of time equals zero.



For more details Details on the used profile "velocity in rest" see section "MotionProfile" !

**Double-Step Synchronization**

The double-step synchronization process consists of velocity adjustment and subsequent position adjustment.

**Step 1 – Velocity adjustment:**

- The drive either accelerates or decelerates from the current actual velocity at the time of activation to the synchronous velocity.
- The synchronous velocity is generated by differentiating the synchronous position command value. The synchronous position command value  $x_{sync}$  is determined from the master axis position ("P-0-0052, Actual position value of measuring encoder" or "P-0-0053, Master axis position") according to the operation mode.
- Velocity adjustment already takes place in position control. When accelerating or decelerating, the drive takes the value in "P-0-0142, Synchronization acceleration" into account.

**Step 2 – Position adjustment:**

After velocity adjustment, there is a difference between the active position command value and the sum of the synchronous position command value ( $x_{sync}$ ), additive position command value (S-0-0048) and additive position command value of the process loop (P-0-0691).

The difference is calculated according to the following equation:

$$\Delta x = x_{synch} + (S-0-0048) + (P-0-0691) - (P-0-0434)$$

$\Delta x$	Difference (distance)
$x_{synch}$	Synchronous position command value
S-0-0048	Additive position command value
P-0-0691	Additive position command value, process loop
P-0-0434	Position command value of controller

*Fig.7-65: Difference With Absolute Synchronization (Travel Distance)*

In the second step of synchronization, the difference generated during velocity adjustment is compensated by a travel motion taking "P-0-0142, Synchronization acceleration" and "P-0-0143, Synchronization velocity" into account. This position adjustment is added to the synchronous movement.

**Optimized Double-Step Synchronization**

The third synchronization method available for selection is a mixture between one-step and double-step synchronization. This method has the following characteristics:

- not master-axis-synchronous
- Immediate start when activating the synchronous mode
- No separation between velocity and position adjustment
- Superimposed synchronization motion with 2nd order interpolator
- Limitation of synchronization motion by "P-0-0142, Synchronization acceleration" and "P-0-0143, Synchronization velocity"
- Reduce braking acceleration (deceleration) during positioning in order to reduce the number of acceleration jumps

**Specific features with modulo position scaling**

We distinguish between two cases:

- At the start of the synchronization process, the braking distance is **smaller** than a synchronization range.

The initial velocity of the synchronization motion is so small that immediate positioning is possible. For determining the synchronization distance "P-0-0154, Synchronization direction", in conjunction with "P-0-0151, Synchronization window for modulo format", is evaluated.

- At the start of the synchronization process, the braking distance is **greater** than a synchronization range.

The velocity of the synchronization motion is first reduced until the braking distance is smaller than a synchronization range. In this case, a parameterized synchronization direction is ignored, so that the velocity of the synchronization motion has no change of sign

### Relative/Absolute Synchronization

In the synchronous position control modes, it is possible to select either relative or absolute synchronization:

- **Relative synchronization** (P-0-0155, bit 1 = 1)  
→ There is no fixed position reference between master axis and slave axis.
- **Absolute synchronization** (P-0-0155, bit 1 = 0)  
→ There is a fixed position reference between master axis position and position command value that results from the master axis position and the parameterized additive position command value.

#### Relative Synchronization

The figure below illustrates the relative synchronization to a virtual master axis, the master axis being in standstill when the operation mode is activated.

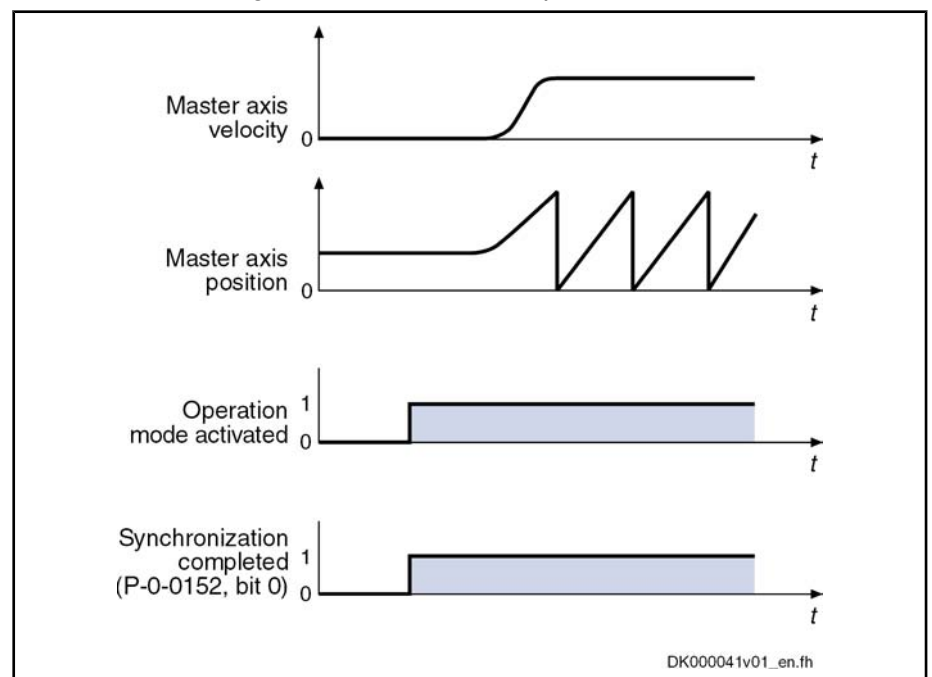


Fig.7-66: Example: Relative Synchronization out of Standstill

- When the operation mode is activated, the synchronous velocity = 0.
- Upon activation of the operation mode, the bits for "synchronization completed" (P-0-0152, bit 0 = 1) and "slave axis has been synchronized" (P-0-0089, bit 8 = 1) are output.

## Operation Modes

- When the machine starts, the axis, based on its current position, follows the master axis position with relatively synchronous position.

The figure below illustrates the relative synchronization to a virtual master axis, the master axis having a velocity  $\neq 0$  when the operation mode is activated.

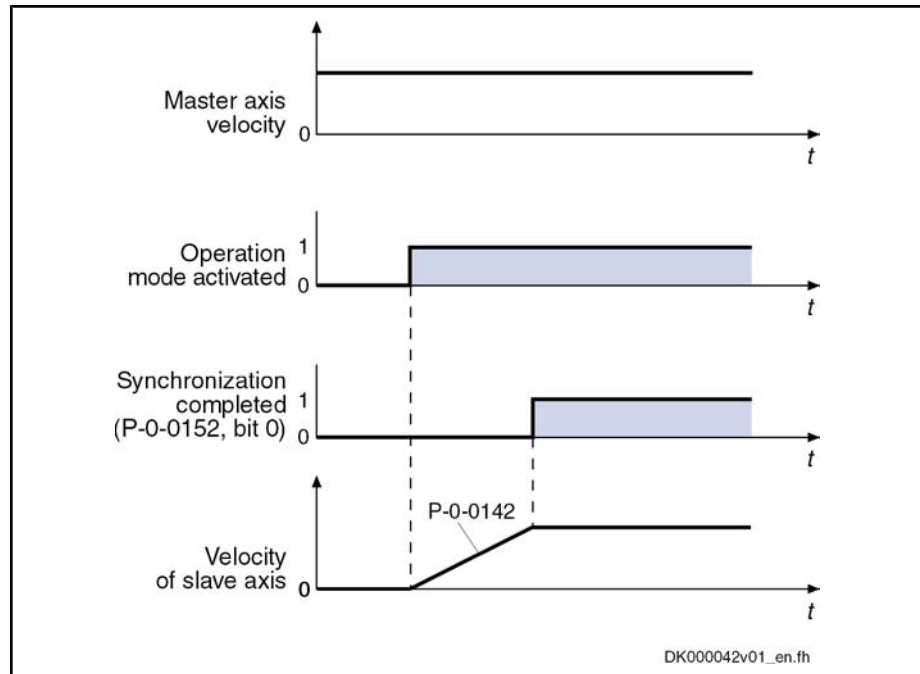


Fig.7-67: Example: Relative Synchronization in Running Operation

- When the operation mode is activated, the master axis moves at constant velocity.
- Based on its current position, the slave axis accelerates to the synchronous velocity. While this is done, the synchronization acceleration (P-0-0142) is effective.
- Upon reaching the synchronous velocity, the bits for "synchronization completed" (P-0-0152, Bit 0 = 1) and "slave axis has been synchronized" (P-0-0089, bit 8 = 1) are output.

**Absolute Synchronization**

The figure below illustrates the absolute synchronization to a virtual master axis, the master axis being in standstill when the operation mode is activated.

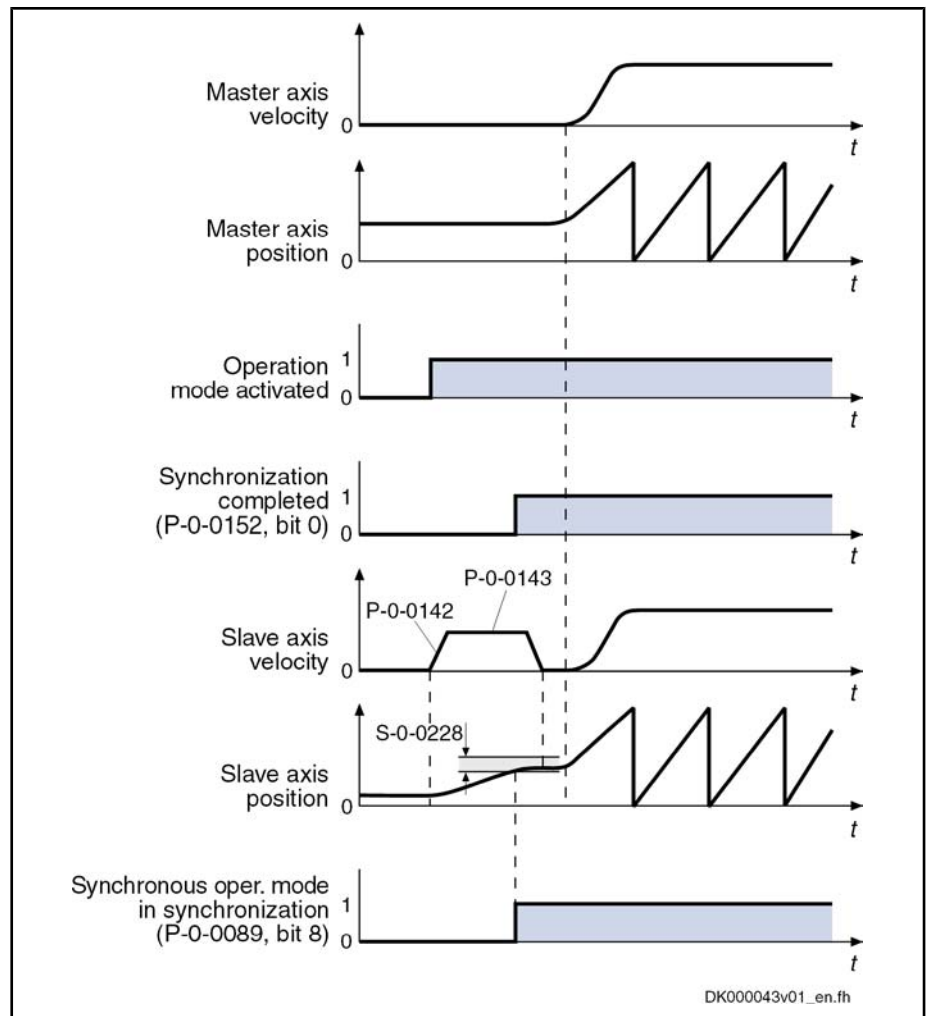
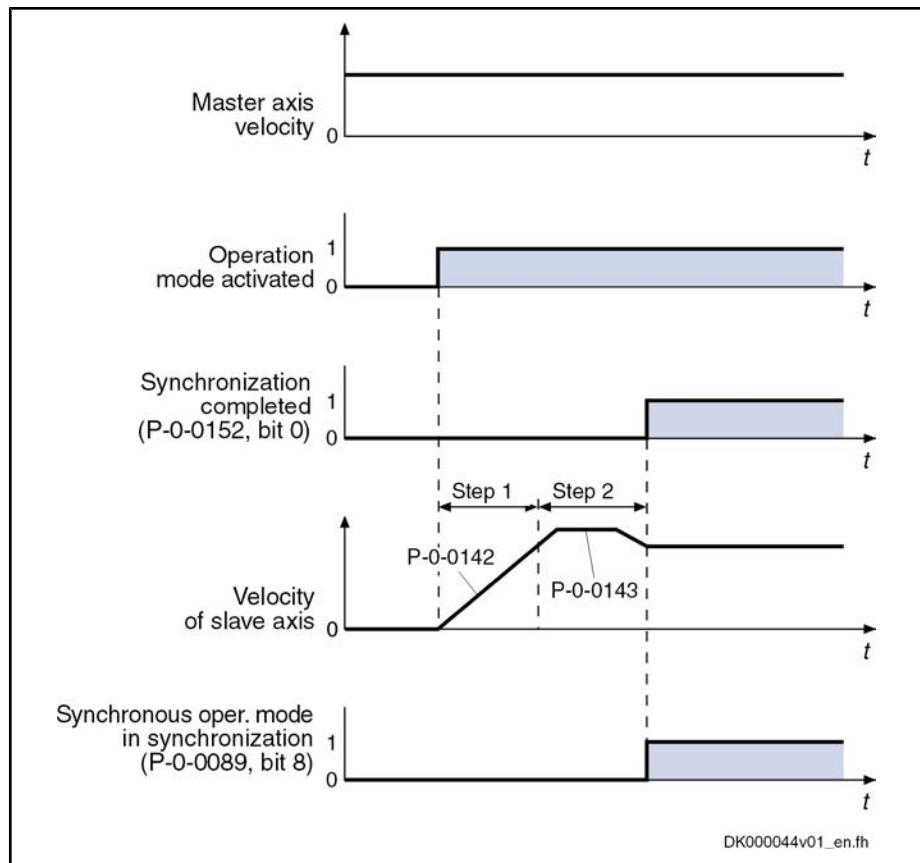


Fig.7-68: Example: Absolute Synchronization out of Standstill

- When the operation mode is activated, the synchronous velocity = 0. The current master axis position differs from the synchronous position.
- The synchronization status signals "synchronization running" (P-0-0152, bit 0 = 0).
- The absolute angle reference between slave axis and master axis position is established. The master axis is turning with the parameterized synchronization velocity (P-0-0143). During acceleration and deceleration, the synchronization acceleration (P-0-0142) is effective.
- As soon as the position difference between master axis and slave axis is smaller than the "position synchronization window" (S-0-0228), the status bit "slave axis has been synchronized" (P-0-0089, bit 8 = 1) is output.  
Bit 0 is set in P-0-0152 when synchronization has been completed.

The figure below illustrates the absolute synchronization to a virtual master axis, the master axis having a velocity  $\neq 0$  when the operation mode is activated.

Operation Modes



Step 1 Velocity adjustment  
 Step 2 Position adjustment

Fig. 7-69: Example: Absolute Synchronization in Running Operation

- When the operation mode is activated, the master axis moves at constant velocity.
- The synchronization status signals "synchronization running" (P-0-0152, bit 0 = 0).
- Based on its current position, the slave axis accelerates to the synchronous velocity. While this is done, the synchronization acceleration (P-0-0142) is effective.
- After velocity adjustment, the absolute position reference is established. Position adjustment takes place with parameterized synchronization acceleration (P-0-0142) and synchronization velocity (P-0-0143).
- As soon as the position difference between master axis and slave axis is smaller than the "position synchronization window" (S-0-0228), the status bit "slave axis has been synchronized" (P-0-0089, bit 8 = 1) is output.  
 Bit 0 is set in P-0-0152 when synchronization has been completed.

Command Value Addition for Slave Axis

**Brief Description**

In the "velocity synchronization" mode, the addition of command values for the slave axis is directly associated with the synchronization process.

In synchronous position control modes, the addition of command values for the slave axis is an independent functional sequence for which you can choose between the following modes as regards command value addition:

- **"Standard" mode**



→ Changes are processed with the values from the parameters P-0-0686 and P-0-0687

- **"Register controller" mode**

→ Changes are smoothed by a 1st order filter (time constant in parameter P-0-0060)

### Standard "Mode"

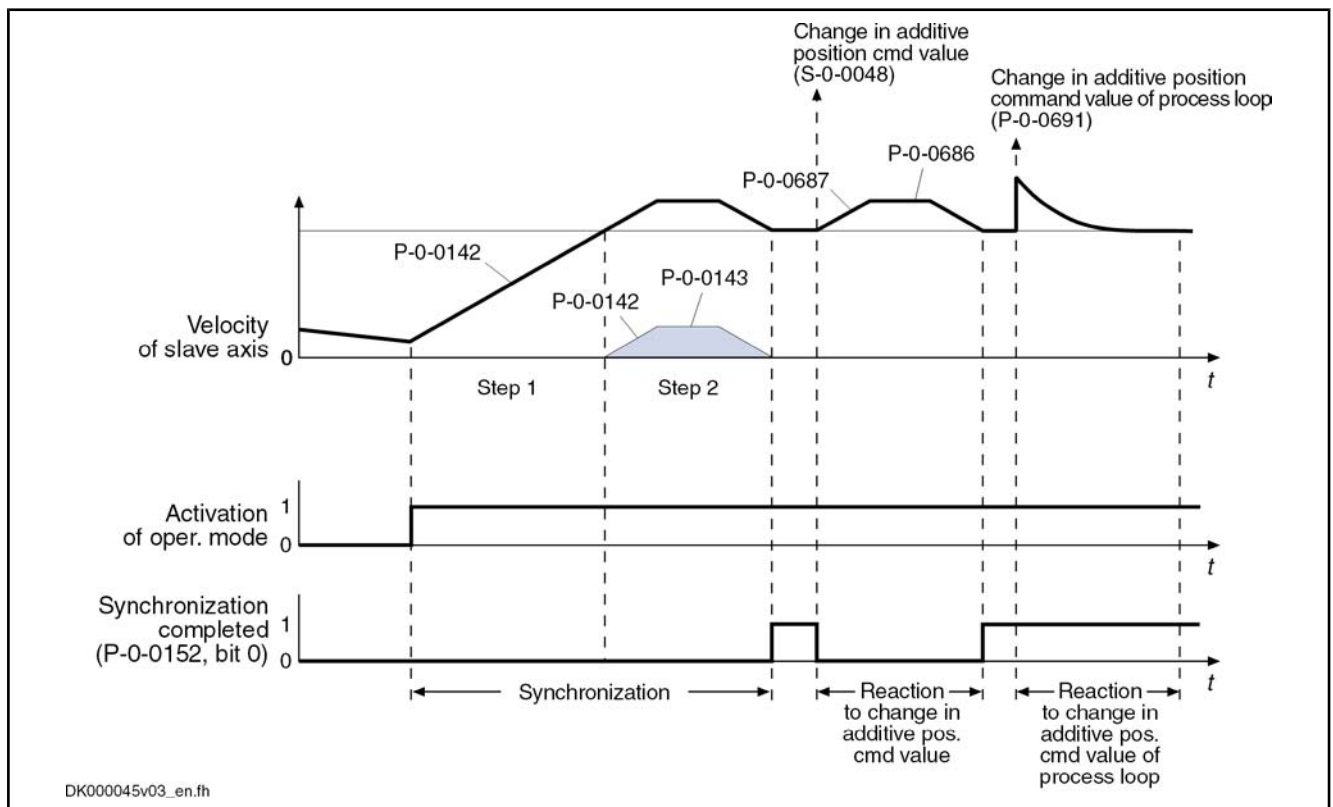
In the "standard" mode, all further changes in the value of "S-0-0048, Additive position command value", after double-step synchronization, are processed with the values set in the following parameters:

- P-0-0686, Additive position command value, positioning velocity
- P-0-0687, Additive position command value, positioning acceleration
- P-0-0151, Synchronization window for modulo format
- P-0-0154, Synchronization direction

The changes made in "P-0-0691, Additive position command value, process loop" are smoothed via a 1st order filter. The time constant of the filter is set in "P-0-0060, Filter time constant additive position cmd value".



The status bit "synchronization completed" is only set when the condition  $P-0-0434 = S-0-0048 + x_{sync}$  has been fulfilled.



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Fig.7-70: "Standard" mode



In the "standard" mode, the command values are limited with regard to "S-0-0091, Bipolar velocity limit value" and "S-0-0138, Bipolar acceleration limit value".

Operation Modes

**Register Controller "Mode"**

In the "register controller" mode, all further changes in "S-0-0048, Additive position command value" are smoothed by a 1st order filter. The time constant of the filter is set in "P-0-0060, Filter time constant additive position cmd value". The value of "P-0-0691, Additive position command value, process loop" is processed in differential form and the difference between old and new value of P-0-0691 is added to the position command value.



The status bit "synchronization completed" is set when the absolute synchronization has been reached and will not be cleared, even with further changes in "S-0-0048, Additive position command value" and "P-0-0691, Additive position command value, process loop".

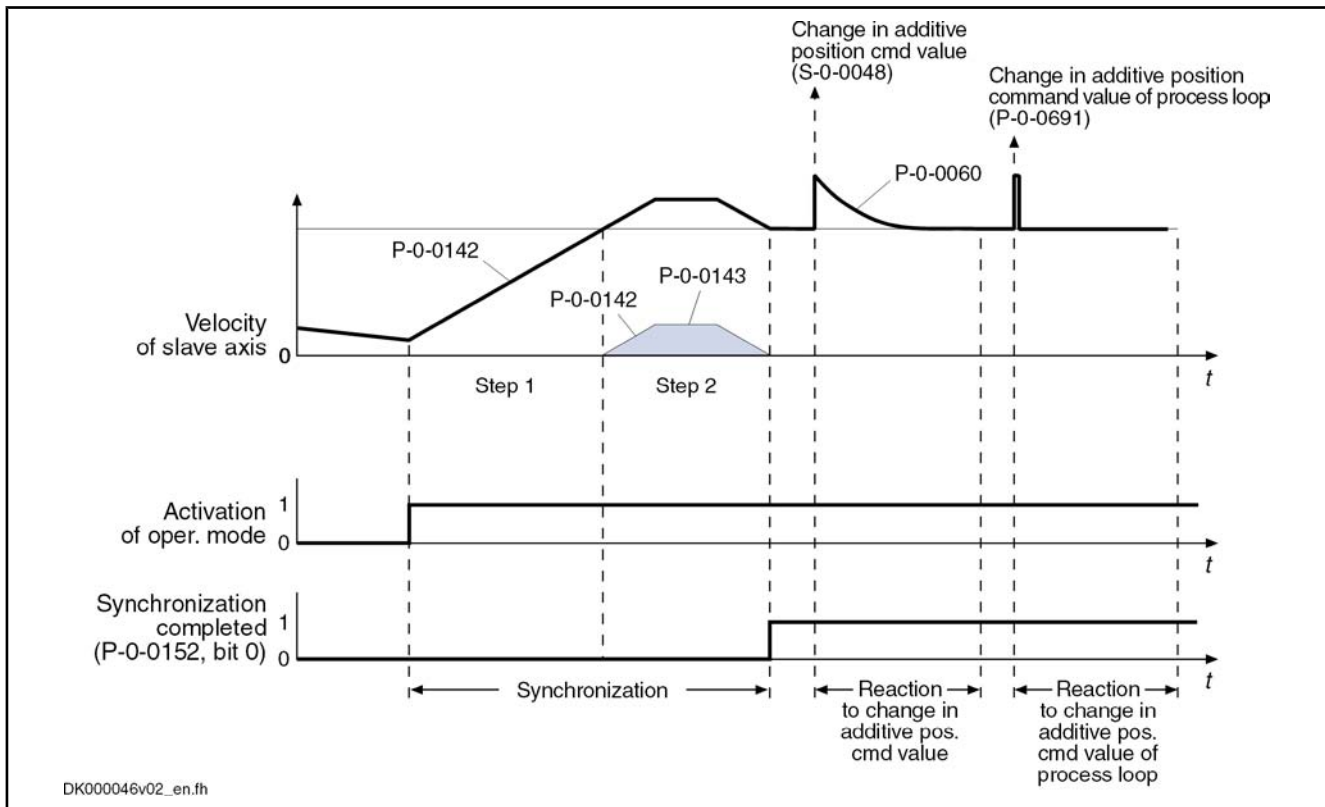


Fig.7-71: "Register Controller" Mode



In the "register controller" mode, the command values are monitored with regard to "S-0-0091, Bipolar velocity limit value" and "S-0-0138, Bipolar acceleration limit value".

If the command values exceed the limit values, the error messages "F2037 Excessive position command difference" or "F2039 Maximum acceleration exceeded" are generated.

Possible countermeasures:

- Increasing the filter time constant
- Reducing the changes in the additive position command value
- Increasing the limit values for velocity and acceleration

## Extended Functions (Command Value Cycle and Actual Value Cycle)

### Applications

The extended functions of synchronization (command value cycle and actual value cycle) are required in conjunction with the following applications:

- Change of format, i.e. variable master axis gear settings in operation
- Necessity of mechanical relation of slave axis to master axis



Command value cycle and actual value cycle are only relevant for the synchronization modes "phase synchronization", "cam shaft" and "motion profile".

The figure below illustrates the interaction of the pertinent parameters for the command value cycle and the actual value cycle:

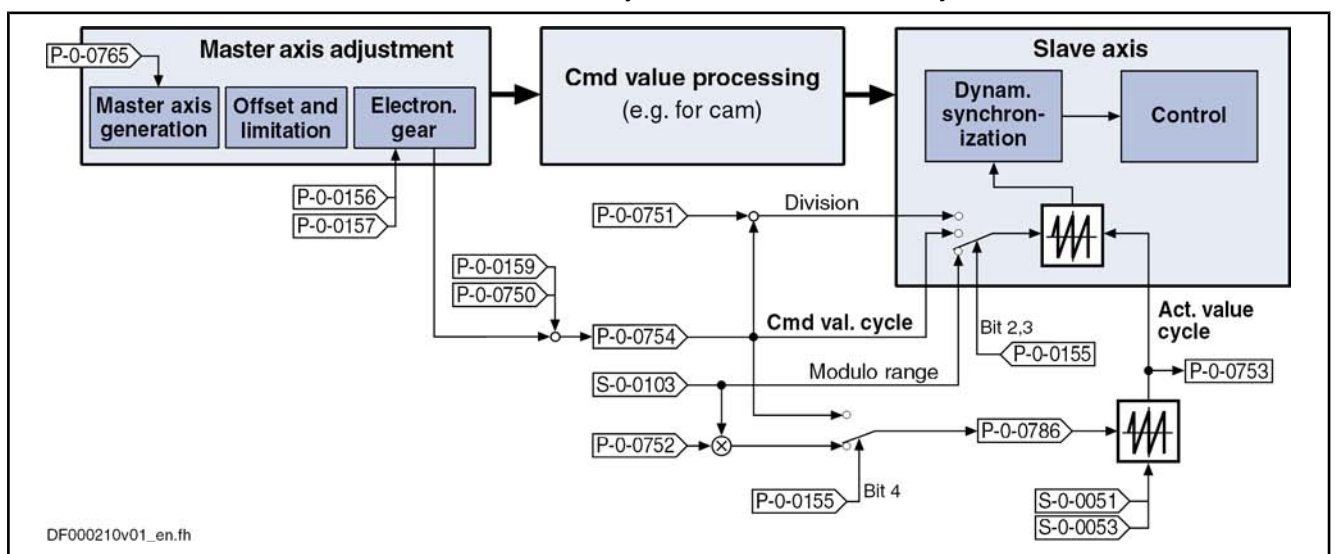


Fig.7-72: Generation and Operating Principle of the Command Value and Actual Value Cycle

### Command Value Cycle

The command value cycle defines a modulo limitation of the synchronous position command values, which takes effect in a synchronous position control mode during synchronization, in the slave axis.



The command value cycle is calculated internally by the drive and displayed in "P-0-0754, Command value cycle".

$$P-0-0754 = \frac{P-0-0157}{P-0-0156} \times \frac{P-0-0750}{P-0-0159}$$

Fig.7-73: Internal Calculation Formula of the Value for P-0-0754

### Actual Value Cycle

In the case of modulo position scaling (S-0-0076, bit 7), the actual value cycle determines the modulo range of the actual position values at the slave axis relevant for the synchronization process.



The command value cycle is calculated internally by the drive and displayed in "P-0-0786, Modulo value actual value cycle".

## Operation Modes

For the setting of bit 4 in "P-0-0155, Synchronization mode" we distinguish the following cases:

- **Bit 4 = 1**  
→ The actual value cycle (P-0-0786) equals the command value cycle (P-0-0754).
- **Bit 4 = 0**  
→ The actual value cycle is calculated internally by the drive and can be modified by means of the setting in "P-0-0752, Load revolutions per actual value cycle slave axis".

$$P-0-0786 = S-0-0103 \times P-0-0752$$

Fig. 7-74: Internal Calculation Formula of the Value for P-0-0786



The parameterization of the actual value cycle is required if, in the case of phase synchronization, synchronization is to be carried out in a range greater than the modulo value (S-0-0103).

### Position Actual Value in Actual Value Cycle

In the case of "phase synchronization" or "cam and modulo position scaling", the "P-0-0753, Position actual value in actual value cycle" displays a current actual position value of the slave axis limited via P-0-0786.

When activating the synchronization mode, the **travel distance for synchronization** is determined with the actual position value in the actual value cycle.

The value of P-0-0753 is again limited to the synchronization range which has been set (P-0-0754 or S-0-0103) and then is used as travel range for synchronization (see figure above).

### Synchronization Range

In the case of modulo scaling, the range for synchronization can be set in "P-0-0155, Synchronization mode", i.e. the distance to be traveled is limited to this range:

- Modulo value (S-0-0103)
- Command value cycle (P-0-0754)
- Division of the command value cycle



The actual position value used for calculating the distance must be unequivocal in the range in which synchronization is to take place. The actual value cycle from which the actual position value is derived must therefore be determined in such a way that is a multiple of the synchronization range.

### Synchronization in the Command Value Cycle

By setting "P-0-0750, Master axis revolutions per master axis cycle" = 0, it is possible to select absolute handling of the master axis within a range of  $\pm 2048$  revolutions.

The distance traveled during synchronization is the result of the difference between synchronous position command value (+ "S-0-0048, Additive position command value" + "P-0-0691, Additive position command value, process loop") and the actual position value. The synchronization distance is limited to the modulo command value cycle.

$$\text{Distance} = \% \text{ cmd value cycle} \left[ x_{\text{sync}} + (S-0-0048) + (P-0-0691) - \text{actual position value} \right]$$

Fig. 7-75: Synchronization Distance During Synchronization in Command Value Cycle

The range for the command value cycle at the slave axis is defined by the master axis cycle and the electronic gear.

- **Modulo Scaling**

With "Phase synchronization",

with "Cam without gear reduction" and (P-0-0755 = 0) and

with "MotionProfile without gear reduction" (P-0-0755 = 0):

$$\text{Command value cycle} = P-0-0750 \times \frac{P-0-0157}{P-0-0156} \times S-0-0103$$

With "Cam with gear reduction" (P-0-0755 ≠ 0) and

with "MotionProfile with gear reduction" (P-0-0755 ≠ 0):

$$\text{Command value cycle} = P-0-0750 \times \frac{P-0-0157 \times S-0-0103}{P-0-0156 \times P-0-0755}$$

Fig.7-76: Command Value Cycle With Modulo Scaling

- **Linear modulo scaling**

For "path synchronization" and "cam shaft without gear reduction" (P-0-0755 = 0):

$$\text{cmd value cycle} = P-0-0750 \times \frac{P-0-0157}{P-0-0156} \times P-0-0159$$

For "cam shaft with gear reduction" (P-0-0755 ≠ 0):

$$\text{cmd value cycle} = P-0-0750 \times \frac{P-0-0157 \times P-0-0159}{P-0-0156 \times P-0-0755}$$

Fig.7-77: Command Value Cycle With Linear Modulo Scaling

The active value is displayed in "P-0-0754, Command value cycle". The command value cycle describes the range containing the calculated synchronous position command values.

For modulo division, the number of command value cycles per actual value cycle is used. The number is calculated with the following formula:

$$\text{Number of cmd value cycles} = \frac{\text{actual value cycle}}{\text{command value cycle}}$$

Fig.7-78: Number of Command Value Cycles per Actual Value Cycle

### Synchronization in a Division of the Command Value Cycle

The distance traveled during synchronization is the result of the difference between synchronous position command value (+ "S-0-0048, Additive position command value" + "P-0-0691, Additive position command value, process loop") and the actual position value. The synchronization distance is limited to a division of the modulo command value cycle.

$$\text{Distance} = \% \text{ division of cmd value cycle} \left[ x_{\text{sync}} + (S-0-0048) + (P-0-0691) - \text{actual position value} \right]$$

Fig.7-79: Synchronization Distance for Synchronization in a Division of the Command Value Cycle

The actual position value in the division of the command value cycle is derived from "P-0-0753, Position actual value in actual value cycle". For modulo divi-

## Operation Modes

sion, the number of divisions per actual value cycle is used. The number is calculated with the following formula:

$$\text{Number of divisions} = P-0-0751 \times \frac{\text{actual value cycle}}{\text{command value cycle}}$$

Fig.7-80: Number of Synchronization Divisions per Actual Value Cycle

## Synchronization in the Modulo Range

The distance traveled during synchronization is the result of the difference between synchronous position command value (+ "S-0-0048, Additive position command value" + "P-0-0691, Additive position command value, process loop") and the actual position value. The synchronization distance is limited to the modulo value.

$$\text{Distance} = \% \text{ modulo value} \left[ x_{\text{sync}} + (S-0-0048) + (P-0-0691) - \text{actual position value} \right]$$

Fig.7-81: Synchronization Distance for Synchronization in Modulo Range

## Notes on Usage and Parameterization

## Selecting the Actual Value Cycle and Command Value Cycle

When using the command value cycle or actual value cycle, observe the following aspects:

- For synchronization, the actual position value in the command value cycle or a division of it is deduced from the actual position value in the actual value cycle by means of modulo division. In order to always have unequivocal values, the actual value cycle has to be an integer multiple of the command value cycle. Take this into account for the parameter setting o P-0-0752, P-0-0750, P-0-0751, P-0-0159 and P-0-0155!
- Take the value of "P-0-0156, Master drive gear input revolutions" into account as a factor for determining the master axis cycle (P-0-0750).  
**Note:** If the requirement cannot be fulfilled by parameterizing the actual value cycle, it is possible to have the range of the actual value cycle calculated by the drive by analogy to the command value cycle by setting bit 4 in "P-0-0155, Synchronization mode".
- If several electronic gear ratios are to be set at an axis (e.g. because of different formats), there are several command value cycles resulting at this axis. The actual value cycle then has to be set in such a way that it complies with the least common multiple (LCM) of these command value cycles (P-0-0155; bit 4 = 0).
- If the electronic gear is not to be changed, the actual value cycle is set in such a way that it complies with the command value cycle or a multiple of it.
- If synchronization is to be carried out only within the modulo range, the number of load revolutions per actual value cycle of the slave axis can be set to "1".

## Establishing the Position Data Reference

"P-0-0753, Position actual value in actual value cycle" is set by

- the command "set absolute measuring",
- "Drive-controlled homing" for the actual position value which was selected in the synchronization mode that has been set.

If, for example, the operation mode "phase synchronization with virtual master axis, encoder 1" has been set, the actual position value in actual value cycle (P-0-0753) will change by analogy with the actual position value 1 (S-0-0051).



In contrast to the actual position value in actual value cycle (P-0-0753), the actual position value 1 (S-0-0051) is limited to the modulo value (S-0-0103)!

Homing of the actual position value 1 then causes the actual position value in actual value cycle (P-0-0753) to be set to the same value as actual position value 1.



The position status of the actual position value in actual value cycle is displayed in bit 4 of "P-0-0089, Status word synchronization modes".

### Calculating the Actual Value Cycle (P-0-0786)

The actual value cycle (P-0-0786) is calculated

- automatically when progressing from parameter mode to operating mode
- or -
- manually by starting the command "P-0-0071, C3100 Command Recalculate actual value cycle" for recalculating the actual value cycle in the operating mode when a parameter, that is used for calculating the actual value cycle, was changed in the operating mode.



At the start of command C3100, the status bits in "S-0-0403, Position feedback value status" and the status bit in "P-0-0089, Status word synchronization modes" (bit 4) are cleared. After the position data reference has been successfully established, the bits are set again.

The actual value cycle is calculated in dependence of bit 4 of parameter "P-0-0155, Synchronization mode".

- With **bit 4 = 0** in P-0-0155, the actual value cycle is determined in dependence of "P-0-0752, Load revolutions per actual value cycle slave axis":

$$P-0-0786 = S-0-0103 \times P-0-0752$$

Fig.7-82: "Modulo Value Actual Value Cycle" (P-0-0786) With Rotary and Linear Modulo Scaling and P-0-0155, bit 4 = 0

- With **bit 4 = 1** in P-0-0155 (actual value cycle = command value cycle), the actual value cycle is determined according to the formulas below:

## Operation Modes

With "Phase synchronization",

with "Cam without gear reduction" (P-0-0755 = 0) and

with "MotionProfile without gear reduction" (P-0-0755 = 0):

$$\text{Actual value cycle (P-0-0786)} = P-0-0750 \times \frac{P-0-0157}{P-0-0156} \times S-0-0103$$

With "Cam with gear reduction" (P-0-0755 ≠ 0) and

with "MotionProfile with gear reduction" (P-0-0755 ≠ 0):

$$\text{Actual value cycle (P-0-0786)} = P-0-0750 \times \frac{P-0-0157 \times S-0-0103}{P-0-0156 \times P-0-0755}$$

Fig.7-83: "Modulo Value Actual Value Cycle" With Modulo Scaling and P-0-0155, bit 4 = 1

## Synchronization Direction

In the case of absolute position scaling, the calculated synchronization distance is always traveled. In this case, the settings in "P-0-0154, Synchronization direction" and "P-0-0151, Synchronization window for modulo format" are **not** taken into account.

For modulo axes, the distance is limited to  $\pm 0.5 \times$  synchronization range. In addition, the settings in "P-0-0154, Synchronization direction" and "P-0-0151, Synchronization window for modulo format" are taken into account.



The setting in "P-0-0154, Synchronization direction" will only take effect, if the shortest distance (absolute value =  $0.5 \times$  synchronization range) is greater than the synchronization window. In this case, the synchronization direction according to P-0-0154 is used (positive or negative or shortest distance). If the shortest distance is smaller than the synchronization window, the shortest distance will always be traveled.

## Synchronization With Absolute Scaling

The position command value is generated in absolute form. There is no command value cycle and no actual value cycle calculated.

Absolute synchronization is only possible up to  $\pm 2048$  revolutions, because the max. master axis encoder range is only  $2^{32}$  increments.



Make sure that the motion of the slave axis does not exceed the range defined in parameter "S-0-0278, Maximum travel range"

In order to be able to travel in absolutely synchronous form within the max. travel range (S-0-0278), the "P-0-0750, Master axis revolutions per master axis cycle" has to be initialized with zero.



Incorrect parameterization can cause unwanted jumps in position.

Recommendation: Activate position limit value monitor!



See "Position Limitation/Travel Range Limit Switch"

The synchronization distance is calculated according to the following formula:

$$\text{Distance} = x_{\text{sync}} + (S-0-0048) + (P-0-0691) - \text{actual position value}$$

Fig.7-84: Synchronization Distance With Absolute Scaling



	The synchronization range corresponds to the maximum travel range.
	When the "register controller" mode (P-0-0155, bit 0 = 1) has been activated, it is not possible any more to switch back to the "standard" mode (P-0-0155, bit 0 = 0).

## Diagnostic and Status Messages

### Status Messages

In addition to some status and display parameters that are valid for all operation modes, the "P-0-0089, Status word synchronization modes" and "P-0-0152, Synchronization completed" are available for diagnosing the synchronization modes.

#### Synchronous Mode in Synchronization

The feedback signaling that the slave axis has been synchronized takes place in bit 8 of "P-0-0089, Status word synchronization modes".

- Bit 8 = 0 → Slave axis has not been synchronized
- Bit 8 = 1 → Slave axis has been synchronized

Depending on the synchronization mode, the drive sets bit 8 in P-0-0089.

#### In the case of velocity synchronization:

$$\left| dx_{\text{sync}} + (S-0-0037) + (P-0-0690) - (S-0-0040) \right| < S-0-0183$$

Fig. 7-85: Condition for "Slave Axis has Been Synchronized" in the Case of Velocity Synchronization

#### In the case of synchronous position control modes:

$$\left| x_{\text{sync}} + (S-0-0048) + (P-0-0691) - (P-0-0753) \right| < S-0-0228$$

Fig. 7-86: Condition for "Slave Axis has Been Synchronized" in the Case of Synchronous Position Control Modes

#### Synchronization Status

The information on whether a synchronization process is active or has been completed is mapped to bit 0 of parameter "P-0-0152, Synchronization completed":

- Bit 0 = 0 → Synchronization running
- Bit 0 = 1 → Synchronization completed

As regards the generation of bit 0 in parameter P-0-0152, the following cases have to be distinguished for the operation modes "phase synchronization" and "electronic cam":

- First synchronization process  
→ Bit 0 is set when the distance up to the absolute or relative position has been traveled.
- Cyclic normal operation  
→ When bit 0 has been set, the fact of whether bit 0 is cleared for the duration of the following travel reaction when the additive position command value (S-0-0048) is changed, depends on the setting of bit 0 in "P-0-0155, Synchronization mode". If bit 0 = 1 in P-0-0155 ("register controller" mode), bit 0 remains set in P-0-0152.

## Operation Modes

**Diagnostic Messages**

In conjunction with the synchronization modes, there is a number of diagnostic messages specific to operation mode.

**Diagnostic command messages:**

- C0244 Act. modulo value cycle greater than max. travel range
- C3100 Recalculate actual value cycle
- C3101 Act. modulo value cycle greater than max. travel range
- C3102 Drive is still in drive enable

**Warnings:**

- E2040 Device overtemperature 2 prewarning
- E2063 Velocity command value > limit value

**Diagnostic messages for errors:**

- F2005 Cam table invalid
- F2037 Excessive position command difference
- F2039 Maximum acceleration exceeded

## 7.8.2 Velocity Synchronization With Real/Virtual Master Axis

### Brief Description




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Assignment to functional firmware package, see chapter "Supported Operation Modes".

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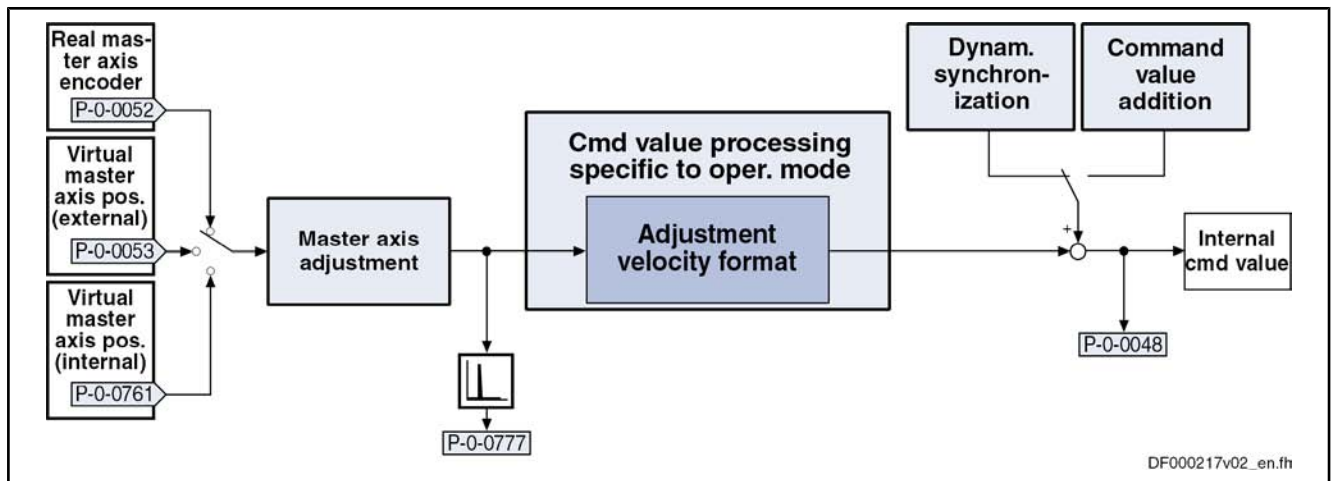
In the operation mode "velocity synchronization with real/virtual master axis", the drive follows a preset master axis velocity in a velocity-synchronous way.

The real master axis velocity is generated by a measuring encoder, the virtual master axis velocity is preset by the master or the integrated master axis generator.

See also "Dynamic Synchronization of the Slave Axis" in section "Basic Functions of the Synchronization Modes"

- Features**
- Determination of the effective velocity command value (P-0-0048) from the differentiated and fine interpolated sum of master axis position (P-0-0053) or measuring encoder position (P-0-0052) and additive components of "P-0-0054, Additive master axis position" and "P-0-0692, Additive master axis position, process loop", multiplied with master axis gear and fine adjustment
  - Adjustable master axis polarity
  - Synchronization takes place in single-step form
  - Activation time for synchronization can be selected

The figure below illustrates the interaction of the individual subfunctions (function blocks) of the "velocity synchronization" mode:



- P-0-0048 Effective velocity command value
- P-0-0052 Actual position value of measuring encoder
- P-0-0053 Master axis position
- P-0-0761 Master axis position for slave axis
- P-0-0777 Effective master axis velocity

Fig.7-87: Function Blocks of the Operation Mode "Velocity Synchronization With Real/Virtual Master Axis"

**Variants of the Operation Mode**

There are the following variants of the operation mode to be selected:

- Velocity synchronization with real master axis
- Velocity synchronization with virtual master axis

**Application of the Operation Mode**

Velocity synchronization is used, for example, for simple transport rolls of printing machines. The drive runs with a velocity synchronous to the master axis. The track speed at the circumference of the transport roll or the winder is preset by the electric gear. A defined tension can be set by the fine adjustment of the gear.

**Pertinent Parameters**

In addition to the general parameters of all synchronization modes, there are other parameters involved in velocity synchronization:

- S-0-0103, Modulo value
- S-0-0183, Velocity synchronization window
- P-0-0088, Control word synchronization modes
- P-0-0089, Status word synchronization modes
- P-0-0159, Slave drive feed travel
- P-0-0777, Effective master axis velocity

See also "Pertinent Parameters" in the subsections of "Basic Functions of the Synchronization Modes"

**Pertinent Diagnostic Messages**

In addition to the general diagnostic messages of all synchronization modes, there are other diagnostic messages involved in velocity synchronization:

- A0110 Velocity synchronization, virtual master axis
- A0111 Velocity synchronization, real master axis
- A0164 Velocity synchronization
- E2063 Velocity command value > limit value

See also "Pertinent Diagnostic Messages" in the subsections of "Basic Functions of the Synchronization Modes"

## Operation Modes

## Overview of the Operation Mode

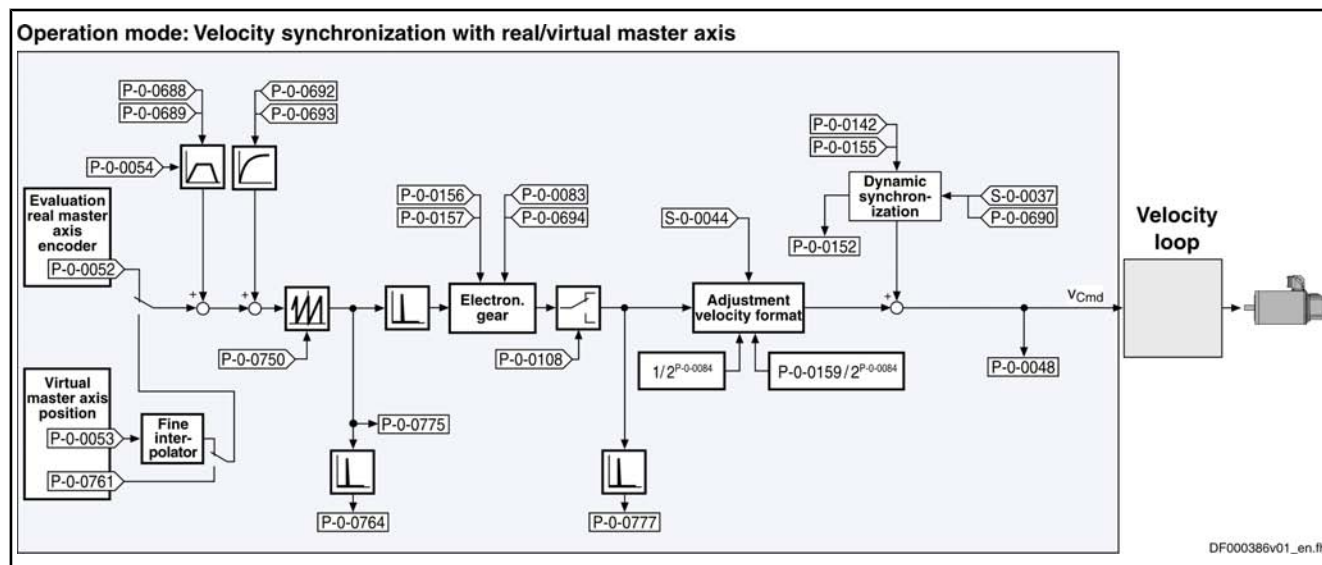


Fig.7-88: Block Diagram: Velocity Synchronization With Real/Virtual Master Axis

## Master Axis Adjustment

Master axis adjustment is realized by means of the following subfunctions:

- Generation of master axis
- Master axis offset and modulo limitation
- Electronic gear with fine adjustment

See "Basic Functions of the Synchronization Modes"

## Command Value Adjustment

**Overview** Command value adjustment in the "velocity synchronization" mode consists of the following basic functions:

- Master axis adjustment
- Command value processing specific to operation mode
- Command value adjustment slave axis, consisting of
  - Dynamic synchronization
  - Command value addition



Only the function block "command value processing" specific to velocity synchronization is described in detail below. The detailed descriptions of the other function blocks are contained in section "Basic Functions of the Synchronization Modes".

See "Basic Functions of the Synchronization Modes"

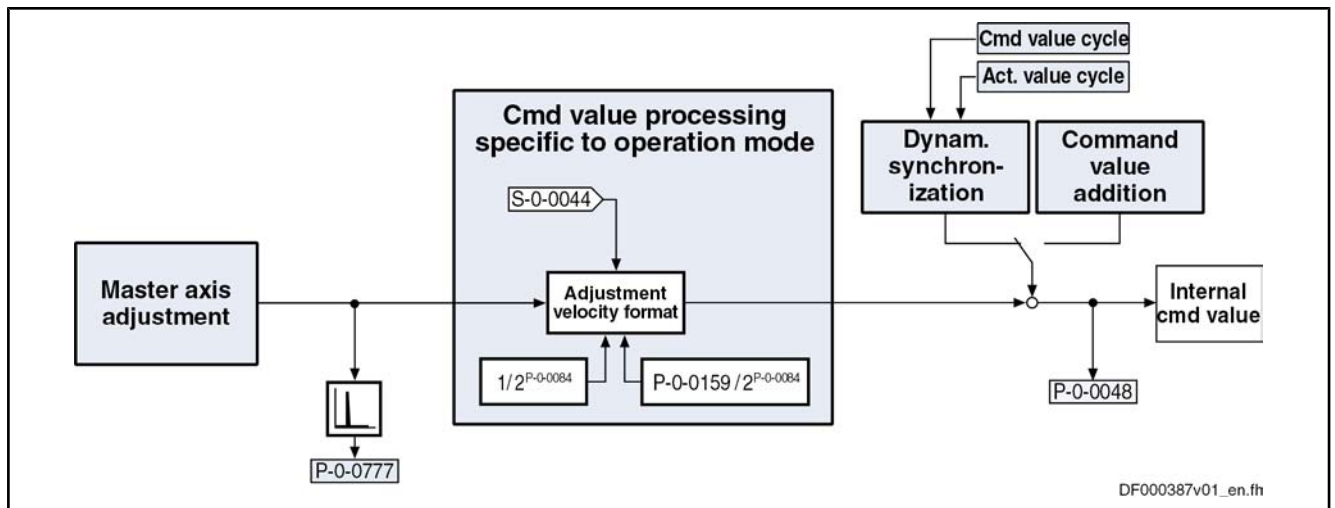


Fig.7-89: Command Value Processing Specific to Operation Mode for Velocity Synchronization

**Generating the Synchronous Velocity Command Value**

The synchronous velocity command value ( $dx_{sync}$ ) is generated in terms of the selected master axis polarity (P-0-0108) and the scaling type (S-0-0044) that was set, using one of the following equations:

$$dx_{sync} = \pm \Delta [(P-0-0053) + (P-0-0054) + (P-0-0692)] \times \frac{P-0-0157}{P-0-0156} \times [1 + (P-0-0083)] \times [1 + (P-0-0694)] \times \frac{1}{2^{P-0-0084}}$$

$dx_{sync}$  Synchronous velocity command value  
Fig.7-90: Generating the Synchronous Velocity Command Value With Rotary Scaling

$$dx_{sync} = \pm \Delta [(P-0-0053) + (P-0-0054) + (P-0-0692)] \times \frac{P-0-0157}{P-0-0156} \times [1 + (P-0-0083)] \times [1 + (P-0-0694)] \times \frac{P-0-0159}{2^{P-0-0084}}$$

$dx_{sync}$  Synchronous velocity command value  
Fig.7-91: Generating the Synchronous Velocity Command Value With Linear Scaling



One master axis revolution is standardized to  $2^N$  increments (with  $N =$  value from "P-0-0084, Number of bits per master axis revolution"). This means that the LSB of the master axis position corresponds to  $2^{-N}$  master axis revolutions.

**Synchronization With Velocity Synchronization**

The synchronization process is a drive-controlled motion with the aim of synchronizing the axis to the master axis velocity. The slave axis is velocity-synchronous when the following condition has been fulfilled:

$$dx_{sync} + (S-0-0037) + (P-0-0690) = S-0-0040$$

$dx_{sync}$  Synchronous velocity command value  
S-0-0040 Velocity feedback value  
Fig.7-92: Condition for Velocity Synchronism of the Slave Axis

**Synchronization Process**

Upon activation of the operation mode, a **velocity adjustment** is first executed. This means that the drive either accelerates or decelerates from the current actual velocity at the time of activation to the synchronous velocity.

## Operation Modes

The drive generates the synchronous velocity by differentiating the master axis position:

$$\Delta [(P-0-0053) + (P-0-0054) + (P-0-0692)]$$

-or-

$$\Delta [(P-0-0052) + (P-0-0054) + (P-0-0692)]$$

Fig.7-93: Drive-Side Generation of the Synchronous Velocity

After the synchronous velocity has been reached, another change of the synchronous velocity is processed depending on "P-0-0155, Synchronization mode".

The following variants are available to do this:

- **P-0-0155, bit 5 = 0**  
→ Velocity adjustment only carried out once, all following changes of velocity are carried out with maximum acceleration
- **P-0-0155, bit 5 = 1**  
→ Every change of velocity is limited by the value of "P-0-0142, Synchronization acceleration"



See also Parameter Description "P-0-0155, Synchronization mode"

## Notes on Commissioning and Parameterization

**General Parameterization** For general parameterization, it is necessary to make machine-specific pre-settings:

- Scaling of parameter data (linear or rotary)
  - S-0-0076, S-0-0077, S-0-0078 and S-0-0079 for position data
  - S-0-0044, S-0-0045 and S-0-0046 for velocity data
  - S-0-0160, S-0-0161 and S-0-0162 for acceleration data
 See "Scaling of Physical Data"
- For linear scaling with rotary motor, parameterizing the feed constant per slave axis revolution (S-0-0123)
- Parameterizing the load gear of the slave axis (S-0-0121 and S-0-0122)

### Parameterizing the Operation Mode

Sequence of parameterization specific to operation mode:

1. Depending on "P-0-0750, Master axis revolutions per master axis cycle" the range of values for the master axis can be between 0 and  $2047 \times 2^{P-0-0084}$  increments. In the special case  $P-0-0750 = 0$ , the master axis range is from  $-(2^{31})$  to  $(2^{31})-1$ .
2. The distance that the slave axis covers per master axis revolution is determined in "P-0-0159, Slave drive feed travel".
3. Settings for the electronic gear are made in the following parameters:
  - P-0-0083, Gear ratio fine adjustment
  - P-0-0108, Master drive polarity
  - P-0-0156, Master drive gear input revolutions
  - P-0-0157, Master drive gear output revolutions
4. The following settings have to be made for synchronization:

- P-0-0142, Synchronization acceleration
- Time of activation for synchronization (P-0-0155, bit 5)

## Diagnostic and Status Messages

**Diagnostic Status Messages** The following diagnostic status messages are displayed in normal operation of the operation mode (drive enabled, "AF"):

- A0110 Velocity synchronization, virtual master axis
- A0111 Velocity synchronization, real master axis
- A0164 Velocity synchronization

**Error Messages and Warnings** Different drive errors can occur in operation that cause error messages or warnings to be generated. The error messages listed below are only the messages specific to operation mode:

- E2063 Velocity command value > limit value

There are also several status messages specific to operation mode generated in the drive that are mapped to specific status bits (see also "P-0-0089, Status word synchronization modes" and "P-0-0152, Synchronization completed").

## 7.8.3 Phase Synchronization With Real/Virtual Master Axis

### Brief Description



Assignment to functional firmware package, see chapter "Supported Operation Modes".

In the operation mode "phase synchronization with real/virtual master axis", the drive follows a preset master axis position in an absolute or relative phase synchronous way.

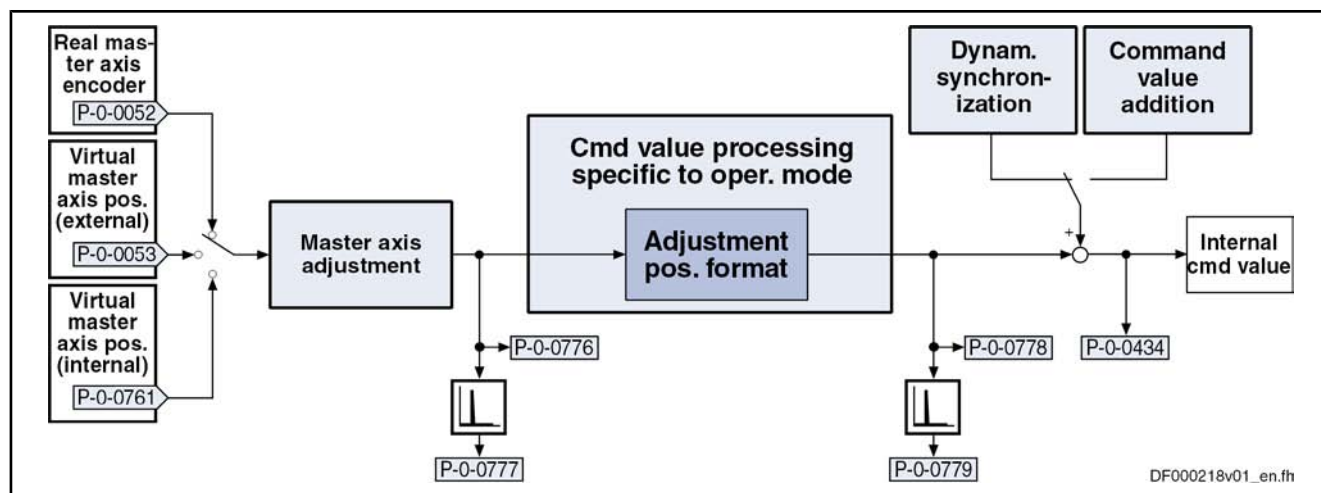
The real master axis velocity is generated by a measuring encoder, the virtual master axis velocity is preset by the master or the integrated master axis generator.

See also "Dynamic Synchronization of the Slave Axis" in section "Basic Functions of the Synchronization Modes"

- Features**
- Determination of the position command value from the master axis position using the electronic gear with fine adjustment, adjustable master axis polarity
  - Synchronization mode to be selected
  - Single-step or double-step synchronization
  - Absolute or relative phase synchronization
  - Synchronization range to be selected

The figure below illustrates the interaction of the individual subfunctions (function blocks) of the "phase synchronization" mode:

Operation Modes



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- P-0-0052 Actual position value of measuring encoder
- P-0-0053 Master axis position
- P-0-0434 Position command value of controller
- P-0-0761 Master axis position for slave axis
- P-0-0776 Effective master axis position
- P-0-0777 Effective master axis velocity
- P-0-0778 Synchronous position command value
- P-0-0779 Synchronous velocity

Fig. 7-94: Function Blocks of the Operation Mode "Phase Synchronization With Real/Virtual Master Axis"

Variants of the Operation Mode

There are the following variants of the operation mode to be selected:

- Position synchronization
- Phase synchronization with real master axis, encoder 1
- Phase synchronization with real master axis, encoder 2
- Phase synchronization with real master axis, encoder 1, lagless
- Phase synchronization with real master axis, encoder 2, lagless
- Phase synchronization with virtual master axis, encoder 1
- Phase synchronization with virtual master axis, encoder 2
- Phase synchronization with virtual master axis, encoder 1, lagless
- Phase synchronization with virtual master axis, encoder 2, lagless



In the operation mode variant "position synchronization", select phase synchronization and the master axis in "P-0-0088, Control word synchronization modes". The encoder selection and lagless position control are set in "S-0-0520, Control word of axis controller".

Application "Absolute Phase Synchronization"

In machining processes that require absolute phase synchronization, e.g. printing, punching or perforating in printing machines, the absolute position reference to the master axis is established in the operation mode "phase synchronization". The drive synchronizes with a position command value that is generated from master axis position and additive position command value.

Application "Relative Phase Synchronization"

For machining processes that only require relative phase synchronization, e.g. synchronization of belts or feed rollers without defined starting point, a relative position reference to the master axis is established. During the first synchronization, there is only an adjustment to the synchronous velocity but no position adjustment carried out.



**Pertinent Parameters** In addition to the general parameters of all synchronization modes, there are other parameters involved in phase synchronization:

- S-0-0103, Modulo value
- S-0-0520, Control word of axis controller
- S-0-0521, Status word of position loop
- P-0-0086, Configuration word synchronous operation modes
- P-0-0088, Control word synchronization modes
- P-0-0089, Status word synchronization modes
- P-0-0159, Slave drive feed travel
- P-0-0776, Effective master axis position
- P-0-0777, Effective master axis velocity
- P-0-0778, Synchronous position command value
- P-0-0779, Synchronous velocity

See also "Pertinent Parameters" in the subsections of "Basic Functions of the Synchronization Modes"

**Pertinent Diagnostic Messages** In addition to the general diagnostic messages of all synchronization modes, there are other diagnostic messages involved in phase synchronization:

- A0112 Phase synchronization, encoder 1, virtual master axis
- A0113 Phase synchronization, encoder 2, virtual master axis
- A0114 Phase synchronization, encoder 1, real master axis
- A0115 Phase synchronization, encoder 2, real master axis
- A0116 Phase synchr. lagless, encoder 1, virtual master axis
- A0117 Phase synchr. lagless, encoder 2, virtual master axis
- A0118 Phase synchr. lagless, encoder 1, real master axis
- A0119 Phase synchr. lagless, encoder 2, real master axis
- A0163 Position synchronization

See also "Pertinent Diagnostic Messages" in the subsections of "Basic Functions of the Synchronization Modes"

Operation Modes

Overview of the Operation Mode

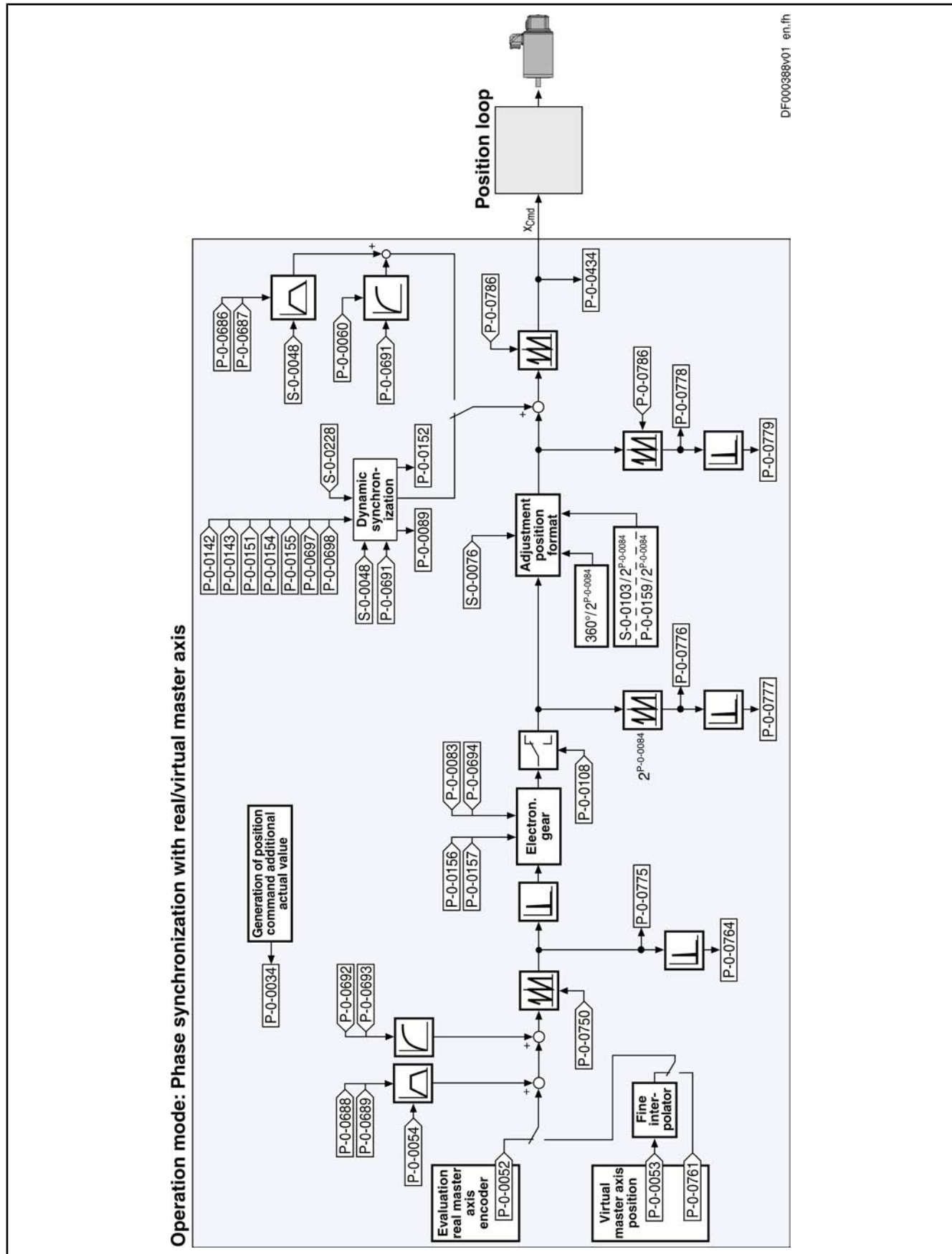


Fig. 7-95: Block Diagram: Phase Synchronization With Real/Virtual Master Axis

## Master Axis Adjustment

Master axis adjustment is realized by means of the following subfunctions:

- Generation of master axis
- Master axis offset and modulo limitation
- Electronic gear with fine adjustment

See "Basic Functions of the Synchronization Modes"

## Command Value Adjustment

**Overview** Command value adjustment in the "phase synchronization" mode consists of the following basic functions:

- Master axis adjustment
- Command value processing specific to operation mode
- Command value adjustment slave axis, consisting of
  - Dynamic synchronization
  - Command value addition



Only the function block "command value processing" specific to phase synchronization is described in detail below. The detailed descriptions of the other function blocks are contained in section "Basic Functions of the Synchronization Modes".

See "Basic Functions of the Synchronization Modes"

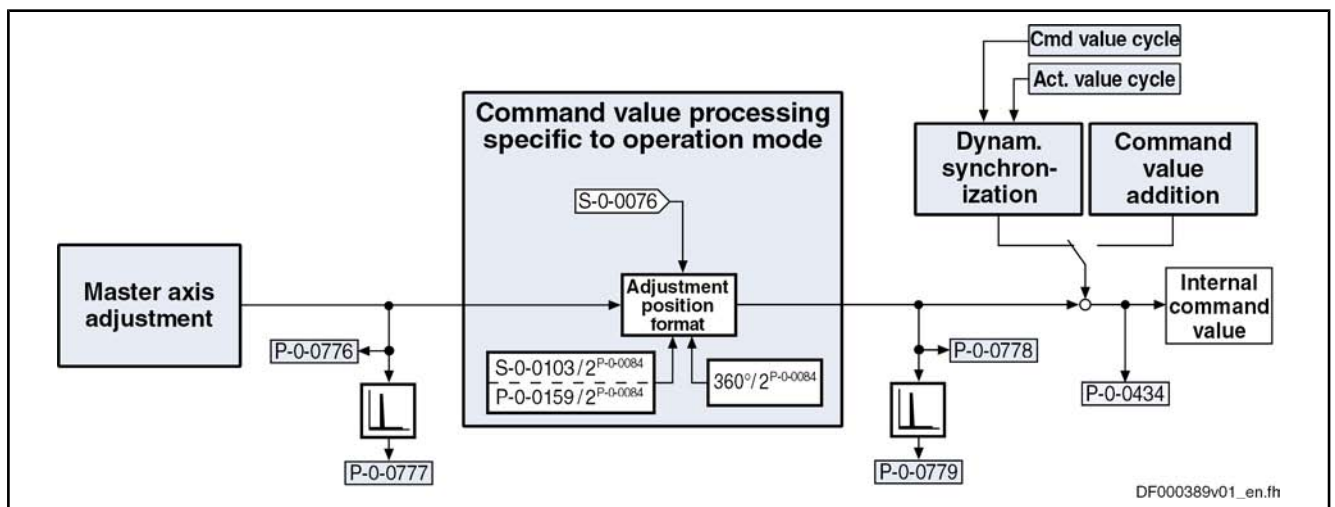


Fig. 7-96: Command Value Processing Specific to Operation Mode for Phase Synchronization

### Generating the Internal Position Command Value

In the operation mode "phase synchronization with real/virtual master axis", the internal position command value (P-0-0434) is generated by addition of the synchronous position command value ( $x_{\text{sync}}$ ) with the components of the additive position command value (S-0-0048) and the additive position command value of process loop (P-0-0691).

## Operation Modes

$$P-0-0434 = x_{\text{sync}} + x_{\text{add}} + x_{\text{add\_PR}}$$

P-0-0434	Position command value of controller
$x_{\text{sync}}$	Synchronous position command value
$x_{\text{add}}$	Filter output of "S-0-0048, Additive position command value"
$x_{\text{add\_PR}}$	Filter output of "P-0-0691, Additive position command value, process loop"

Fig.7-97: Generating the Internal Position Command Value

**Note:** In the synchronized status (P-0-0089; bit 8 = 1), the following applies:

$$P-0-0434 = x_{\text{sync}} + (S-0-0048) + (P-0-0691)$$

Fig.7-98: Generating the Internal Position Command Value in the Synchronized Status

## Generating the Synchronous Position Command Value

The synchronous position command value ( $x_{\text{sync}}$ ) is generated in terms of the selected master axis polarity (P-0-0108) and the scaling type (S-0-0076) that was set, using the following equation:

$$x_{\text{sync}} = \left\langle P-0-0775 \times \frac{P-0-0157}{P-0-0156} \times [1 + (P-0-0083)] \times [1 + (P-0-0694)] \times \frac{S-0-0103}{2^{P-0-0084}} \right\rangle \% P-0-0786$$

Fig.7-99: Generating the Synchronous Position Command Value With Modulo Scaling

$$x_{\text{sync}} = \left\langle P-0-0775 \times \frac{P-0-0157}{P-0-0156} \times [1 + (P-0-0083)] \times [1 + (P-0-0694)] \times \frac{360^\circ}{2^{P-0-0084}} \right\rangle \% P-0-0786$$

Fig.7-100: Generating the Synchronous Position Command Value With Rotary Absolute Scaling

$$x_{\text{sync}} = \left\langle P-0-0775 \times \frac{P-0-0157}{P-0-0156} \times [1 + (P-0-0083)] \times [1 + (P-0-0694)] \times \frac{P-0-0159}{2^{P-0-0084}} \right\rangle \% P-0-0786$$

Fig.7-101: Generating the Synchronous Position Command Value With Linear Absolute Scaling



One master axis revolution is standardized to  $2^N$  increments (with  $N$  = value from "P-0-0084, Number of bits per master axis revolution"). This means that the LSB of the master axis position corresponds to  $2^{-N}$  master axis revolutions.

## Synchronization

See "Basic Functions of the Synchronization Modes"

## Notes on Commissioning and Parameterization

## General Parameterization

For general parameterization, it is necessary to make machine-specific pre-settings:

- Scaling of Data**
- Scaling of parameter data (linear or rotary)

- S-0-0076, S-0-0077, S-0-0078 and S-0-0079 for position data
- S-0-0044, S-0-0045 and S-0-0046 for velocity data
- S-0-0160, S-0-0161 and S-0-0162 for acceleration data

See "Scaling of Physical Data"

- For linear scaling with rotary motor, parameterizing the feed constant per slave axis revolution (S-0-0123)
- Parameterizing the load gear of the slave axis (S-0-0121 and S-0-0122)
- Determining the synchronization velocity (P-0-0143) and the synchronization acceleration (P-0-0142)

### "Modulo" Parameterization

For "modulo" parameterization, make the following settings:

#### 1. Modulo Range

In "S-0-0103, Modulo value", set the modulo range to that value at which the overflow of the position data (from modulo value to "0") is to take place with infinitely turning axis.

#### 2. Maximum Travel Range

Select the maximum travel range (S-0-0278) at least as large as the actual value cycle. Set the actual value cycle greater than or equal to the modulo range (S-0-0103).

#### 3. Master Axis Position Range/ Master Axis Cycle

Depending on "P-0-0750, Master axis revolutions per master axis cycle" the range of values for the master axis can be between 0 and  $2047 \times 2^{P-0-0084}$  increments. In the special case  $P-0-0750 = 0$ , the master axis range is from  $-(2^{31})$  to  $(2^{31})-1$ . This case is utilized for the "Flying Saw" application. The actual value cycle in which "P-0-0753, Position actual value in actual value cycle" is contained, then has to be selected in such a way that the synchronous position data generated by the determined master axis cycle can be displayed.

#### 4. "Modulo" Master Axis

The "modulo" master axis is a master axis the master axis positions of which are within the master axis cycle determined by "P-0-0750, Master axis revolutions per master axis cycle". The master axis positions may overflow or underflow (infinitely turning master axis).

#### 5. Electronic Gear

Settings for the electronic gear are made in the following parameters:

- P-0-0083, Gear ratio fine adjustment
- P-0-0694, Gear ratio fine adjustment, process loop
- P-0-0108, Master drive polarity
- P-0-0156, Master drive gear input revolutions
- P-0-0157, Master drive gear output revolutions

#### 6. "Modulo" Synchronization

The following settings have to be made for synchronization:

- Mode for reaction to changes in S-0-0048 after first synchronization (P-0-0155, bit 0)
- Single-step or double-step synchronization (P-0-0155, bit 6)
- Relative or absolute synchronization (P-0-0155, bit 1)

## Operation Modes

- Synchronization range (P-0-0155, bits 2 and 3)
- Generation of actual value cycle (P-0-0155, bit 4)



The actual value cycle has to be an integral multiple of the synchronization range.

### "Absolute" Parameterization

For "absolute" parameterization, make the following settings:

#### 1. Maximum Travel Range

In the case of absolute scaling, the maximum travel range in S-0-0278 has to be selected at least as large as the range in which the synchronous position data are to be contained.

#### 2. Master Axis Position Range/ Master Axis Cycle

Depending on "P-0-0750, Master axis revolutions per master axis cycle" the range of values for the master axis can be between 0 and  $2047 \times 2^{P-0-0084}$  increments. In the special case  $P-0-0750 = 0$ , the master axis range is from  $-(2^{31})$  to  $(2^{31})-1$ . This case is utilized for the "Flying Saw" application. The actual value cycle in which "P-0-0753, Position actual value in actual value cycle" is contained, then has to be selected in such a way that the synchronous position data generated by the determined master axis cycle can be displayed.

#### 3. "Absolute" Master Axis

The "absolute" master axis is a master axis the master axis positions of which are within the master axis cycle determined by "P-0-0750, Master axis revolutions per master axis cycle". The master axis positions **mustn't** overflow nor underflow. If the master axis does overflow, this causes an unwanted jump in position.

**Note:** Incorrect parameterization can cause unwanted jumps in position. It is recommended that you activate the position limit value monitor (see "Position Limitation/Travel Range Limit Switch")!

#### 4. Slave Drive Feed Travel

The distance that the slave axis covers per master axis revolution is determined in "P-0-0159, Slave drive feed travel".

#### 5. Electronic Gear

Settings for the electronic gear are made in the following parameters:

- P-0-0083, Gear ratio fine adjustment
- P-0-0694, Gear ratio fine adjustment, process loop
- P-0-0108, Master drive polarity
- P-0-0156, Master drive gear input revolutions
- P-0-0157, Master drive gear output revolutions

#### 6. "Absolute" Synchronization

The following settings have to be made for synchronization:

- Mode for reaction to changes in S-0-0048 after first synchronization (P-0-0155, bit 0)
- Relative or absolute synchronization (P-0-0155, bit 1)
- Single-step or double-step synchronization (P-0-0155, bit 6)

### Commissioning Summary

The figure below illustrates the basic sequence of commissioning.

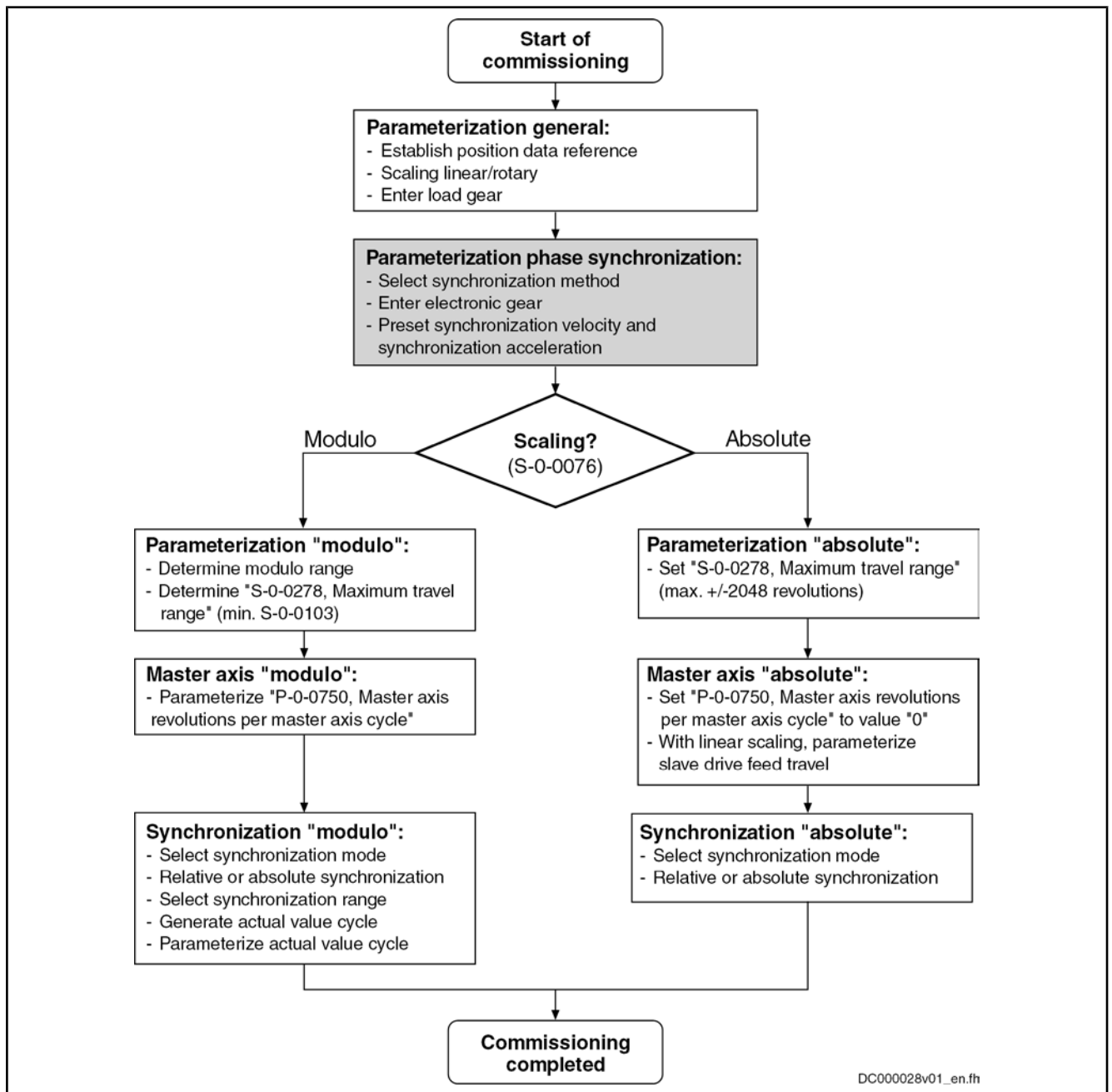


Fig. 7-102: Overview of Commissioning Steps for Phase Synchronization

### Diagnostic and Status Messages

#### Diagnostic Status Messages

The following diagnostic status messages are displayed in normal operation of the operation mode (drive enabled, "AF"):

- A0112 Phase synchronization, encoder 1, virtual master axis
- A0113 Phase synchronization, encoder 2, virtual master axis
- A0114 Phase synchronization, encoder 1, real master axis
- A0115 Phase synchronization, encoder 2, real master axis

## Operation Modes

- A0116 Phase synchr. lagless, encoder 1, virtual master axis
- A0117 Phase synchr. lagless, encoder 2, virtual master axis
- A0118 Phase synchr. lagless, encoder 1, real master axis
- A0119 Phase synchr. lagless, encoder 2, real master axis
- A0163 Position synchronization

**Error Messages and Warnings**

Different drive errors can occur in operation that cause error messages or warnings to be generated. The error messages listed below are only the messages specific to operation mode:

- F2039 Maximum acceleration exceeded  
→ The preset acceleration value of two successive command values was greater than the value parameterized in "S-0-0138, Bipolar acceleration limit value".
- F2037 Excessive position command difference  
→ The velocity preset for the drive by two successive command values is greater than the value in "S-0-0091, Bipolar velocity limit value".

**Status Bits**

There are also several status messages specific to operation mode generated in the drive that are mapped to specific status bits (see also "P-0-0089, Status word for synchronous operation modes" and "P-0-0152, Synchronization completed").

**Position Loop Status**

The status display via the control encoder and for lagless operation or operation with lag error takes place in "S-0-0521, Status word of position loop".

## 7.8.4 Electronic Cam With Real/Virtual Master Axis

### Brief Description



Assignment to functional firmware package, see chapter "Supported Operation Modes".

In the operation mode "electronic cam with real/virtual master axis", there is a fixed relationship between the master axis position and the slave axis.

The real master axis velocity is generated by a measuring encoder, the virtual master axis velocity is preset by the master or the integrated master axis generator.

See also "Dynamic Synchronization of the Slave Axis" in section "Basic Functions of the Synchronization Modes"

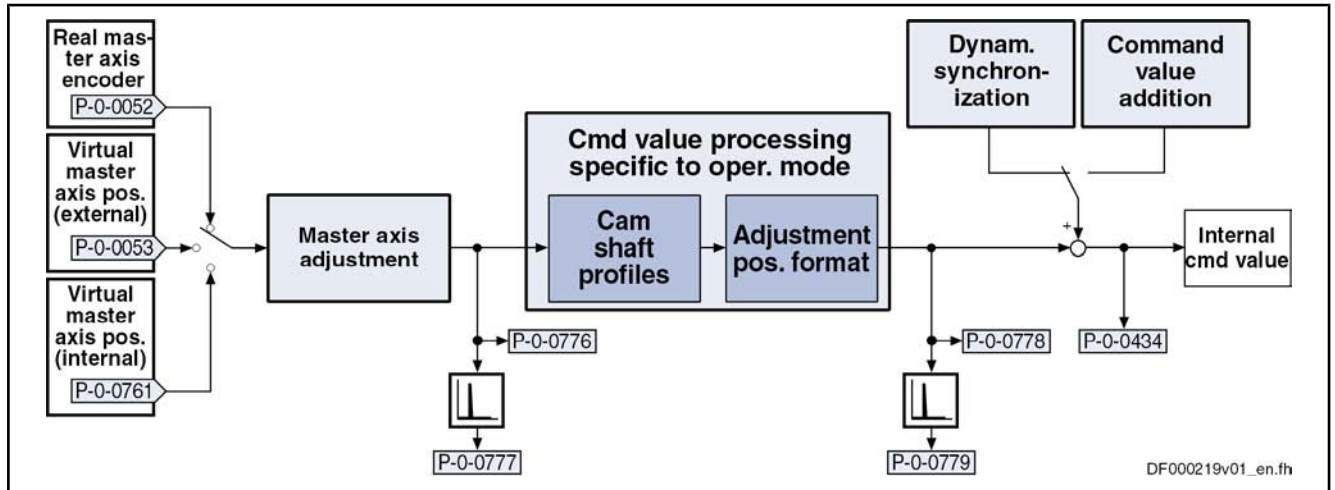
**Features**

- 4 cam shaft profiles with a max. of 1024 data points (P-0-0072, P-0-0092, P-0-0780, P-0-0781)
- 4 cam shaft profiles with a max. of 128 data points (P-0-0783, P-0-0784, P-0-0785, P-0-0786)
- Cubic spline interpolation of the cam data points
- Dynamic angle offset and angle offset at begin of profile
- Freely definable switch angle for cam and cam distance
- Synchronization mode to be selected
- Single-step or double-step synchronization
- Absolute or relative phase synchronization
- Synchronization range to be selected
- Change of format "on the fly"



- Cross cutter function
- Clocked Pull Roll

The figure below illustrates the interaction of the individual subfunctions (function blocks) of the "electronic cam" mode:



- P-0-0052 Actual position value of measuring encoder
- P-0-0053 Master axis position
- P-0-0434 Position command value of controller
- P-0-0761 Master axis position for slave axis
- P-0-0776 Effective master axis position
- P-0-0777 Effective master axis velocity
- P-0-0778 Synchronous position command value
- P-0-0779 Synchronous velocity

Fig.7-103: Function Blocks of the Operation Mode "Electronic Cam"

**Variants of the Operation Mode**

There are the following variants of the operation mode to be selected:

- Position synchronization
- Cam with real master axis, encoder 1
- Cam with real master axis, encoder 2
- Cam with real master axis, encoder 1, lagless
- Cam with real master axis, encoder 2, lagless
- Cam with virtual master axis, encoder 1
- Cam with virtual master axis, encoder 2
- Cam with virtual master axis, encoder 1, lagless
- Cam with virtual master axis, encoder 2, lagless



In the operation mode variant "position synchronization", select electronic cam shaft and the master axis in "P-0-0088, Control word synchronization modes". The encoder selection and lagless position control are set in "S-0-0520, Control word of axis controller".

**Pertinent Parameters**

In addition to the general parameters of all synchronization modes, there are other parameters involved in this operation mode:

- S-0-0103, Modulo value
- S-0-0520, Control word of axis controller
- S-0-0521, Status word of position loop
- P-0-0061, Angle offset begin of table

## Operation Modes

- P-0-0072, Cam table 1
- P-0-0073, Cam distance 2
- P-0-0085, Dynamic angle offset
- P-0-0086, Configuration word synchronous operation modes
- P-0-0088, Control word synchronization modes
- P-0-0089, Status word synchronization modes
- P-0-0092, Cam table 2
- P-0-0093, Cam distance
- P-0-0094, Cam switch angle
- P-0-0144, Cam distance switch angle
- P-0-0158, Angle offset change rate
- P-0-0159, Slave drive feed travel
- P-0-0227, Cam table, access angle
- P-0-0695, Angle offset begin of profile, process loop
- P-0-0696, Filter time constant, angle offset profile, process loop
- P-0-0776, Effective master axis position
- P-0-0777, Effective master axis velocity
- P-0-0778, Synchronous position command value
- P-0-0779, Synchronous velocity
- P-0-0780, Cam table 3
- P-0-0781, Cam table 4
- P-0-0782, Cam table 5
- P-0-0783, Cam table 6
- P-0-0784, Cam table 7
- P-0-0785, Cam table 8

See also "Pertinent Parameters" in the subsections of "Basic Functions of the Synchronization Modes"

### Pertinent Diagnostic Messages

In addition to the general diagnostic messages of all synchronization modes, there are other diagnostic messages involved in this operation mode:

- A0128 Cam, encoder 1, virtual master axis
- A0129 Cam, encoder 2, virtual master axis
- A0130 Cam, encoder 1, real master axis
- A0131 Cam, encoder 2, real master axis
- A0132 Cam, lagless, encoder 1, virt. master axis
- A0133 Cam, lagless, encoder 2, virt. master axis
- A0134 Cam, lagless, encoder 1, real master axis
- A0135 Cam, lagless, encoder 2, real master axis
- A0163 Position synchronization
- F2005 Cam table invalid

See also "Pertinent Diagnostic Messages" in the subsections of "Basic Functions of the Synchronization Modes"

## Overview of the Operation Mode

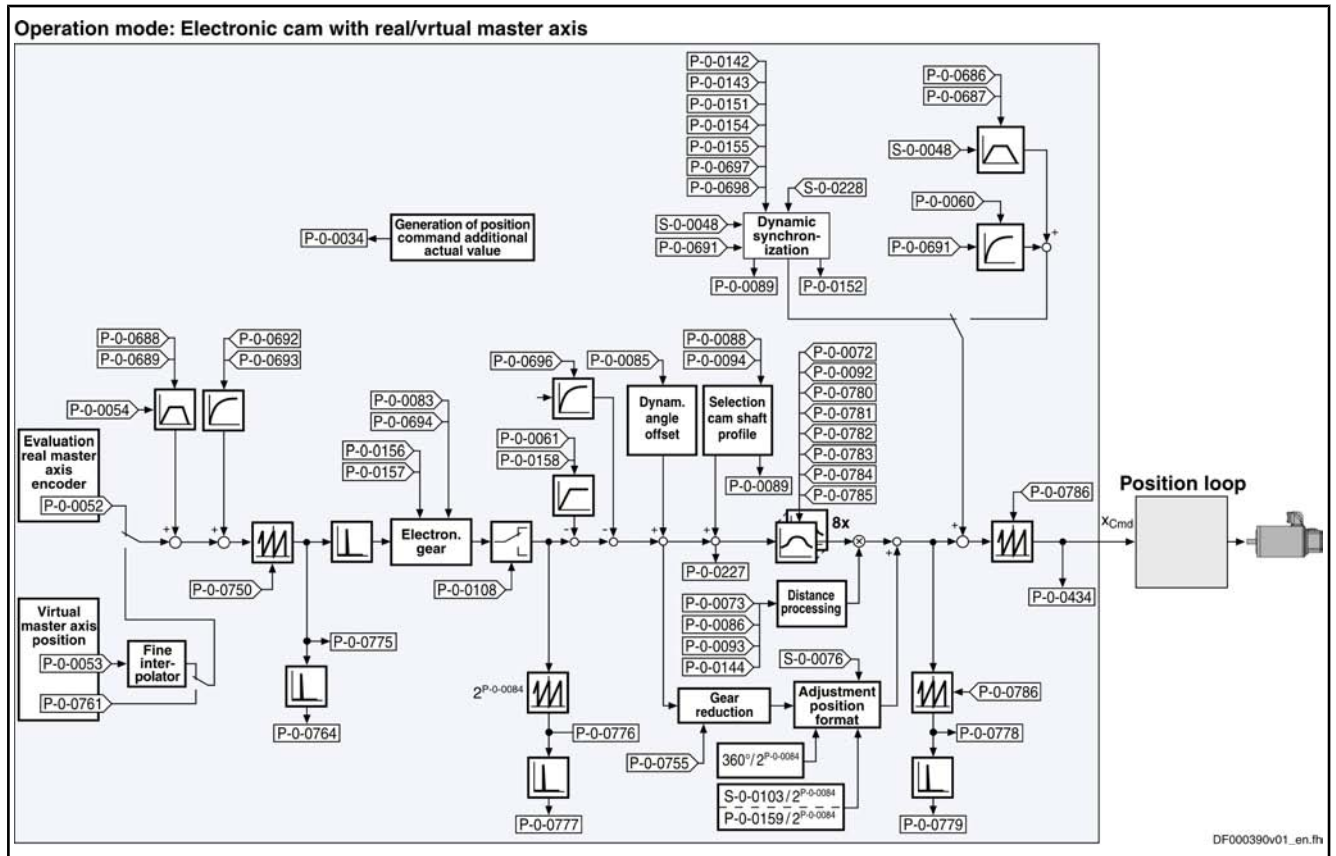


Fig.7-104: Block Diagram: Electronic Cam Shaft With Real/Virtual Master Axis

## Master Axis Adjustment

Master axis adjustment is realized by means of the following subfunctions:

- Generation of master axis
- Master axis offset and modulo limitation
- Electronic gear with fine adjustment

See "Basic Functions of the Synchronization Modes"

## Command Value Adjustment

**Overview** Command value adjustment in the "electronic cam" mode consists of the following basic functions:

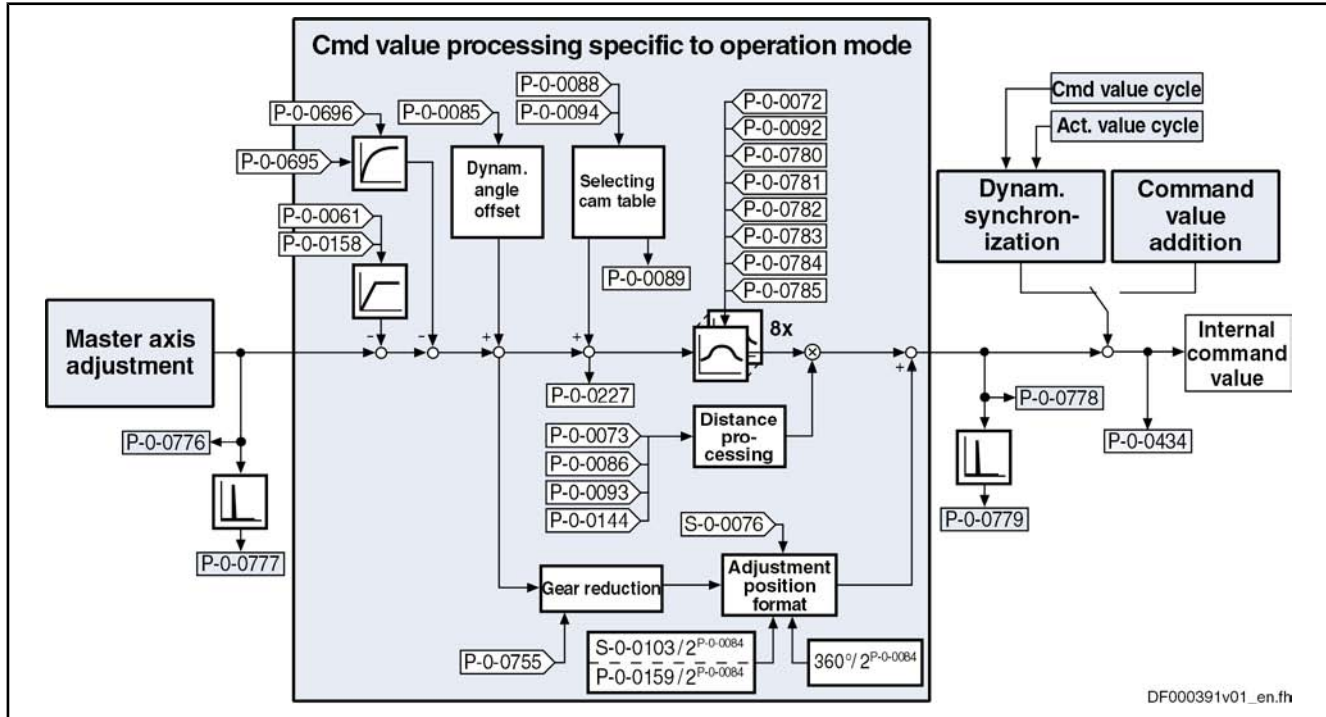
- Master axis adjustment
- Command value processing specific to operation mode, consisting of
  - Cam shaft profiles (incl. access)
  - Adjustment of position format
- Command value adjustment slave axis, consisting of
  - Dynamic synchronization
  - Command value addition

Operation Modes



Only the function block "command value processing" specific to the cam shaft mode is described in detail below. The detailed descriptions of the other function blocks are contained in section "Basic Functions of the Synchronization Modes".

See "Basic Functions of the Synchronization Modes"



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Fig.7-105: Command Value Processing Specific to Operation Mode for Cam Mode

Generating the Internal Position Command Value

In the operation mode "electronic cam with real/virtual master axis", the internal position command value (P-0-0434) is generated by addition of the synchronous position command value ( $x_{sync}$ ) with the components of the additive position command value (S-0-0048) and the additive position command value of process loop (P-0-0691).

$$P-0-0434 = x_{sync} + x_{add} + x_{add\_PR}$$

- P-0-0434 Position command value of controller
- $x_{sync}$  Synchronous position command value
- $x_{add}$  Filter output of "S-0-0048, Additive position command value"
- $x_{add\_PR}$  Filter output of "P-0-0691, Additive position command value, process loop"

Fig.7-106: Generating the Internal Position Command Value

**Note:** In the synchronized status (P-0-0089; bit 8 = 1), the following applies:

$$P-0-0434 = x_{sync} + (S-0-0048) + (P-0-0691)$$

Fig.7-107: Generating the Internal Position Command Value in the Synchronized Status

In the function block "command value processing specific to operation mode" the calculations specific to the cam mode are carried out for generating the synchronous position command value.

Depending on "P-0-0061, Angle offset begin of table" and "P-0-0695, Angle offset begin of profile, process loop", an interpolated profile value is taken from the cam shaft profiles in every control cycle and the difference to the last interpolated profile value is multiplied by the cam shaft distance. The result is added to the position command value.

If the phase-synchronous path has been activated by bit 4 of parameter "P-0-0086, Configuration word synchronous operation modes", the master axis position at the output of the electronic gear is additionally divided by the gear reduction (P-0-0755) and multiplied with a scaling-dependent factor. The result is differentiated and added to the position command value.



If the profile limit is exceeded in positive direction, the profile continues with its first value, the same happens if the limit is exceeded in negative direction.

#### Calculating the Internal Position Command Value (Initialization)

Upon activation of the operation mode "electronic cam with real/virtual master axis", the position command value of the drive is first initialized in terms of the following relation:

$$x_{F(\phi L)} = \left[ h \times \text{tab}(\phi_{ZGW}) + \frac{\phi_{ZGW}}{U} + x_V + x_{VPR} \right] \%IWZ$$

$x_F$	Position command value of slave drive (P-0-0434)
$\phi_L$	Resulting master axis position (P-0-0775)
$h$	Cam shaft distance (P-0-0093 or P-0-0073)
$\text{tab}(\phi)$	Cam shaft profiles (P-0-0072, P-0-0092, P-0-0780, P-0-0781)
$\phi_{ZGW}$	Profile access angle
$U$	Gear reduction (P-0-0755)
$x_V$	Additive position command value (S-0-0048)
$x_{VPR}$	Additive position command value, process loop (P-0-0691)
$IWZ$	Modulo actual value cycle (P-0-0786)

Fig.7-108: Initializing the Position Command Value

$$\phi_{ZGW} = \pm \phi_L \times \frac{G_a}{G_e} \times (1 + F) \times (1 + F_{PR}) - \phi_V - \phi_{VPR}$$

$\phi_{ZGW}$	Profile access angle
$\pm/-$	Master drive polarity (P-0-0108)
$\phi_L$	Resulting master axis position (P-0-0775)
$G_a$	Master drive gear output revolutions (P-0-0157)
$G_e$	Master drive gear input revolutions (P-0-0156)
$F$	Gear ratio fine adjustment (P-0-0083)
$F_{PR}$	Gear ratio fine adjustment, process loop (P-0-0694)
$\phi_V$	Angle offset begin of profile (P-0-0061)
$\phi_{VPR}$	Angle offset begin of profile, process loop (P-0-0695)

Fig.7-109: Determining the Profile Access Angle

## Operation Modes



With the operation mode activated, differences, that later on will be added again, are processed in the electronic gear and the cam shaft profiles. Therefore, changes in the electronic gear and the cam shaft distance do not cause position command value jumps. Velocity jumps, however, can occur and the absolute position reference, established when activating the operation mode, is lost.

### Accessing the Cam Shaft Profiles

In every position loop cycle (Advanced: 250 μs, Basic: T = 500 μs), an interpolated table value is taken from the activated cam table, the difference to the last interpolated profile value is generated and a multiplication with the cam distance is carried out. The result is added to the position command value.

Cubic spline interpolation takes place between the profile values.



With an infinite cam shaft the difference between initial value and final value of the cam shaft profile is 100%.

### Calculating the Internal Position Command Value (in Cyclic Operation)

The position command value is generated as per the following relation:

$$x_{F(n)(\phi_L)} = \left\langle x_{F(n-1)(\phi_L)} + \left[ h \times \Delta \text{tab}(\pm \phi_L) \times \frac{G_a}{G_e} - \phi_V + \phi_d \right] \pm \Delta \phi_L \times \left[ \frac{G_a}{G_e} \times (1+F) - \frac{\phi_V}{U} + x_V \right] \right\rangle \% \text{IWZ}$$

$x_F$	Position command value of slave drive (P-0-0434)
$\phi_L$	Resulting master axis position (P-0-0775)
$h$	Cam shaft distance (P-0-0093 or P-0-0073)
$\text{tab}(\phi)$	Cam shaft profiles (P-0-0072, P-0-0092, P-0-0780, P-0-0781)
$\pm$	Master drive polarity (P-0-0108)
$G_a$	Master drive gear output revolutions (P-0-0157)
$G_e$	Master drive gear input revolutions (P-0-0156)
$\phi_V$	Angle offset begin of profile (P-0-0061+ P-0-0695)
$\phi_d$	Dynamic angle offset (P-0-0085)
$F$	Fine adjustment (P-0-0083)
$U$	Gear reduction (P-0-0755)
$x_V$	Additive position command value (S-0-0048 + P-0-0691)
IWZ	Modulo actual value cycle (P-0-0786)

*Fig.7-110: Cyclically Generating the Position Command Value for the Slave Drive*

## Synchronization

See "Basic Functions of the Synchronization Modes"

## Notes on Commissioning and Parameterization

### General Parameterization

For general parameterization, it is necessary to make machine-specific pre-settings:

#### Scaling of Data

- Scaling of parameter data (linear or rotary)
  - S-0-0076, S-0-0077, S-0-0078 and S-0-0079 for position data
  - S-0-0044, S-0-0045 and S-0-0046 for velocity data
  - S-0-0160, S-0-0161 and S-0-0162 for acceleration data
- See "Scaling of Physical Data"
- For linear scaling with rotary motor, parameterizing the feed constant per slave axis revolution (S-0-0123)

**Selecting and Acknowledging Active Cam Shaft**

- Parameterizing the load gear of the slave axis (S-0-0121 and S-0-0122); if available
- Determining the synchronization velocity (P-0-0143) and the synchronization acceleration (P-0-0142)

Select and acknowledge the active cam shaft profile:

- The active cam shaft profile (P-0-0072, P-0-0092, P-0-0780 to P-0-0785) is selected with parameters "P-0-0088, Control word synchronization modes" and "P-0-0094, Cam switch angle".
- The active cam shaft is included in "P-0-0089, Status word synchronization modes". Switching of the cam shaft is started by changing the control word. It is carried out by the drive and acknowledged in the status word, when the master axis position exceeds the angle set in "P-0-0094, Cam switch angle".



For constantly fault-free processing of the position data with infinitely turning axes, the values resulting from gear reduction (P-0-0086, bit 4 = 1) must be used for forward motion. A finite cam shaft profile can be superimposed. When using an infinite cam shaft profile (difference between first and last profile value > 50%), a small error can occur with each profile sequence. Exception: Cam shaft distance corresponds to modulo value (S-0-0103).



When cam shafts are used with a difference between the profile values of two cam shaft elements > 50%, the "linear cam shaft interpolation" must be activated (P-0-0086, bit 7 = 1). An exception is a difference of > 50% between the first and the last profile value of one cam shaft.

**Parameterizing the Cam Distance**

Parameterize the cam shaft distance:

- "P-0-0144, Cam distance switch angle" defines at which profile access angle and thus profile element a change in value becomes effective for "P-0-0093, Cam distance". If the profile values in the switch range = 0, an absolute position reference is maintained in the case of a change.
- In "P-0-0086, Configuration word synchronous operation modes", select with bits 0 and 1 whether new values for cam distance (P-0-0093) and for the electronic gear (P-0-0156/P-0-0157) take effect immediately or only when the cam distance switch angle is passed or when the cam table is switched.

In bit 6 you can determine which reference is to be valid for delayed acceptance of changes (cam shaft distance switch angle or cam shaft profile switching).



See also Parameter Description "P-0-0086, Configuration word synchronous operation modes"

**Parameterizing Angle Offset**

To avoid great position jumps when changing the profile access angle, a new value for "P-0-0061, Angle offset begin of table" does not immediately become effective. Starting with the current value, a ramp-like approximation to the new value is carried out. The approximation is carried out over the shortest possible distance. The gradient of the ramp is set in "P-0-0158, Angle offset change rate".

Approximation to a new value always takes place over the shortest distance.

## Operation Modes



With "P-0-0158, Angle offset change rate" equal zero, the angle offset is carried out in one step (immediately effective).

Process loops can additionally write data to "P-0-0695, Angle offset begin of profile, process loop". After the electronic gear, the master axis position is reduced via a 1st order filter by the angle determined in parameter P-0-0695. The filter time constant is determined in "P-0-0696, Filter time constant, angle offset profile, process loop".

**Dynamic Angle Offset**

"P-0-0085, Dynamic angle offset" can be used for compensating a lag error in operation with lag distance, if the mechanical system does not allow lagless operation.

With dynamic angle offset, the profile access angle is offset depending on the velocity so that the internal master axis position can be calculated according to the formula below:

$$\varphi_{\text{effective internal master axis pos.}} = \varphi_{\text{internal master axis pos.}} + \frac{v_{\text{internal master axis velocity}}}{Kv\text{-factor}} \times \text{dynam. angle offset}$$

Internal After electronic gear (P-0-0156/P-0-0157) and fine adjustment (P-0-0083)

Fig. 7-111: Effective Internal Master Axis Position Taking the Dynamic Angle Offset Into Account



The master axis velocity used is generated on the timebase  $T_A = \text{communication cycle time}$  so that a moving average filter results with  $T_A = N \times T_{\text{position}}$ .

**Clocked Pull Roll**

For the special case "clocked pull roll", it is possible, with bit 2 = 1 of parameter "P-0-0086, Configuration word synchronous operation modes", to change between "P-0-0093, Cam distance" and "P-0-0073, Cam distance 2", depending on the gradient of the cam shaft.

Positive gradient means that "P-0-0093, Cam distance" is active, negative gradient means that "P-0-0073, Cam distance 2" is active.

**Cross Cutter Function**

By means of the command values of "P-0-0755, Gear reduction", a cross cutter axis can be operated. A cross cutter (rotating knife) is used to cut a defined piece (format) off some material that is transported at constant velocity. The format is set by the electronic gear. With an electronic gear 1:1, the format corresponds to the circumference of the cutting cylinder (with number of knives = 1). Smaller formats are realized by an electronic gear [(output/input) > 1]. The slave axis (cutting cylinder) then turns faster than the master axis. In this case, the cutting cylinder, in the cutting range, has to be decelerated to the transport velocity of the material. After the cutting range, the cylinder is accelerated again. This is achieved by superimposing a more or less sinusoidal cam shaft to the constant speed of the axis that is caused by the linear component of the gear reduction. With constant cam table, it is then possible to define, by means of the distance, whether the axis decelerates (distance > 0) or accelerates (distance < 0) within the cutting range.

- The number of knives that are distributed at the circumference of the cutting cylinder is entered in "P-0-0755, Gear reduction". Per cam shaft profile sequence, the cutting cylinder will move by the distance of two knives at the circumference.
- To change the format "on the fly", it is necessary to simultaneously change electronic gear and cam shaft distance in the cutting range. This function is switched on by setting bit 1 in "P-0-0086, Configuration word synchronous operation modes". A change in the electronic gear will only



take effect, when the new value, after having changed the distance, is accepted when passing the angle of "P-0-0144, Cam distance switch angle".

### "Modulo" Parameterization

For "modulo" parameterization, make the following settings:

#### 1. Modulo Range

In "S-0-0103, Modulo value", set the modulo range to that value at which the overflow of the position data (from modulo value to "0") is to take place with infinitely turning axis.

#### 2. Maximum Travel Range

Select the maximum travel range (S-0-0278) at least as large as the actual value cycle. Set the actual value cycle greater than or equal to the modulo range (S-0-0103).

#### 3. Master Axis Position Range/ Master Axis Cycle

Depending on "P-0-0750, Master axis revolutions per master axis cycle" the range of values for the master axis can be between 0 and  $2047 \times 2^{P-0-0084}$  increments. In the special case  $P-0-0750 = 0$ , the master axis range is from  $-(2^{31})$  to  $(2^{31})-1$ .

#### 4. "Modulo" Master Axis

The "modulo" master axis is a master axis the master axis positions of which are within the master axis cycle determined by "P-0-0750, Master axis revolutions per master axis cycle". The master axis positions may overflow or underflow (infinitely turning master axis).

#### 5. Electronic Gear

Settings for the electronic gear are made in the following parameters:

- P-0-0083, Gear ratio fine adjustment
- P-0-0694, Gear ratio fine adjustment, process loop
- P-0-0108, Master drive polarity
- P-0-0156, Master drive gear input revolutions
- P-0-0157, Master drive gear output revolutions

#### 6. "Modulo" Synchronization

The following settings have to be made for synchronization:

- Mode for reaction to changes in S-0-0048 after first synchronization (P-0-0155, bit 0)
- Relative or absolute synchronization (P-0-0155, bit 1)
- Single-step or double-step synchronization (P-0-0155, bit 6)
- Synchronization range (P-0-0155, bits 2 and 3)
- Generation of actual value cycle (P-0-0155, bit 4)



The actual value cycle has to be an integral multiple of the synchronization range.

---

### "Absolute" Parameterization

For "absolute" parameterization, make the following settings:

## Operation Modes

## 1. Maximum Travel Range

In the case of absolute scaling, the maximum travel range in S-0-0278 has to be selected at least as large as the range in which the synchronous position data are to be contained.

2. Master Axis Position Range/  
Master Axis Cycle

Depending on "P-0-0750, Master axis revolutions per master axis cycle" the range of values for the master axis can be between 0 and  $2047 \times 2^{P-0-0084}$  increments. In the special case  $P-0-0750 = 0$ , the master axis range is from  $-(2^{31})$  to  $(2^{31})-1$ .

## 3. "Absolute" or "Modulo" Master Axis

The "absolute" master axis is a master axis the master axis positions of which are within the master axis cycle determined by "P-0-0750, Master axis revolutions per master axis cycle". The master axis positions in this case do neither overflow nor underflow.

This possibility is not used for practical application. Theoretically, the absolute master axis could be used for infinite cam shafts (e.g. linear cam shafts) and/or when a gear reduction (P-0-0755) unequal zero is selected.

**Note:** When a gear reduction (bit 4, P-0-0086 = 1) has been parameterized, the modulo overflow of the master axis mustn't take place with absolute position scaling! Otherwise, this would cause unwanted jumps in position.

The "modulo" master axis is a master axis the master axis positions of which are within the master axis cycle determined by "P-0-0750, Master axis revolutions per master axis cycle". The master axis positions may overflow or underflow (infinitely turning master axis).

This master axis is used in conjunction with a finite cam shaft (initial value = final value) and when there is no gear reduction (bit 4, P-0-0086 = 0). If you select a gear reduction, the drive, with infinitely turning master axis, will leave the maximum travel range at some time.

**Note:** Incorrect parameterization can cause unwanted jumps in position. It is recommended that you activate the position limit value monitor (see "Position Limitation/Travel Range Limit Switch")!

## 4. Slave Drive Feed Travel

The distance that the slave axis covers per master axis revolution is determined in "P-0-0159, Slave drive feed travel".

## 5. Electronic Gear

Settings for the electronic gear are made in the following parameters:

- P-0-0083, Gear ratio fine adjustment
- P-0-0694, Gear ratio fine adjustment, process loop
- P-0-0108, Master drive polarity
- P-0-0156, Master drive gear input revolutions
- P-0-0157, Master drive gear output revolutions

## 6. "Absolute" Synchronization

The following settings have to be made for synchronization:

- Mode for reaction to changes in parameters S-0-0048 and P-0-0691 after first synchronization (P-0-0155, bit 0)
- Single-step or double-step synchronization (P-0-0155, bit 6)

- Relative or absolute synchronization (P-0-0155, bit 1)

### Commissioning Summary

The figure below illustrates the basic sequence of commissioning.

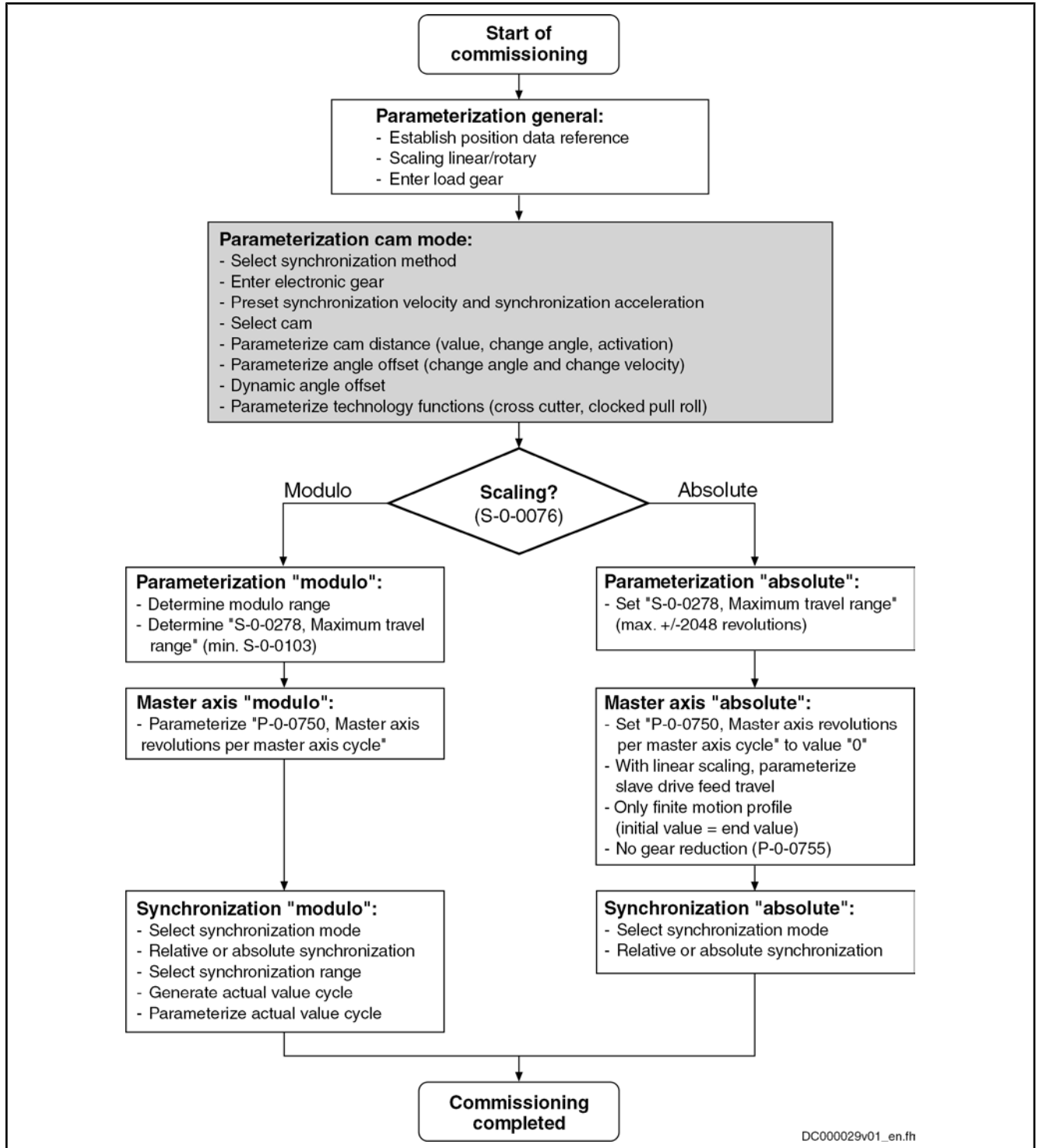


Fig.7-112: Overview of Commissioning Steps for Cam Shaft Mode

## Operation Modes

**Diagnostic and Status Messages**

**Diagnostic Status Messages** The following diagnostic status messages are displayed in normal operation of the operation mode (drive enabled, "AF"):

- A0128 cam shaft, Cam, encoder 1, virtual master axis
- A0129 Cam, encoder 2, virtual master axis
- A0130 Cam, encoder 1, real master axis
- A0131 Cam, encoder 2, real master axis
- A0132 Cam, lagless, encoder 1, virt. master axis
- A0133 Cam, lagless, encoder 2, virt. master axis
- A0134 Cam, lagless, encoder 1, real master axis
- A0135 Cam, lagless, encoder 2, real master axis
- A0163 Position synchronization

**Error Messages and Warnings** Different drive errors can occur in operation that cause error messages or warnings to be generated. The error messages listed below are only the messages specific to operation mode:

- F2005 Cam table invalid  
→ This message is generated when there is, with the drive having been enabled, an access to a cam shaft profile (P-0-0072, P-0-0092, P-0-0780, P-0-0781) that has not been written with 8, 16, 32, 64, 128, 512 or 1024 valid values.

**Status Bits** There are also several status messages specific to operation mode generated in the drive that are mapped to specific status bits (see also "P-0-0089, Status word for synchronous operation modes Status word synchronization modes").

**Position Loop Status** The status display via the control encoder for legless operation or operation with lag error takes place in "S-0-0521, Status word of position loop".

**7.8.5 MotionProfile With Real/Virtual Master Axis****Brief Description**

Assignment to functional firmware package, see chapter "Supported Operation Modes".

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In the operation mode "MotionProfile with real/virtual master axis", there is a fixed relationship between the master axis position and the slave axis.

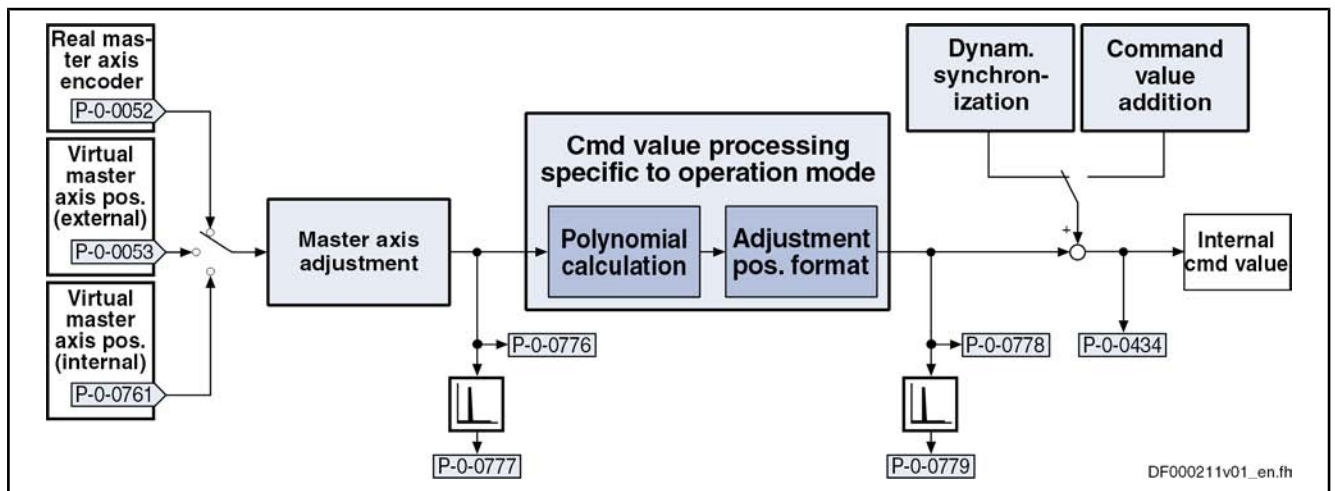
The real master axis velocity is generated by a measuring encoder, the virtual master axis velocity is preset by the master or the integrated master axis generator.

See also "Dynamic Synchronization of the Slave Axis" in section "Basic Functions of the Synchronization Modes"

- Features**
- 2 sequences of motion with up to 8 motion steps per master axis revolution
  - Definition of a motion step by standardized profile or cam shaft profile
  - Motion laws can be selected (rest in rest, rest in velocity, velocity in rest, velocity in velocity, constant velocity)
  - Motion laws realized by 5th order polynomial or, in the case of rest in rest, alternatively by inclined sine curve
  - Individual distance for each motion step
  - Dynamic angle offset and angle offset at begin of profile

- Absolute synchronization can be switched off
- Synchronization mode to be selected
- Absolute or relative processing of the motion steps to be selected
- Synchronization range to be selected
- Cross cutter function

The figure below illustrates the interaction of the individual subfunctions (function blocks) of the "MotionProfile" mode:



- P-0-0052 Actual position value of measuring encoder
- P-0-0053 Master axis position
- P-0-0434 Position command value of controller
- P-0-0761 Master axis position for slave axis
- P-0-0776 Effective master axis position
- P-0-0777 Effective master axis velocity
- P-0-0778 Synchronous position command value
- P-0-0779 Synchronous velocity

Fig.7-113: Function Blocks of Operation Mode "MotionProfile"

**Variants of the Operation Mode**

There are the following variants of the operation mode to be selected:

- Position synchronization
- Motion Profile synchronization with real master axis, encoder 1
- Motion Profile synchronization with real master axis, encoder 2
- MotionProfile with real master axis, encoder 1, lagless
- MotionProfile with real master axis, encoder 2, lagless
- MotionProfile with virtual master axis, encoder 1
- MotionProfile with virtual master axis, encoder 2
- MotionProfile with virtual master axis, encoder 1, lagless
- MotionProfile with virtual master axis, encoder 2, lagless



In the operation mode variant "position synchronization", select MotionProfile and the master axis in "P-0-0088, Control word synchronization modes". The encoder selection and lagless position control are set in "S-0-0520, Control word of axis controller".

**Pertinent Parameters**

In addition to the general parameters of all synchronization modes, there are other parameters involved in this operation mode:

- S-0-0103, Modulo value

## Operation Modes

- S-0-0520, Control word of axis controller
- S-0-0521, Status word of position loop
- P-0-0061, Angle offset begin of table
- P-0-0085, Dynamic angle offset
- P-0-0086, Configuration word synchronous operation modes
- P-0-0088, Control word synchronization modes
- P-0-0089, Status word synchronization modes
- P-0-0158, Angle offset change rate
- P-0-0159, Slave drive feed travel
- P-0-0227, Cam table, access angle
- P-0-0695, Angle offset begin of profile, process loop
- P-0-0696, Filter time constant, angle offset profile, process loop
- P-0-0700, MotionProfile, master axis switching position
- P-0-0701, Motion step 1, slave axis initial position
- P-0-0702, MotionProfile, diagnosis, set 0
- P-0-0703, Number of motion steps, set 0
- P-0-0704, Master axis velocity, set 0
- P-0-0705, List of master axis initial positions, set 0
- P-0-0706, List of motion laws, set 0
- P-0-0707, List of distances, set 0
- P-0-0708, List of slave axis velocities, set 0
- P-0-0709, MotionProfile, diagnosis, set 1
- P-0-0710, Number of motion steps, set 1
- P-0-0711, Master axis velocity, set 1
- P-0-0712, List of master axis initial positions, set 1
- P-0-0713, List of motion laws, set 1
- P-0-0714, List of distances, set 1
- P-0-0715, List of slave axis velocities, set 1
- P-0-0755, Gear reduction
- P-0-0776, Effective master axis position
- P-0-0777, Effective master axis velocity
- P-0-0778, Synchronous position command value
- P-0-0779, Synchronous velocity

See also "Pertinent Parameters" in the subsections of "Basic Functions of the Synchronization Modes"

### Pertinent Diagnostic Messages

In addition to the general diagnostic messages of all synchronization modes, there are other diagnostic messages involved in this operation mode:

- A0136 MotionProfile, encoder 1, virtual master axis
- A0137 MotionProfile, encoder 2, virtual master axis
- A0138 MotionProfile, encoder 2, real master axis
- A0139 MotionProfile, encoder 1, real master axis
- A0140 MotionProfile lagless, encoder 1, virtual master axis
- A0141 MotionProfile lagless, encoder 2, virtual master axis

- A0142 MotionProfile lagless, encoder 1, real master axis
- A0143 MotionProfile lagless, encoder 2, real master axis
- A0163 Position synchronization
- F2003 Motion step skipped
- F2004 Error in MotionProfile

See also "Pertinent Diagnostic Messages" in the subsections of "Basic Functions of the Synchronization Modes"

Operation Modes

Overview of the Operation Mode

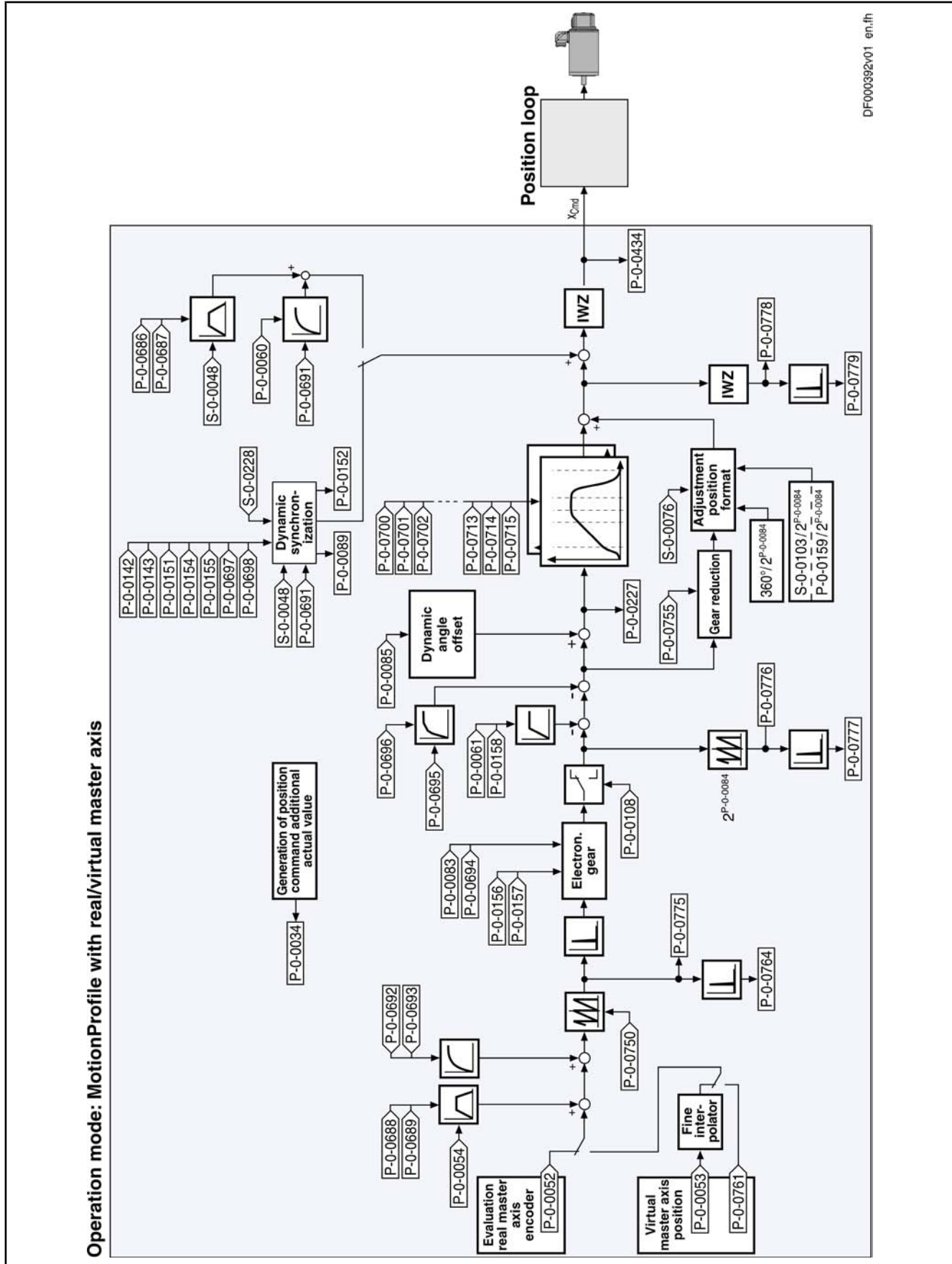


Fig. 7-114: Block Diagram: MotionProfile With Real/Virtual Master Axis



## Master Axis Adjustment

Master axis adjustment is realized by means of the following subfunctions:

- Generation of master axis
- Master axis offset and modulo limitation
- Electronic gear with fine adjustment

See "Basic Functions of the Synchronization Modes"

## Command Value Adjustment

**Overview** Command value adjustment in the "MotionProfile" mode consists of the following basic functions:

- Master axis adjustment
- Command value processing specific to operation mode, consisting of
  - Cam shaft profiles (incl. access)
  - Adjustment of position format
- Command value adjustment slave axis, consisting of
  - Dynamic synchronization
  - Command value addition



In the following only the function block "command value processing" specific to operation mode for the MotionProfile will be described in detail. The detailed descriptions of the other function blocks are contained in section "Basic Functions of the Synchronization Modes".

See "Basic Functions of the Synchronization Modes"

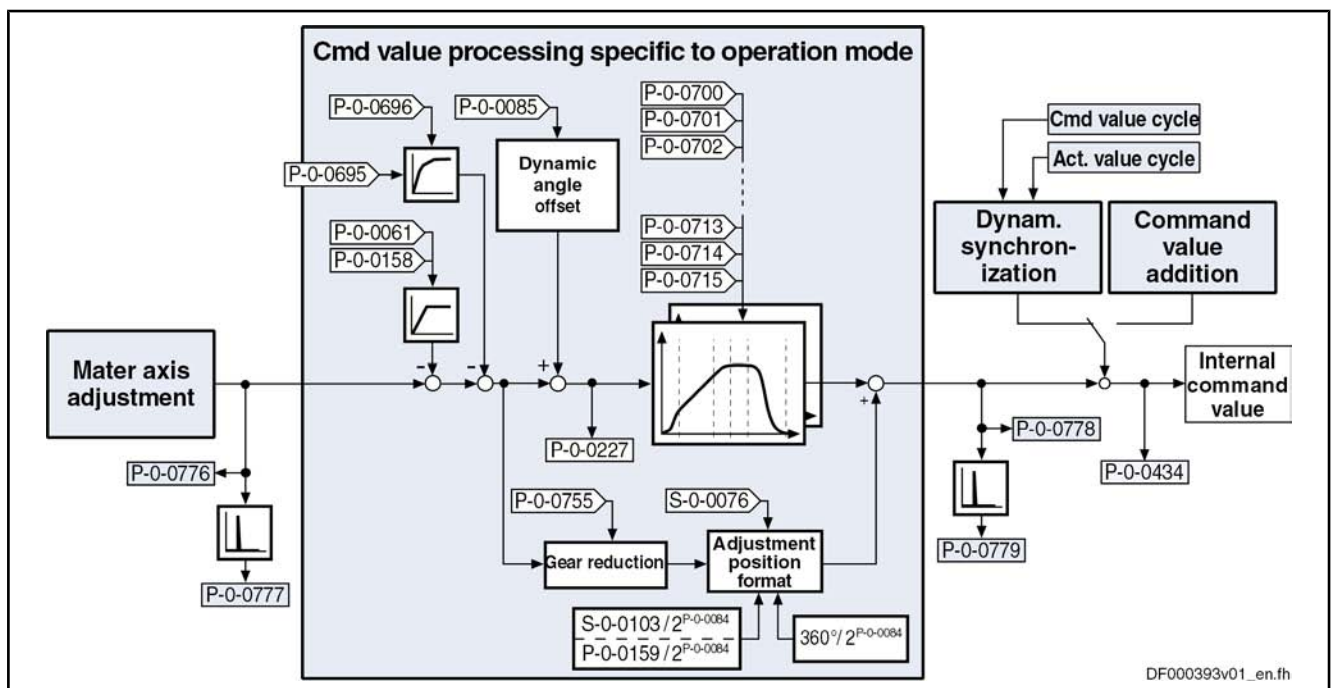


Fig.7-115: Command Value Processing Specific to Operation Mode with MotionProfile

### Generating the Internal Position Command Value

In the operation mode "MotionProfile with real/virtual master axis", the internal position command value (P-0-0434) is generated by addition of the synchro-

Operation Modes

nous position command value ( $x_{sync}$ ) with the components of the additive position command value (S-0-0048) and the additive position command value of process loop (P-0-0691).

$$P-0-0434 = x_{sync} + x_{add} + x_{add\_PR}$$

- P-0-0434 Position command value of controller
- $x_{sync}$  Synchronous position command value
- $x_{add}$  Filter output of "S-0-0048, Additive position command value"
- $x_{add\_PR}$  Filter output of "P-0-0691, Additive position command value, process loop"

Fig.7-116: *Generating the Internal Position Command Value*

**Note:** In the synchronized status (P-0-0089; bit 8 = 1), the following applies:

$$P-0-0434 = x_{sync} + (S-0-0048) + (P-0-0691)$$

Fig.7-117: *Generating the Internal Position Command Value in the Synchronized Status*

In the function block "command value processing specific to operation mode" the calculations specific to the MotionProfile are carried out for generating the synchronous position command value.

"P-0-0227, Cam table, access angle" is generated first. The current motion step is determined from this value and the master axis initial positions of the individual motion steps. Depending on the motion law of this motion step, the decision is taken as to whether the current step is determined by a cam shaft profile or a standard profile. With the profile access angle, profile access or a polynomial calculation takes place accordingly to calculate the standardization value (factor) for the distance of this step. The standardization value for a cam shaft profile is between +799,999999 % and -799,999999 %, for a standard profile it is between 0 and 1. The multiplication of standardization value and distance of the current step results in a position command value which is added to the final position value of the previous motion step. Depending on the setting in the motion law of this step, the sum is processed in absolute or relative form.

If the phase-synchronous path has been activated by bit 4 of "P-0-0086, Configuration word synchronous operation modes", the master axis position at the output of the electronic gear is additionally divided by the gear reduction (P-0-0755) and multiplied with a scaling-dependent factor. The result is differentiated and added to the position command value.

**Calculating the Internal Position Command Value (Initialization)**

Upon activation of the operation mode "MotionProfile with real/virtual master axis", the position command value of the drive is first initialized in terms of the following relation:

$$x_{F(\varphi_L)} = \left[ x_{\text{start}_n} + H_n \times f_n(\varphi_{ZGW}) + \left( \frac{\varphi_{ZGW}}{U} \right) \times \left( \frac{MW}{2^{20}} \right) + x_V + x_{VPR} \right] \%IWZ$$

$x_F$	Position command value of slave drive (P-0-0434)
$x_{\text{start}_n}$	Slave axis initial position of the current motion step
$H_n$	Distance of the current motion step
$f_n(\varphi_{ZGW})$	Standardized function value of the current motion step from profile access or polynomial calculation
$\varphi_{ZGW}$	Profile access angle
$U$	Gear reduction (P-0-0755)
$MW$	Modulo value
$x_V$	Additive position command value (S-0-0048)
$x_{VPR}$	Additive position command value, process loop (P-0-0691)
$IWZ$	Modulo actual value cycle

Fig.7-118: Initializing the Position Command Value

$$\varphi_{ZGW} = \pm \varphi_L \times \frac{G_a}{G_e} \times (1 + F) \times (1 + F_{PR}) - \varphi_V - \varphi_{VPR}$$

$\varphi_{ZGW}$	Profile access angle
+/-	Master drive polarity (P-0-0108)
$\varphi_L$	Resulting master axis position (P-0-0775)
$G_a$	Master drive gear output revolutions (P-0-0157)
$G_e$	Master drive gear input revolutions (P-0-0156)
$F$	Gear ratio fine adjustment (P-0-0083)
$F_{PR}$	Gear ratio fine adjustment, process loop (P-0-0694)
$\varphi_V$	Angle offset begin of profile (P-0-0061)
$\varphi_{VPR}$	Angle offset begin of profile, process loop (P-0-0695)

Fig.7-119: Determining the Profile Access Angle

The slave axis initial position of the current motion step is supposed to be zero, when relative processing of the position data (bit 10 = 1) has been set in the control word for synchronous operation modes (P-0-0088). Otherwise, the slave axis initial position of the current motion step is the sum of the slave axis initial position (P-0-0701) and the distances up to the current step.

The cyclic calculation of the position command value takes place according to the above formula, too. The slave axis initial position of the respective current step is determined by the end position of the previous step.



With the operation mode activated, differences, that later on will be added again, are processed in the electronic gear. Therefore, changes in the electronic gear do not cause position command value jumps. Velocity jumps, however, can occur and the absolute position reference, established when activating the operation mode, is lost.

## Synchronization

See "Basic Functions of the Synchronization Modes"

## Operation Modes

## Notes on Commissioning and Parameterization

## General Parameterization

**Parameterizing Angle Offset** "P-0-0061, Angle offset begin of table" allows shifting the profile access angle. To avoid great position jumps when changing the profile access angle, a new value for P-0-0061, does not immediately become effective. Starting with the current value, a ramp-like approximation to the new value is carried out. The approximation is carried out over the shortest possible distance. The gradient of the ramp is set in "P-0-0158, Angle offset change rate".



With "P-0-0158, Angle offset change rate" equal zero, the angle offset is carried out in one step (immediately effective).

**Dynamic Angle Offset** "P-0-0085, Dynamic angle offset" can be used for compensating a lag error in operation with lag distance, if the mechanical system does not allow lagless operation.

With dynamic angle offset, the profile access angle is offset depending on the velocity so that the internal master axis position can be calculated according to the formula below:

$$\varphi_{\text{effective internal master axis pos.}} = \varphi_{\text{internal master axis pos.}} + \frac{v_{\text{internal master axis velocity}}}{Kv\text{-factor}} \times \text{dynam. angle offset}$$

Internal After electronic gear (P-0-0156/P-0-0157) and fine adjustment (P-0-0083)

*Fig. 7-120: Effective Internal Master Axis Position Taking the Dynamic Angle Offset Into Account*



The master axis velocity used is generated on the timebase  $T_A = \text{communication cycle time}$  so that a moving average filter results with  $T_A = N \times T_{\text{position}}$ .

**Switching the Electronic Gear** When bit 1 (gear switching) has been set in "P-0-0086, Configuration word synchronous operation modes", any change, with active operation mode, in the electronic gear (P-0-0156 and P-0-0157) will only take effect when a set is switched.

**Gear Reduction (Cross Cutter Function)** By activating the phase-synchronous path (P-0-0086, bit 4 = 1), the master axis position at the output of the electronic gear is additionally divided by the gear reduction (P-0-0755) and multiplied with a scaling-dependent factor. The result is differentiated and added to the position command value.

## Parameterization of MotionProfile

**Number of Motion Steps** In "P-0-0703, Number of motion steps, set 0" and "P-0-0710, Number of motion steps, set 1" first set the number of motion steps of which the sequence of motion consists. A maximum of 8 motion steps can be set per motion profile.

**Absolute or Relative Motion Step** In the control word for synchronous operation modes (P-0-0088, bit 10), set whether the motion is to have absolute or relative position reference. Only with absolute position reference is the value in "P-0-0701, Motion step 1, slave axis initial position" taken into account to establish the position reference of the motion profile during synchronization.



In the case of relative processing, at least 2 motion steps have to be used.

**Master Axis Velocity** Via "P-0-0704, Master axis velocity, set 0" or "P-0-0711, Master axis velocity, set 1" set the master axis velocity required for calculating specific motion steps.




---

Set the master axis velocity after the electronic gear.

---

**Defining a Step**

To specify the individual steps, there are 4 list parameters available for each of the two sets:

- P-0-0705, List of master axis initial positions, set 0
- P-0-0706, List of motion laws, set 0
- P-0-0707, List of distances, set 0
- P-0-0708, List of slave axis velocities, set 0
- P-0-0712, List of master axis initial positions, set 1
- P-0-0713, List of motion laws, set 1
- P-0-0714, List of distances, set 1
- P-0-0715, List of slave axis velocities, set 1

A motion step is limited by a master axis initial position and a master axis end position. The master axis end position is determined by the master axis initial position of the following motion step or by 360 degrees.

The slave axis velocity can be preset in the case of certain standard profiles or is preset by the distance and the profile.




---

The positions of the data in the lists define to which step the values belong. For example, the data at the second position of the lists for master axis initial position, mode, distance and slave axis velocity define the second motion step.

This means that the number of elements defined in the lists as must be at least the number of motion steps.

---

**Standard Profiles**

Different standard profiles or a cam shaft profile can be defined as the motion law of a step.

The following motion laws are available:

- Rest in rest (R-R)
- Rest in velocity (R-G)
- Velocity in rest (G-R)
- Constant velocity (G)
- Velocity in velocity (G-G)
- Cam Shaft Profile

**Rest in Rest**

For the profile "rest in rest", there are three profiles available. These profiles are characterized by the fact that velocity and acceleration are zero at the start and at the end of the motion. You can choose between the standardized motion laws "5th order polynomial" and "inclined sine curve". The third profile "rest in rest with limited velocity" is realized in a 5th order polynomial. For this profile the indication of a maximum velocity of the slave axis is required.

In addition, these profiles are defined by the distance and the master axis range.

The following relation applies to the profile "5th order polynomial":

## Operation Modes

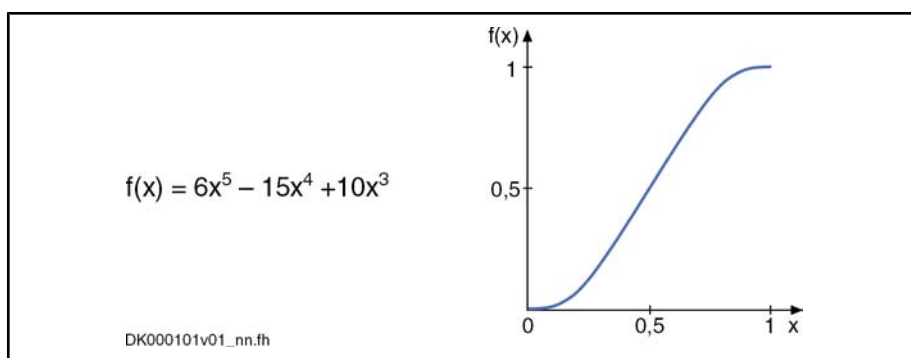


Fig.7-121: Profile "5th Order Polynomial"

The following relation applies to the profile "inclined sine curve":

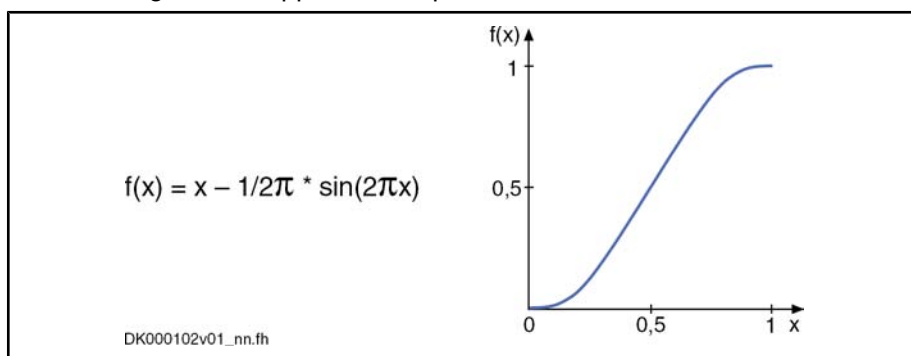


Fig.7-122: Profile "Inclined Sine Curve"



You should prefer the profile with inclined sine curve for mechanical systems susceptible to oscillation, as the jerk curve is better. The occurring maximum values for velocity and acceleration, however, are higher.

For the profile "rest in rest with limited velocity" the maximum occurring slave axis velocity is calculated from the indicated values of master axis velocity, master axis distance and master axis range. If this velocity is lower than the indicated maximum slave axis velocity, the above-mentioned 5th order polynomial is used. The maximum velocity is parameterized in the list of the slave axis velocity. If the maximum slave axis velocity would be exceeded, this step would be divided into three individual steps "rest in velocity", "constant velocity" and "velocity in rest". During the middle range the axis moves with the maximum slave axis velocity.

The following figure illustrates the velocity curves of a simple 5th order polynomial (black) and of the profile "rest in rest with limited velocity" (blue) for identical values of axis distance, master axis range and master axis velocity.

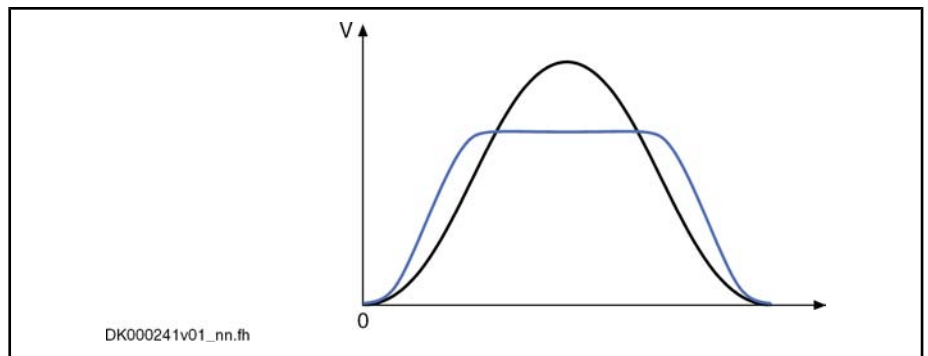


Fig.7-123: Profile "Rest in Rest With Limited Velocity" → Curve of the Slave Axis Velocity

In case it is not possible to divide this step into three individual steps, maybe due to the distance being too large, on examination of this profile, the respective error number (81...88, meaning, please see Description of the Diagnosis F2004) is indicated in the diagnosis parameter of the MotionProfile set in question.

If the profile "rest in rest" is divided into the three steps "rest in velocity", "constant velocity" and "velocity in rest", acceleration values will occur in the first and the last partial range which are significantly higher than for the profile with the simple 5th order polynomial. Monitoring of the acceleration values is not carried out!

#### Rest in Velocity

The profile "rest in velocity" is used for transition from standstill to a certain velocity. The velocity and the acceleration at the beginning of the profile are zero. At the end of the profile, the slave axis velocity preset by the corresponding parameter has been reached. The acceleration at the end of the profile is zero.

The drive calculates the coefficients of this polynomial from the following values preset for this motion step:

- Master axis range
- Distance
- Slave axis velocity
- Master axis velocity

The profile is calculated with a 5th order polynomial:

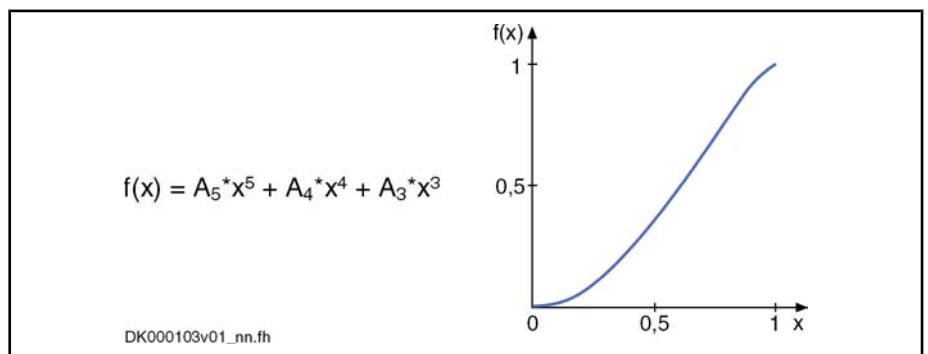


Fig.7-124: Profile "Rest in Velocity"



The function curve contains a reversal point, when the standardized velocity  $v_{\text{standard}}$  is not between the values 1.66 and 2.5.

The standardized velocity can be calculated with the following formula, the master axis range being the difference of two master axis initial positions:

Operation Modes

$$v_{\text{standard}} = \frac{v_{\text{slave axis}} \times \text{master axis range}}{v_{\text{master axis}} \times \text{distance}}$$

Fig.7-125: Calculating the Standardized Velocity



The distance belonging to this motion step mustn't be zero!

**Velocity in Rest**

The profile "velocity in rest" is used for transition from a defined velocity to standstill. The velocity at the beginning of the profile must correspond to the slave axis velocity indicated in the parameter. At the end of the profile the velocity is zero. The acceleration at the beginning and at the end of the profile is zero.

The path traveled with this motion profile is defined by the distance for this motion step.

The drive calculates the coefficients of this polynomial from the following values preset for this motion step:

- Master axis range
- Distance
- Slave axis velocity
- Master axis velocity

The profile is calculated with a 5th order polynomial:

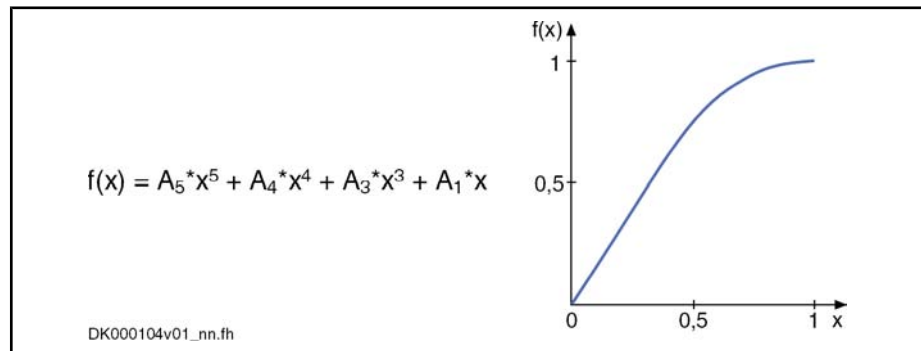


Fig.7-126: Profile "Velocity in Rest"



The function curve contains a reversal point, when the standardized velocity  $v_{\text{standard}}$  is not between the values 1.66 and 2.5.

The standardized velocity can be calculated with the following formula, the master axis range being the difference of two master axis initial positions:

$$v_{\text{standard}} = \frac{v_{\text{slave axis}} \times \text{master axis range}}{v_{\text{master axis}} \times \text{distance}}$$

Fig.7-127: Calculating the Standardized Velocity



The distance belonging to this motion step mustn't be zero!



**Constant Velocity**

The profile "constant velocity" of this motion step is a straight line. The velocity within this step is constant. The path traveled is defined by the distance for this motion step.

The profile results from the following formula (in standardized form):

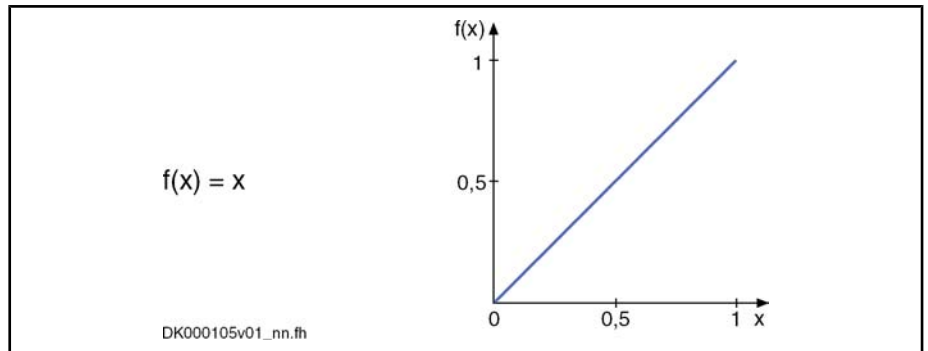


Fig.7-128: Profile "Constant Velocity"

The slave axis velocity is determined from the following values preset for this motion step:

- Master axis range
- Distance
- Master axis velocity

$$v_{\text{slave axis}} = \frac{\text{distance} \times v_{\text{master axis}}}{\text{master axis range}}$$

Fig.7-129: Calculating the Slave Axis Velocity

It is not necessary to enter a value for the slave axis velocity. For the validation check, a value is calculated in the drive according to the above formula. The calculated value can be read from the list parameter for the slave axis velocities.

**Velocity in Velocity  
(2 Velocities)**

The profile "velocity in velocity" is used for transition from one slave axis velocity to a different slave axis velocity. The velocity at the beginning of the profile must correspond to the indicated slave axis velocity. The velocity at the end of the profile is determined by the velocity parameter of the subsequent motion step. The acceleration at the beginning and at the end of the profile is zero.

The profile is calculated with a 5th order polynomial:

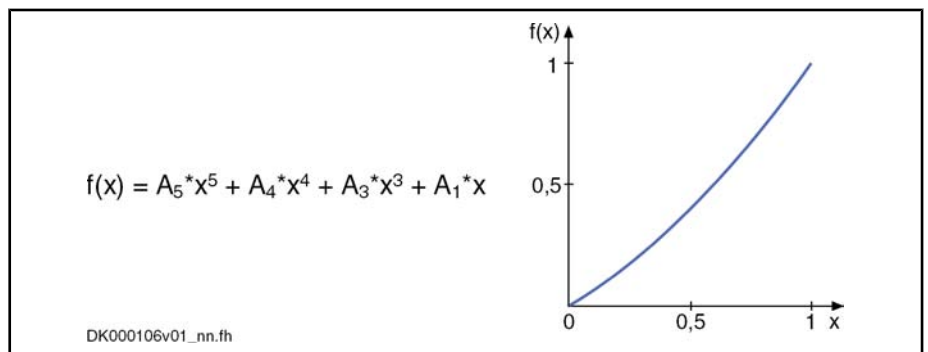


Fig.7-130: Profile "Velocity in Velocity"

The drive calculates the coefficients of this polynomial from the following values preset for this motion step:

- Master axis range

Operation Modes

- Distance
- Master axis velocity
- 2 slave axis velocities



The function curve contains a reversal point, when the pair of values  $v_{\text{standard}0}$  and  $v_{\text{standard}1}$  is not in the range that is defined by the functions  $f_1(x) = (5 - 2x)/3$  and  $f_2(x) = (5 - 3x)/2$ . The range is marked in the figure below.

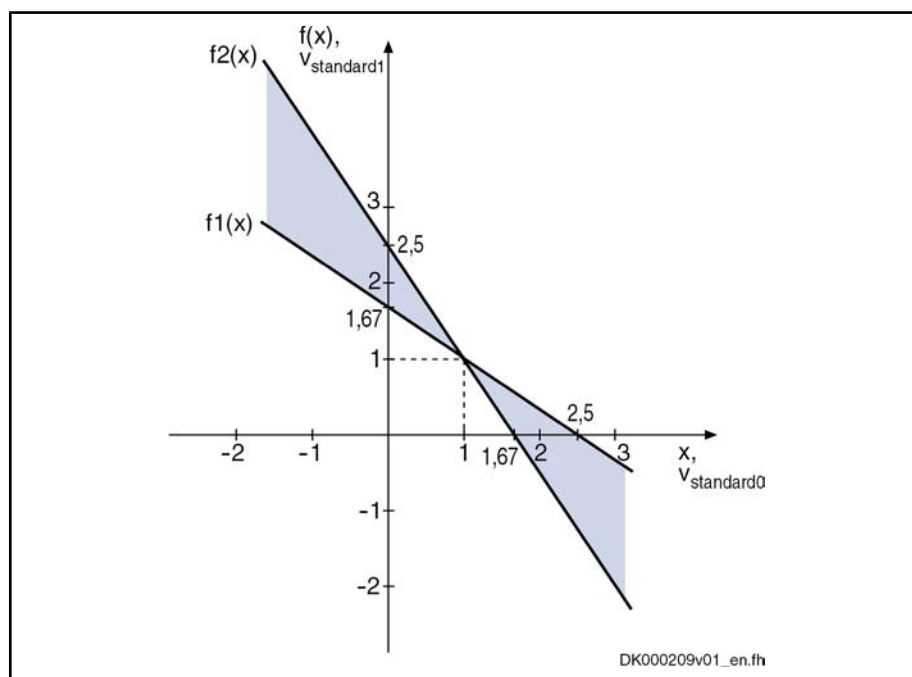


Fig.7-131: Advantageous Range for the Pair of Values  $v_{\text{standard}0}$  and  $v_{\text{standard}1}$

$$v_{\text{standard}0} = \frac{v_{\text{BS}0} \times \text{master axis range}}{v_{\text{master axis}} \times \text{distance}}$$

$$v_{\text{standard}1} = \frac{v_{\text{BS}1} \times \text{master axis range}}{v_{\text{master axis}} \times \text{distance}}$$

$v_{\text{BS}0}$  Slave axis velocity i  
 $v_{\text{BS}1}$  Slave axis velocity i+1  
 Master axis range Difference of two master axis initial positions

Fig.7-132: Calculating the Standardized Velocities  $v_{\text{standard}0}$  and  $v_{\text{standard}1}$



The distance belonging to this motion step mustn't be zero!

**Cam Shaft Profile** When you select a cam shaft profile via "P-0-0706, List of motion laws, set 0" or "P-0-0713, List of motion laws, set 1", the selected cam shaft is used instead of a motion profile.

The value selected from "P-0-0705, List of master axis initial positions, set 0" or "P-0-0712, List of master axis initial positions, set 1" determines as of which master axis position a profile is processed. This master axis initial position determines the position of the 1st profile element, the master axis end position determines the position of the last profile element. The master axis end position is determined by the master axis initial position of the following motion step or by 360 degrees for the last motion step.

The number of data points of a profile is variable. The profile length results from the parameterized actual length.

The data point distance is calculated according to the formula below:

$$\text{Data point distance} = (\text{master axis end position} - \text{master axis initial position}) \times 2^{P-0-0084} / 360 / (n-1)$$

P-0-0084 Number of bits per master axis revolution

n Number of profile elements

*Fig. 7-133: Calculating the Data Point Distance (in Increments)*

The profile values can be between  $-799,999999\%$  and  $+799,999999\%$ .

The first profile value has to be zero. The value of the last profile element is arbitrary.

For one profile sequence the traveled path results from the product of the distance and the last profile element.

Cubic spline interpolation is carried out between the data points.



The format of the cam in the MotionProfile must be the "new" cam format for which the last profile value corresponds to the value at 360 degrees (corresponding bit in P-0-0086, bit 8...15 = 1).

See also operation mode "Electronic Cam With Real/Virtual Master Axis"

**Changing the MotionProfile** A change in the data of a motion step normally requires changes in other motion steps. An individual change therefore mustn't be immediately applied. When the operation mode is active, position command value jumps might occur.

When the master axis velocity is changed, it is also necessary, for motion steps with contained velocity, to recalculate the polynomial coefficients.

To allow changes while the operation mode is active, there are two sets with a maximum of 8 motion steps. The use of the second data set is selected by bit 9 of "P-0-0088, Control word synchronization modes".

In the control word, make the setting to determine which one of the two sets is to be active. For switching, you have to change bit 9; switching takes place when the position set in parameter "P-0-0700, MotionProfile, master axis switching position" is passed.

The active set is displayed in bit 3 of "P-0-0089, Status word synchronization modes".



In case a profile is processed in relative form, the switch angle must comply with the master axis initial position of a motion step.

**Checking the MotionProfile** To check a MotionProfile you can query information on both sets from the status word (P-0-0089). After a set has been changed, the complete set is checked. The check was carried out when the bit "profile check carried out" has been set

## Operation Modes

for the selected set. The status word also shows whether the check was successful.

When switching to a set, for which the profile check has not been carried out successfully, takes place with active operation mode, the message "F2004 Error in MotionProfile" (class 1 diagnostics error) is generated. This error message is also generated when the active set, with active operation mode, is changed in such a way that the profile check is unsuccessful.

There are the following validation checks for the sequence of motion:

- The master axis initial positions of the motion steps used must increase and be smaller than 360 degrees.
- Motion law "constant velocity"  
→ The motion profile is defined by master axis range and distance. The velocity is calculated and possibly compared to preset velocities of previous and following step.
- Motion law "rest in velocity"  
→ The following step mustn't start with a rest position. If the following motion step is "velocity in rest", "constant velocity" or "velocity in velocity", the velocity values have to match. The distance must not be zero.
- Motion law "velocity in rest"  
→ The previous step must not end with a rest position. If the previous motion step is "rest in velocity" or "constant velocity", the velocity values have to match. The distance must not be zero.
- Motion law "velocity in velocity"  
→ The previous step must not end with a rest position. If the previous motion step is "rest in velocity" or "constant velocity", the velocity values have to match. The distance must not be zero.
- The first value of a cam shaft profile must be zero.
- In the case of absolute position scaling and absolute MotionProfile, the sum of travel distances must be zero. The travel distances are to be taken from the distance values or, for a motion step with profile, from the product of final profile value and distance.
- In the case of modulo position scaling and absolute MotionProfile, the sum of travel distances must be zero or a multiple of the modulo value (S-0-0103). The travel distances of the individual steps are determined like in the case of absolute position scaling.

The profile is checked after every change. When the bit "profile check carried out" has been set for a set and the bit "without error" has not been set, an extended diagnosis can be read in the respective diagnosis parameter (P-0-0702 or P-0-0709).



When switching between relative and absolute processing of the motion step takes place (P-0-0088, bit 10), there is no profile check carried out.

This can cause problems when switching from relative to absolute processing takes place after the definition of the motion step.

---

**Example of a Motion Profile**

The figure below illustrates a sequence of motion consisting of 5 steps.

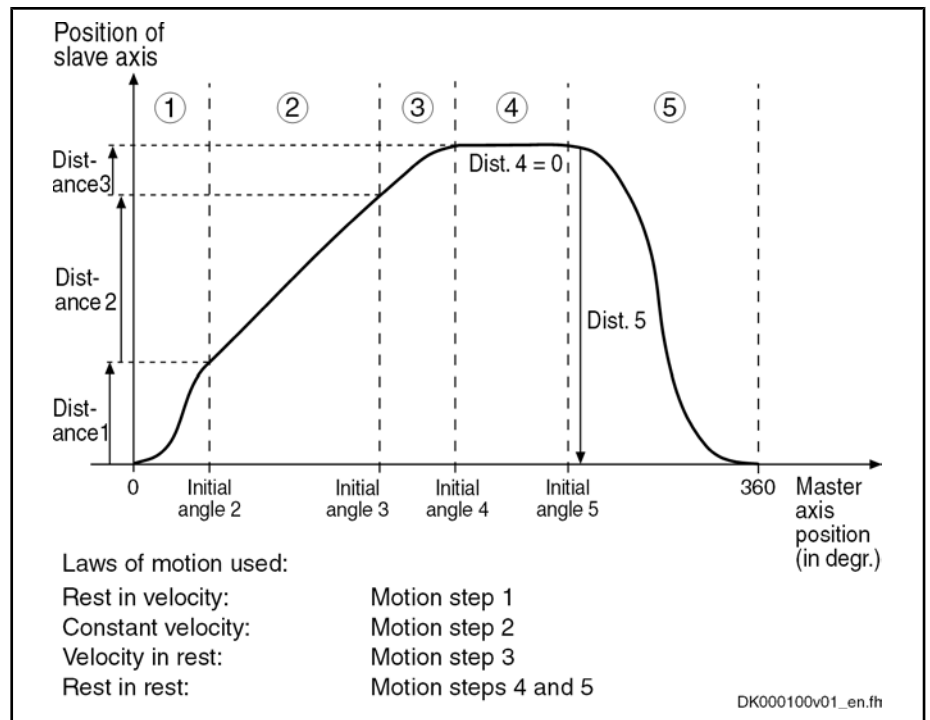


Fig.7-134: Example of a MotionProfile With 5 Motion Steps

### Commissioning Summary

The figure below illustrates the basic sequence of commissioning.

Operation Modes

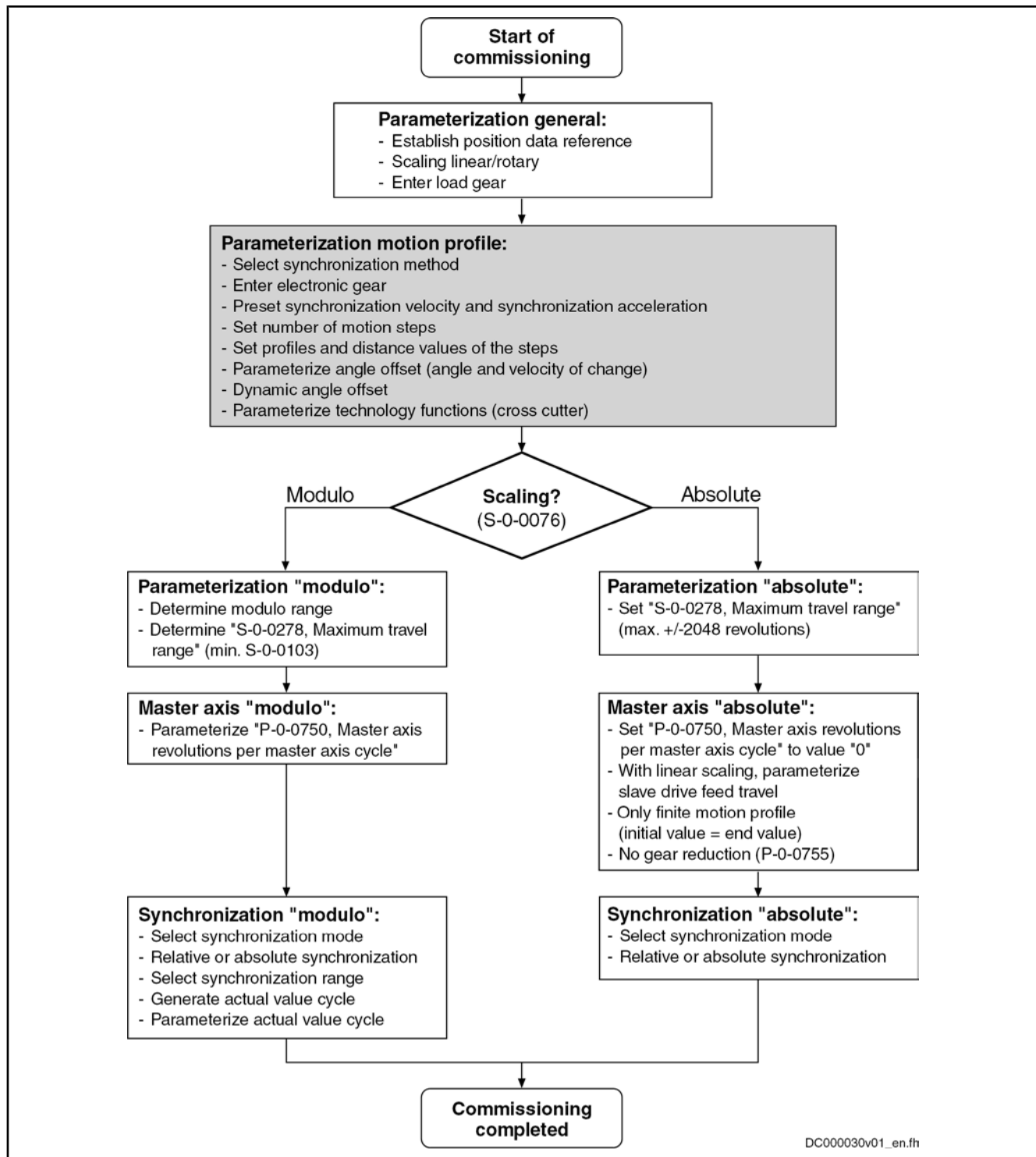


Fig.7-135: Overview of Commissioning Steps for Motion Profile

Diagnostic and Status Messages

Diagnostic Status Messages

The following diagnostic status messages are displayed in normal operation of the operation mode (drive enabled, "AF"):

- A0136 MotionProfile, encoder 1, virtual master axis
- A0137 MotionProfile, encoder 2, virtual master axis

- A0138 MotionProfile, encoder 2, real master axis
- A0139 MotionProfile, encoder 1, real master axis
- A0140 MotionProfile lagless, encoder 1, virtual master axis
- A0141 MotionProfile lagless, encoder 2, virtual master axis
- A0142 MotionProfile lagless, encoder 1, real master axis
- A0143 MotionProfile lagless, encoder 2, real master axis
- A0163 Position synchronization

**Error Messages and Warnings**

Different drive errors can occur in operation that cause error messages or warnings to be generated. The error messages listed below are only the messages specific to operation mode:

- F2003 Motion step skipped
  - This error message is indicated in the event that the master axis velocity is that high that a motion step is skipped during processing of the profile. This is the case when the product from master axis velocity and position loop cycle time (see Parameter Description "P-0-0556, Config word of axis controller") becomes larger than the master axis range of a step.
- F2004 Error in MotionProfile
  - This message is generated, if a profile that has not passed the validation checks is activated with the drive having been enabled.

If a discrepancy is detected during the validation check, its possible cause is encoded by means of an error number (for its significance see description of Diagnostic Message F2004) in one of the following diagnosis parameters:

- P-0-0702, MotionProfile, diagnosis, set 0
- P-0-0709, MotionProfile, diagnosis, set 1

**Status Bits**

There are also several status messages specific to operation mode generated in the drive that are mapped to specific status bits (see also "P-0-0089, Status word synchronization modes").

**Position Loop Status**

The status display via the control encoder for lagless operation or operation with lag error takes place in "S-0-0521, Status word of position loop".





## 8 Extended Axis Functions

### 8.1 Availability of the Extended Axis Functions

The following overview illustrates by which base packages or functional packages the respective extended axis function is supported (if not stated otherwise, this applies to all 3 firmware versions, MPB, MPD, MPH and MPC).

Extended axis function	In base package (characteristic)	In functional package ... (on the basis of a base package with the following characteristics)		
		Servo function	Synchronization	Main spindle
Drive halt	OL/CL	–	–	–
v <sub>cmd</sub> reset ("emergency halt")	OL/CL	–	–	–
v <sub>cmd</sub> reset with ramp ("quick stop")	OL/CL	–	–	–
v <sub>cmd</sub> reset while maintaining a <sub>max</sub>	OL/CL	–	–	–
Torque disable	OL/CL	–	–	–
Return motion	–	CL	–	–
Package reaction on error	OL/CL	–	–	–
NC reaction on error	OL/CL	–	–	–
MLD reaction on error	OL/CL <sup>2)</sup>	–	–	–
E-Stop function	OL/CL	–	–	–
Friction torque compensation	CL	–	–	–
Encoder error correction	CL	–	–	–
Backlash on reversal correction	CL	–	–	–
Precision axis error correction	–	CL <sup>1)</sup>	–	–
Control-side axis error correction	–	CL <sup>1)</sup>	–	–
Temperature error correction	–	CL	–	–
Quadrant error correction	–	CL	–	–
Cogging torque compensation	–	CL <sup>1)</sup>	CL <sup>1)</sup>	–
Measuring wheel mode	–	–	CL	–
Positive stop drive procedure	OL/CL	–	–	–
Redundant motor encoder	CL	–	–	–
Spindle positioning	–	–	–	CL
Parameter set switching	–	CL <sup>2)3)</sup>	OL/CL <sup>2)3)</sup>	OL/CL <sup>2)</sup>
Drive-controlled oscillation	–	–	–	OL/CL <sup>2)</sup>

## Extended Axis Functions

Extended axis function	In base package (characteristic)	In functional package ... (on the basis of a base package with the following characteristics)		
		Servo function	Synchronization	Main spindle
Parking axis	OL/CL	–	–	–
Integrated safety technology	Only available with the corresponding hardware configuration			

- OL            Open-loop characteristic  
 CL            Closed-loop characteristic  
 1)            Not for the firmware version MPB  
 2)            Not for the firmware version MPD  
 3)            For parameter group control loop and application only

*Fig. 8-1: Availability of the Extended Axis Functions*

To use a functional package, it must have been activated (enabled). The currently enabled functional packages are displayed in "P-0-2004, Active functional packages".

See also "Enabling of Functional Packages"

## 8.2 Drive Halt

### 8.2.1 Brief Description



Assignment to functional firmware package, see chapter "Availability of the Extended Axis Functions".

The "Drive Halt" function is used to shut down an axis with defined acceleration and defined jerk.

In the case of default Drive Halt is carried out as quick stop in position control or velocity control. The control mode position is activated if one of the operation modes (S-0-0032 ...) is defined with position control (incl. internal PLC operation modes). Otherwise the control mode velocity is active.

The configuration Drive Halt (P-0-0558, Bit 1,2) allows free selection of the control mode.

- Bit 1,2 = 1,1 position control
- Bit 1,2 = 1,0 velocity control

The configuration "Drive Halt" (P-0-0558, bit 0 = 1) allows switching to the function "operational stop". The operation modes "velocity control", "drive-internal interpolation", "drive-controlled positioning" and "positioning block" are then stopped internally with V-command = 0. After removing "Drive Halt" the motion becomes active again.

The adjustable deceleration of position command value in position clocks (P-0-0456) is limited to a maximum of 32 clocks.



Apart from the "Drive Halt" function there is an operational stop for the operation modes "drive-controlled positioning" and "drive-internal interpolation". However, this function has its own control signal.

- Features**
- Activated via "halt bit" of master communication (see "Device Control and State Machines")
  - Active operation mode interrupted; drive remains in control (after setting the "halt bit" the interrupted operation mode is continued)

- **Quick Stop in Position Control**  
→ Shutdown with acceleration (S-0-0372) and jerk limit values (S-0-0349) in position control.
  - **Quick Stop in Velocity Control**  
→ Shutdown with acceleration (S-0-0372) and jerk limit values (S-0-0349) in velocity control.
  - Acknowledge "Drive Halt" in P-0-0115
- Pertinent Parameters**
- S-0-0124, Standstill window
  - S-0-0349, Bipolar jerk limit
  - S-0-0372, Drive Halt acceleration bipolar
  - P-0-0115, Device control: status word
  - P-0-0434, Position command value of controller
  - P-0-0456, Position command value delay
  - P-0-0457, Position command value generator
  - P-0-0558, Drive Halt configuration

## 8.2.2 Functional Description

When the "Drive Halt" function is activated, the drive no longer follows the command values of the active operation mode, but automatically shuts down while maintaining a parameterized acceleration.

### Activating the "Drive Halt" Function

The "Drive Halt" function is activated by:

- Disabling the Drive Halt bit in control word of master communication (e.g. with SERCOS, bit 13 in "S-0-0134, Master control word"; see "Device Control and State Machines")
- interrupting a drive control command (e.g. "Drive-controlled homing procedure")

### Going Back to the Operation Mode Active Before

The operation mode active before and still selected becomes active again, when the drive halt bit is set again in the control word of the master communication.

The kind of shutdown, in the case of "Drive Halt" depends on the initialization of the operation modes, but can also be determined via the configuration Drive Halt.

### Quick Stop in Position Control

In position control shutdown is carried out using the the deceleration in "S-0-0372, Drive Halt acceleration bipolar" and the jerk in "S-0-0349, Bipolar jerk limit"

If Drive Halt is started from an operation mode with deceleration of position command value, the deceleration is also activated for Drive Halt.

The position command value can be delayed by maximum 32 position clocks after the fine interpolator, before it is fed in the position controller. This allows synchronous control of a master axis with the controlled slave axis. The number of position clocks is set with the position command value delay (P-0-0456). The position command value generator without delay (P-0-0457) is entered in a ring buffer and then the position command value with delay is applied in the position command value controller (P-0-0434).

Extended Axis Functions



Position-controlled shutdown is carried out with position control with lag error, if an operation mode that also contained position control with lag error was active before. If not, the function is carried out with lagless position control.

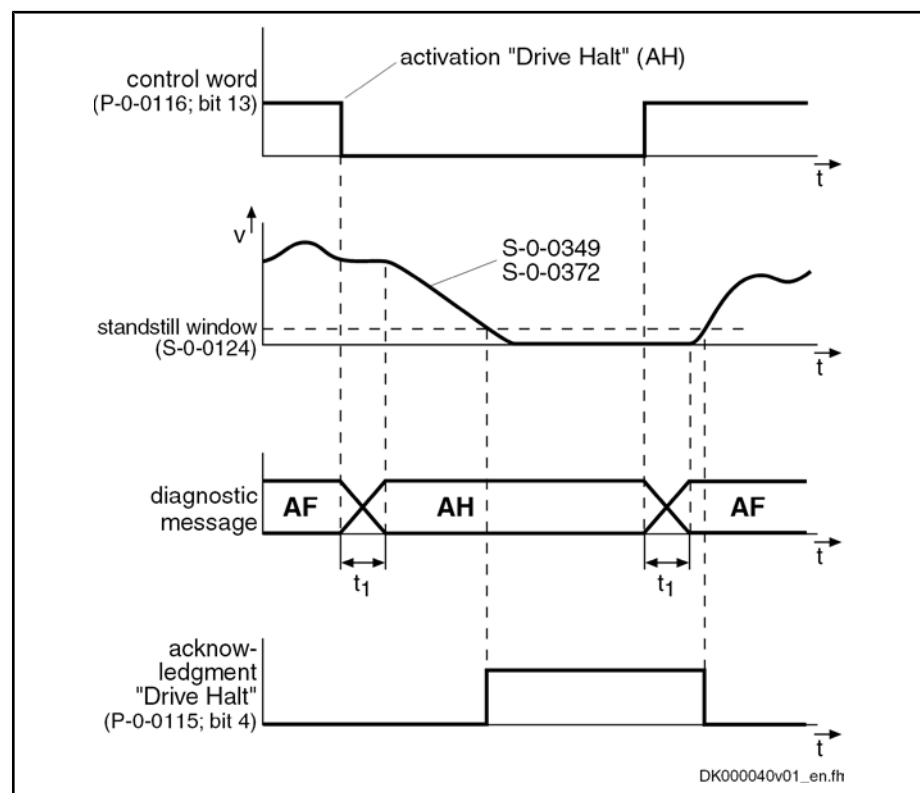
If the value in parameter "S-0-0372, Drive Halt acceleration bipolar" equals "0", the axis does not stop.

**Quick Stop in Velocity Control**

If control mode velocity is set, the shutdown in velocity control is made using the value in parameter "S-0-0372, Drive Halt acceleration bipolar" and the jerk in "S-0-0349, Bipolar jerk limit"



If the content of "S-0-0372, Drive Halt acceleration bipolar" equals "0", deceleration is carried out at the current limit.



S-0-0349 Jerk limit bipolar  
 S-0-0372 Drive Halt acceleration bipolar  
 Fig.8-2: Principle "Drive Halt" for Quick Stop

**Operational Stop**

The function "Drive Halt" as operational stop is activated by disabling the Drive Halt bit in the control word of the master communication (e.g. for SERCOS bit 13 in "S-0-0134, Master control word")

If operation stop is selected in the configuration Drive Halt "P-0-0558, Bit 0 = 1", the active operation mode is maintained. It is shut down with command velocity = 0. For shutdown the parameters of the active operation mode are used. After disabling Drive Halt the operation mode and, if applicable, the axis motion continue to be active.

**8.2.3 Notes on Commissioning**

**Diagnostic and Status Messages**

The activated "Drive Halt" function is displayed as described below:

- "AH" appearing on the control panel display at the front of the device
- Enter "A0010" in parameter "S-0-0390, Diagnostic message number"
- Enter "A0010 Drive HALT" in parameter "S-0-0095, Diagnostic message"
- In the bit "Status of command value processing" in the status word of the master communication (e.g. for SERCOS: Bit 3 = 0 in "S-0-0135, Drive status word")

**Acknowledgment of "Drive Halt"** An acknowledgment is carried out when the actual velocity falls below the threshold defined in "S-0-0124, Standstill window". Bit 4 (Drive Halt acknowledgment) is then set in the drive in parameter "P-0-0115, Device control: status word".

## 8.3 Error Reactions

### 8.3.1 Overview of Error Reactions

Depending on the operating mode that is used and some parameter settings, the drive controller carries out monitoring functions. An error message is generated by the drive controller, if a status is detected that no longer allows correct operation.

Errors are classified in error classes. The error class is represented by the first two digits of the diagnostic message number.

See also "Terms, Basic Principles"

See also "Diagnostic System"

If the drive controller is in control (drive enable was set) and an error occurs, the drive controller automatically starts a drive error reaction.

This drive error reaction depends on:

- The error class of the error occurred and
- The settings of the following parameters:
  - P-0-0117, Activation of control unit reaction on error
  - P-0-0118, Power supply, configuration
  - P-0-0119, Best possible deceleration



At the end of each error reaction, the drive goes torque-free. Power off depends on the setting in P-0-0118!

**Error Classes** There are 8 error classes with different priority:

Diagnos- tic mes- sage num- ber	Error class	Error reaction
F2xxx	non-fatal error	According to setting in parameters "P-0-0119, Best possible deceleration" and "P-0-0117, Activation of control unit reaction on error"
F3xxx	non-fatal safety technolo- gy error	According to setting in "P-0-0119, Best possible deceleration" and "P-0-0117, Activation of control unit reaction on error"
F4xxx	interface error	According to setting in "P-0-0119, Best possible deceleration"

## Extended Axis Functions

Diagnostic message number	Error class	Error reaction
F6xxx	travel range error	Velocity command value reset ("emergency halt")
Not in MPx16: F7xxx	safety technology error	According to setting in bit 9 of parameter "P-0-3210, Safety technology configuration"
F8xxx	Fatal error	Immediate torque disable, if this is the error reaction for non-fatal errors, otherwise general deceleration of the motor via short circuit of motor windings
F9xxx	fatal system error	immediate torque disable
E-xxxx	Fatal system error "processor exception"	immediate torque disable

Fig. 8-3: Error Classes and Drive Reaction



The error class can be recognized by the diagnostic message number and defines the drive behavior in the case of error.

## 8.3.2 Best Possible Deceleration

### Brief Description

The error reaction "best possible deceleration" (to be set in "P-0-0119, Best possible deceleration") is carried out automatically in the case of the following states:

- Non-Fatal Errors (F2xxx)
- Non-Fatal Safety Technology Errors (F3xxx)
- Interface errors (F4xxx)
- travel range errors (F6xxx)
- Safety technology error (F7xxx) (however, depending on bit 9 of "P-0-3210, Safety technology configuration")
- Fatal warnings which require the reaction "velocity command value reset" (e.g. E8034, E6044)
- Communication phase is reset
- Drive enable is removed (see S-0-0134 resp. P-0-4077 or P-0-0115, bit 15)



In the case of fatal system errors (F9xxx/E-0800) the setting in P-0-0119 is ignored, the drive is shut down with immediate torque disable.

One of the following reactions for "best possible deceleration" can be set in P0-0119:

- Velocity command value reset
- Velocity command value reset with ramp and filter ("quick stop")
- Velocity command value reset while maintaining the emergency halt deceleration (S-0-0429) is respected

- Return motion (only with expansion package "servo function")
- Torque disable
- Deceleration via short circuit of motor windings

### Time Flow of the Error Reaction

#### Time Flow With Motor Holding Brake Available

The time flow of the error reaction with motor holding brake available and of the output stage release in the case of velocity command value reset, is described in the section "Functional Description: Error Situation 1" in "Operating Behavior of the Motor Holding Brake" .

The activation and function of the motor holding brake depends on the setting in parameter "P-0-0525, Holding brake control word".

See also "Motor Holding Brake"

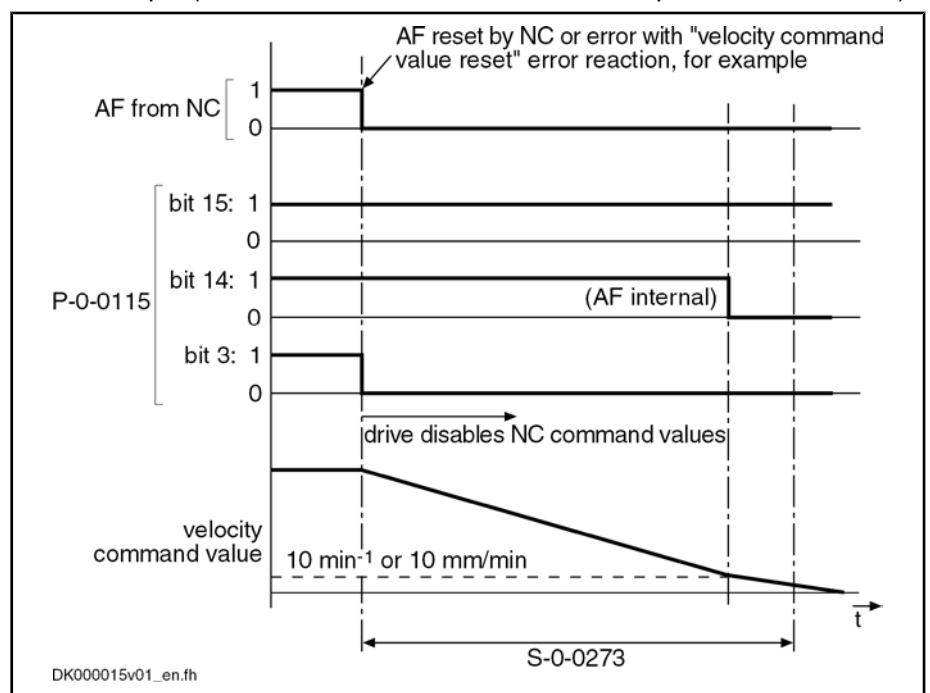
#### Deceleration in U/f Operation

In the case of open-loop-controlled U/f operation, deceleration at the torque limit only takes place, when the stall protection loop has been activated (see "P-0-0045, Control word of current controller"). The maximum deceleration of the shutdown is preset by the value entered in "P-0-0569, Maximum stator frequency slope".

### Velocity Command Value Reset ("Emergency Halt")

P-0-0119, Bit 0...3 = 0;  
P-0-0119, Bit 4...7 = 0

In the case of error, the closed-loop-controlled servo drive in velocity control is shut down with command value = "0". The drive then brakes with its maximum allowed torque (see also "Limitations: Current and Torque/Force Limitation").



S-0-0273 Maximum drive off delay time

P-0-0115 Device control: Status word

Fig. 8-4: Time Flow of Velocity Command Value Reset



If the value entered for S-0-0273 is too small, the error reaction is sometimes aborted without axis standstill!

### Velocity Command Value Reset With Filter and Ramp ("Quick Stop")

P-0-0119, Bit 0...3 = 2 In the case of error

## Extended Axis Functions

- the closed-loop-controlled servo drive in velocity control

- or -

- the open-loop-controlled drive in U/f operation

is decelerated to the final value "0" with a command value ramp and a jerk-limiting command value smoothing filter.



In open-loop-controlled U/f operation, deceleration takes place taking the delay entered in parameter "P-0-0569, Maximum stator frequency slope" into account!

## Pertinent Parameters

- S-0-0349, Bipolar jerk limit
- S-0-0372, Drive Halt acceleration bipolar
- P-0-0569, Maximum stator frequency slope

The parameters take effect as described in the Functional Description, "Drive Halt".

## Velocity Command Value Reset While Maintaining the Emergency Halt Deceleration (S-0-0429)

P-0-0119, Bit 0...3 = 4;  
P-0-0119, Bit 4...7 = 4

In the case of error

- the closed-loop-controlled servo drive in velocity control

- or -

- the open-loop-controlled drive in U/f operation

is shut down with a command value ramp, determined by S-0-0429, Emergency halt deceleration and the jerk-limiting value (S-0-0349). If the value in S-0-0429="0", "S-0-0138, Bipolar acceleration limit value" will take effect.



In open-loop-controlled U/f operation, deceleration takes place taking the delay entered in parameter "P-0-0569, Maximum stator frequency slope" into account!

## Pertinent Parameters

- S-0-0138, Bipolar acceleration limit value
- S-0-0349, Bipolar jerk limit
- S-0-0429, Emergency halt deceleration
- P-0-0569, Maximum stator frequency slope

## Torque Disable

P-0-0119, Bit 0...3 = 1;  
P-0-0119, Bit 4...7 = 1

In the case of error, the drive torque is disabled. The drive in this case is only braked by the friction torque; it "coasts to stop". The time until standstill can be considerable, especially with spindles.



**DANGER**

**Drive continues to move unbraked in the case of error!**

**Danger to life from parts in motion when the safety door at the machining cell is opened!**

⇒ Check drive for motion (e.g. using "S-0-0040, Velocity feedback value", if possible) and wait for standstill!

## Deceleration via Short Circuit of Motor Windings

P-0-0119, Bit 8 = 1

If P-0-0119, Bit 8=1, in the case of F8 errors, the motor will decelerate via a controller-internal short circuit of the motor windings. When the error F8 occurs, a brake controlled by the controller behaves according to the functional principle defined in "P-0-0525, Holding brake control word":



- Immediate applying of the brake, if "servo brake" has been defined
- Applying of brake not until 10 rpm, if "main drive brake" has been defined



Due to the system, deceleration via short circuit of motor windings is not possible for:

- F8000 Fatal hardware error
- F8060 Overcurrent in power section
- F8067 Synchronization PWM-Timer wrong
- F8133 Error when checking interrupting circuits

## Return Motion



Assignment to functional firmware package, see chapter "Availability of the Extended Axis Functions".

P-0-0119, Bit 0...3 = 3

If "return motion" was set as the best possible deceleration, the drive generates a **position command value profile** in order to travel the desired distance in the case of error. This means that a relative process block is activated in the case of error.

### Generating the Position Command Value Profile

With the "drive-internal interpolation" mode, the position command value profile is generated internally by means of predefined travel block data (velocity, acceleration, jerk).

See "Drive-Internal Interpolation"

The value of the parameter "P-0-0055, Return distance" depends on the preceding sign, i.e. positive return distance causes positive motion referring to the coordinate system selected.



The value of "P-0-0055, Return distance" can be configured and transmitted in the cyclic telegram (MDT).

The velocity profile is generated with the parameters

- P-0-0056, Return velocity und
- P-0-0057, Return acceleration.

In addition, the position command values can be smoothed by the position command value average value filter, the order of the average value filter (P-0-0042, Current position command average value filter order) being calculated from "P-0-0057, Return acceleration" and "P-0-0058, Return jerk".

$$P-0-0042 = \frac{P-0-0057}{P-0-0058}$$

Fig. 8-5: Calculating the Value of P-0-0042

### Status Messages for Acknowledgment

After the drive has traveled the process block, i.e. after it moved to the desired target position, the drive is torque-free. The process block is considered to have been traveled when the following applies:

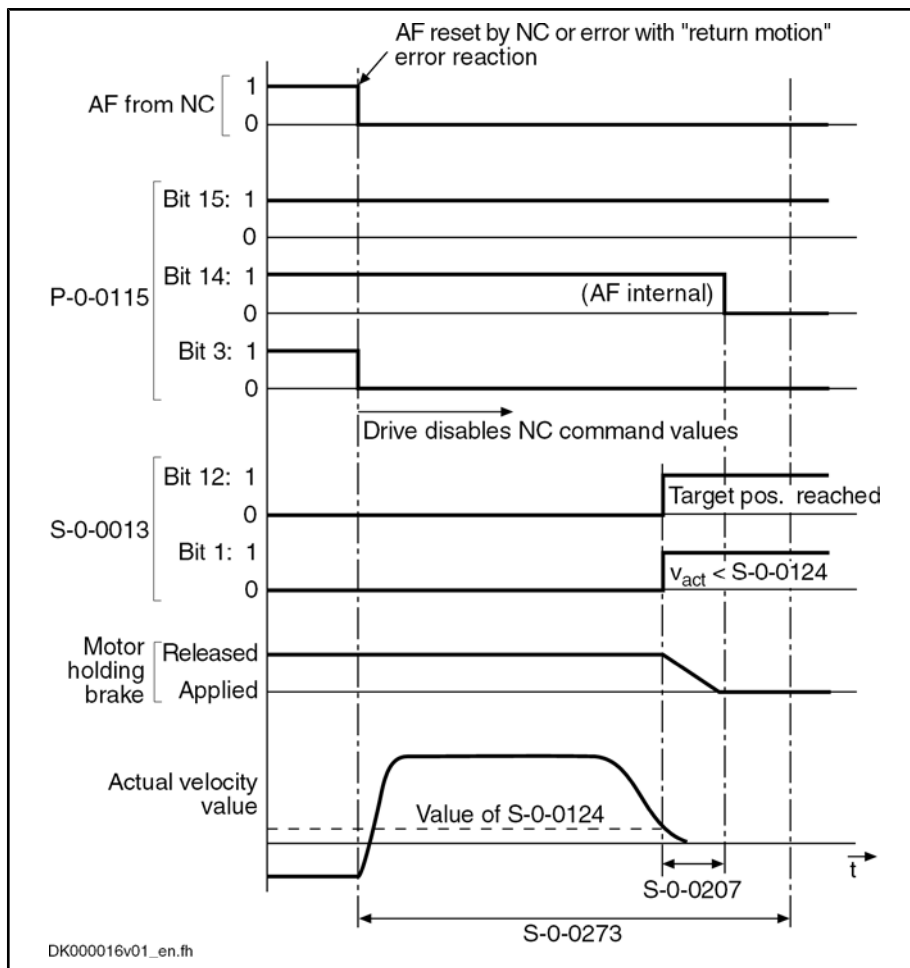
- Target position = active position command value  
→ i.e. "S-0-0013, Class 3 diagnostics", bit 12="1"

- and -

- $v_{act} = 0$

Extended Axis Functions

→ i.e. "S-0-0013, Class 3 diagnostics", bit 1="1" (actual velocity smaller than "S-0-0124, Standstill window")



- S-0-0013 Class 3 diagnostics
- S-0-0207 Drive off delay time
- S-0-0124 Standstill window
- S-0-0273 Maximum drive off delay time
- P-0-0115 Device control: Status word

Fig. 8-6: Time Flow of the Error Reaction "Return Motion"

**Error Reaction "Return Motion" with Activated Position Limit Values**

When the drive-internal position limit values ("S-0-0049, Positive position limit value" and "S-0-0050, Negative position limit value") are activated, i.e. when

- in "S-0-0055, Position polarities", bit 4 for "activation of position limit values" is set to "1"
- and -
- the encoder selected via "S-0-0147, Homing parameter" (bit 3) is in reference ("S-0-0403, Position feedback value status"="1"),

it is ensured that the drive does not leave the defined allowed travel range by executing the "return motion" error reaction.



When the drive is in a position in which the execution of the return motion would exceed a position limit value, the drive in this case only moves up to shortly before the respective position limit value (exactly "S-0-0057, Position window" before the position limit value).

### 8.3.3 Package Reaction on Error

#### Brief Description



Assignment to functional firmware package, see chapter "Availability of the Extended Axis Functions".

---

"Package reaction" is the simultaneous error reaction of all axis drives supplied by a common power bus (DC bus). Drive errors of a drive can be signaled to all other axis drives via the module bus (signal bus) which allows the simultaneous error reaction (according to setting in parameter "P-0-0119, Best possible deceleration") of all axis drives.

The settings for signaling drive errors and package reaction are made individually for each drive in "P-0-0118, Power supply, configuration". This allows activating the package reaction only for individual axes. The behavior of the axes for which the package reaction has not been activated has to be taken into account for the case of error and must be controlled on the master side, if necessary!



The supply unit switches off power supply only in the case of its own errors and in the case of fatal drive errors (F8xxx), if the drive signaling errors signals F8 errors to the supply.

---

#### Fields of Application

Examples of applications with interactive (interpolating, synchronized) use of drives that are supplied by a common power bus ("drive package"):

- Machine tools (e.g. milling, turning, grinding machines)
- Gear cutting machines (gear wheel machining)
- Printing mechanisms of printing machines, etc.

By setting the error reaction of the drive system devices according to the application, the following damages can be minimized:

- Machine damages
- Tool/workpiece/material damages



The package reaction is not suitable for avoiding personal injury!

---

## Extended Axis Functions

Reaction to drive errors	Priority of appropriate error reactions for typical drive applications	Setting in P-0-0117	Setting in P-0-0118	General conditions
NC master-side reaction	NC master-side priority of shutdown and power off	NC reaction active	No package reaction, no signaling of drive errors	Drive with F8 error does not decelerate!
Drive reaction	Shutdown spindle drive (asynchronous motors) Shutdown servo drives (synchronous motors) power off	NC reaction not active	Package reaction, signaling of drive errors	Drive with F8 error does not decelerate! , No DC bus short circuit Power off via NC master
	Shutdown servo drives (synchronous motors) Power off Shutdown spindle drive (asynchronous motors) irrelevant	NC reaction not active	Package reaction, signaling of drive errors, signaling of F8 error to supply	Power off only with F8 error, otherwise via NC master with DC bus short circuit
	Power off Shutdown spindle drive (asynchronous motors) Shutdown servo drives (synchronous motors)	NC reaction not active	Package reaction, signaling of drive errors, signaling of F8 error to supply	Power off only with F8 error, otherwise via NC master; no DC bus short circuit, drive with F8 error does not decelerate!
	Power off Shutdown servo drives (synchronous motors) Shutdown spindle drive (asynchronous motors)	NC reaction not active	Package reaction, signaling of drive errors, signaling of F8 error to supply	Power off only with F8 error, otherwise via NC master with DC bus short circuit

Fig. 8-7: Examples of Settings in P-0-0117 and P-0-0118, Depending on the Priority of Appropriate Error Reactions (With General Conditions)



The above examples are not binding and provide basic information on the settings that have to be made according to the axis-specific and application-dependent requirements.

#### Pertinent Parameters

- P-0-0118, Power supply, configuration
- P-0-0119, Best possible deceleration

#### Notes on Commissioning

Basic settings with regard to error handling have to be made in parameter "P-0-0118, Power supply, configuration":

- Reaction to signaled errors of other drives in the drive system ("package reaction")
- Signaling of own drive errors in drive system via module bus
- Handling of "undervoltage" message for inverters (type HMS or HMD) and converters (type HCS)
- Automatic clearing of error "F2026 Undervoltage in power section" by switching drive enable off
- Signaling of own, fatal drive errors (F8xxx) to the supply via module bus

## 8.3.4 Control Reaction on Error

### NC Reaction on Error

#### Brief Description



Assignment to functional firmware package, see chapter "Availability of the Extended Axis Functions".

To avoid damages to the machine, some applications require that the master (e.g. NC) retains control of the travel profile of the axes in the case of error, too, and shuts down the machine axes in a coordinated way. For this case, the "NC reaction on error" option was implemented; it can be activated via P-0-0117.

The master is informed of an error in the drive controller via the drive status word (see S-0-0135) so that the master can shut down the machine axes in a coordinated way and therefore avoid possible damage.



NC reaction on error is only possible with non-fatal errors (diagnostic message F2xxx), otherwise the drive always reacts with an immediate drive-side error reaction.

#### Pertinent Parameters

- S-0-0135, Drive status word
- P-0-0117, Activation of control unit reaction on error
- P-0-0119, Best possible deceleration

#### Functional Description

In the case of NC reaction on error, the axis reporting the error still is provided with the command values preset by the master and follows them, even in the case of error, for another 30 s. To achieve this, the function has to be activated so that the defined time delay of 30 s becomes effective between the detection of the error and the drive-side reaction.

#### Activating the NC Reaction

The NC reaction on error is activated in "P-0-0117, Activation of control unit reaction on error".

#### P-0-0117, bit 0:

- Bit 0 = 0 → The drive carries out its error reaction **without delay** according to the setting in "P-0-0119, Best possible deceleration", after recognizing the error.
- Bit 0 = 1 → The drive carries out its error reaction according to the setting in P-0-0119 **only 30 s after recognizing the error**. The drive, for the duration of 30 s after detection of the error, continues following the command values of the master and therefore allows an **NC error reaction**.

**Note:** In case that after the recognition of the error, within this waiting period the error message is deleted **no** drive reaction set in P-0-0119 will be executed.



The activation of "NC reaction on error" (P-0-0117, bit 0 = 1) only makes sense for masters that have the respective procedure for the case of error.

## Extended Axis Functions

## MLD Reaction on Error

## Brief Description



Assignment to functional firmware package, see chapter "Availability of the Extended Axis Functions".

As an alternative to the NC reaction, the IndraMotion MLD reaction on error can also be realized for the (local) axis. In this, the MLD reaction and the NC reaction are differentiated functionally insofar that by means of IndraMotion MLD, even for an interface error (F4xxx) an error reaction to be defined by the operator can be executed for the (local) axis.



Prerequisite for the utilization of the MLD error reaction is an enable of the PLC function in the drive (see "Enabling of Functional Packages").

## Pertinent Parameters

- S-0-0135, Drive status word
- P-0-0117, Activation of control unit reaction on error
- P-0-0119, Best possible deceleration
- P-0-2003, Selection of functional packages

## Functional Description

By means of the MLD reaction on error, the (local) axis is commanded by the IndraMotion MLD for another 30 seconds in the case of an error. In case the MLD already had control over the axis before the occurrence of an error, it will maintain it or it will take over control over the axis, which results in any control over by an external controller to be interrupted.

## Activating the NC Reaction

The MLD reaction on error is activated in "P-0-0117, Activation of control unit reaction on error".

**P-0-0117, bit 1** (bit 0 must be Zero):

- Bit 1 = 0 → The drive carries out its error reaction **without delay** according to the setting in "P-0-0119, Best possible deceleration", after recognizing the error.
- Bit 1 = 1 → The drive carries out its error reaction according to the setting in P-0-0119 **only 30 seconds after recognizing the error**. For a period of 30 seconds as of the time of error recognition, the IndraMotion MLD will receive control over the axis and therefore it can carry out an **MLD error reaction**.

**Note:** In case that after the recognition of the error, within this waiting period the error message is deleted **no** drive reaction set in P-0-0119 will be executed.

## Notes on Utilization

When using the function, observe the following aspects:

- The MLD reaction on error, is also carried out if the IndraMotion MLD is not running. Therefore, the activation of "MLD reaction on error" (P-0-0117, Bit 1 = 1) can only be carried out, if a respective reaction is programmed via IndraMotion MLD.
- MLD reaction on error is only possible with non-fatal errors (F2xxx) and with interface errors (F4xxx), otherwise the drive always reacts with an immediate drive-side error reaction.
- The MLD reaction on error facilitates very fast and - above all - flexible reaction on occurrence of an error.

## 8.4 E-Stop Function

### 8.4.1 Brief Description



Assignment to functional firmware package, see chapter "Availability of the Extended Axis Functions".

The E-Stop function is used to shut down the drive with selectable drive reaction (see Parameter Description "P-0-0008, Activation E-Stop function") via a digital input of the drive controller.

To use the E-Stop function, you have the following options:

- E-Stop with reaction to interface error (F4034 Emergency-Stop)  
→ **Reaction:** Best possible deceleration (as set in P-0-0119)
- E-Stop with reaction to travel range error (F6034 Emergency-Stop)  
→ **Reaction:** Velocity command value reset
- E-Stop as fatal warning "E8034 Emergency-Stop"  
→ **Reaction:** Best possible deceleration (as set in P-0-0119)



If "E-Stop" was parameterized as a warning, it is not necessary to clear the diagnostic message!

#### Pertinent Parameters

- P-0-0008, Activation E-Stop function
- P-0-0119, Best possible deceleration
- P-0-0223, E-Stop input

#### Pertinent Diagnostic Messages

- E8034 Emergency-Stop
- F4034 Emergency-Stop
- F6034 Emergency-Stop

### 8.4.2 Functional Description

By activating the E-Stop input (P-0-0008, bit 0 = 1) and assigning bit 0 of P-0-0223 to a digital input, the drive is caused to carry out, with 0 V at the E-Stop input, the reaction defined via P-0-0008 for shutting the drive down.

#### E-Stop Reaction According to P-0-0008, Bit 2

The reaction first of all depends on the setting of bit 2 in P-0-0008.

If the interpretation "fatal warning" was parameterized in P-0-0008 (bit 2 = 1), the drive reacts, as in the case when the external drive enable is switched off, with the reaction set in "P-0-0119, Best possible deceleration".

- The warning "E8034 Emergency-Stop" appears. In "S-0-0012, Class 2 diagnostics" bit 15 is set (manufacturer-specific warning).
- Simultaneously, the bit "change bit class 2 diagnostics" is set in the drive status word.



This change bit is cleared by reading "S-0-0012, Class 2 diagnostics". Using "S-0-0097, Mask class 2 diagnostics", warnings can be adjusted in terms of their effect on the change bit.



To reactivate the drive, the E-Stop input must be deactivated and **another 0-1 edge must be applied to the external drive enable.**

## Extended Axis Functions

If the interpretation was set as an error in P-0-0008 (bit 2 = 0), the reaction selected in bit 1 is carried out:

- The error diagnosis "F4034 Emergency-Stop" (or "F6034 Emergency-Stop") appears
- Bit 15 is set in parameter "S-0-0011, Class 1 diagnostics".
- Bit 13 (drive interlock, error in class 1 diagnostics) is set in the drive status word of the drive telegram. The error message can be cleared via command "S-0-0099, C0500 Reset class 1 diagnostics", or the "Esc" key of the control, if the E-Stop is no longer active.



The error reaction is carried out without delay, independent of "P-0-0117, Activation of control unit reaction on error".

#### E-Stop Reaction According to P-0-0008, Bit 1

If bit 1 = 0 was set in parameter P-0-0008, the drive is shut down according to the error reaction parameterized via "P-0-0119, Best possible deceleration".

The diagnostic message upon activating the E-Stop input then reads "F4034 Emergency-Stop".

If bit 1 = 1 was set in parameter P-0-0008, the drive, when the E-Stop triggers, is braked with maximum torque to speed = 0, independent of the error reaction set in P-0-0119. This setting corresponds to the best possible deceleration "velocity command value reset".

The diagnostic message upon activating the E-Stop input then reads "F6034 Emergency-Stop".

## 8.4.3 Notes on Commissioning

### Activation and Polarity of the E-Stop Input

#### Assigning Digital Input

Prerequisite for using the function is the assignment of bit 0 of parameter P-0-0223 to a digital input (see "Digital Inputs/Outputs"). A voltage level at the digital input therefore also affects bit 0 of P-0-0223.



Without this assignment to the digital input, the E-Stop reaction fails to occur in spite of the input having been activated!

#### Activating E-Stop

The activation of the E-Stop input and the selection of a reaction for shutdown of the drive is carried out via bit 0 of "P-0-0008, Activation E-Stop function" (see also Parameter Description P-0-0008).

#### P-0-0008, bit 0 (activation E-Stop):

- Bit 0 = 0 → Function not activated
- Bit 0 = 1 → Function activated

### Selecting the Drive Reaction

#### Determining Reaction

It is possible to determine whether an error message or a warning is generated when 0 V are detected at the E-Stop input. Bit 1 and bit 2 of "P-0-0008, Activation E-Stop function" are relevant for determining this.

#### P-0-0008, bit 1 (error class when interpreted as error):

- Bit 1 = 0 → F4034 → Best possible deceleration
- Bit 1 = 1 → F6034 → Velocity command value reset

#### P-0-0008, bit 2 (interpretation of the E-Stop input):

- Bit 2 = 0 → Interpreted as error (see bit 1)
- Bit 2 = 1 → Interpreted as fatal warning






---

The error reaction can be determined via "P-0-0119, Best possible deceleration".

---

## Connecting the E-Stop Input



See documentation "Drive Controllers, Control Sections; Project Planning Manual"

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The polarity of the input cannot be selected. It is always active when the signal = 0 V; this means that 0 V at the digital input causes the E-Stop to trigger.

---

## 8.4.4 Diagnostic and Status Messages

### Diagnostic Warning and Error Messages

There are the following diagnostic messages for the E-Stop function:

- Warning "E8034 Emergency-Stop"  
→ E-Stop with best possible deceleration
- Error "F4034 Emergency-Stop"  
→ E-Stop with best possible deceleration
- Error "F6034 Emergency-Stop"  
→ E-Stop with velocity command value reset

### Status Messages

The status of the E-Stop input can be read via "P-0-0223, E-Stop input":

- Bit 0 = 0: 0 V at input  
→ E-Stop triggers
- Bit 0 = 1: 24 V at input  
→ E-Stop does not trigger

## 8.5 Compensation Functions / Corrections

### 8.5.1 Friction Torque Compensation

#### Brief Description




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Assignment to functional firmware package, see chapter "Availability of the Extended Axis Functions".

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The behavior of a machine axis is negatively affected by static friction when starting or when reversing the direction. The drive-internal friction torque compensation allows compensating the static friction by adding, depending on the direction of movement, a torque/force command value.

Extended Axis Functions

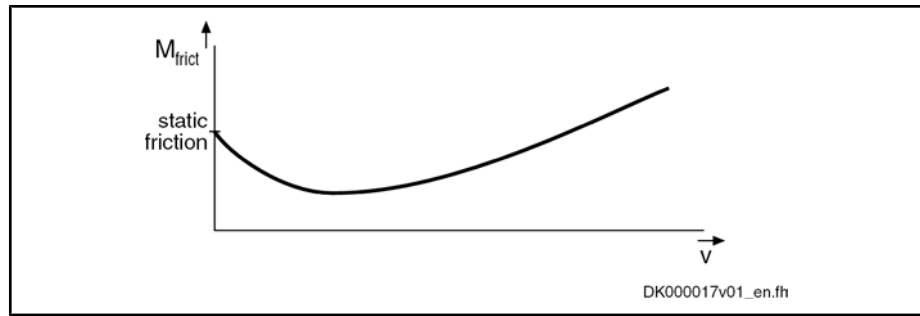


Fig.8-8: Friction Torque Curve With Static Friction



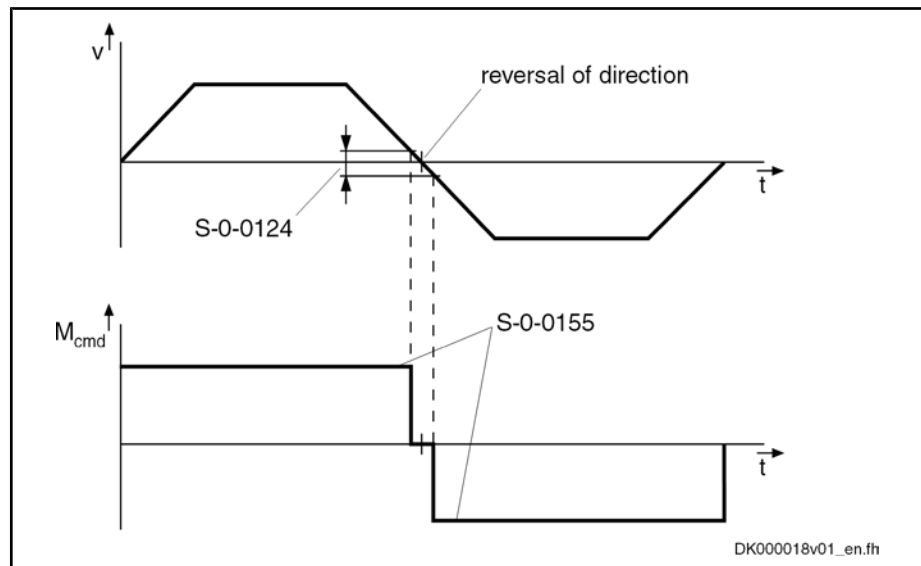
Friction torque compensation is mainly intended to be used in precision machine tools and to reduce the path errors caused by static friction. This applies particularly to circular errors at the quadrant transitions.

Pertinent Parameters

- S-0-0092, Bipolar torque/force limit value
- S-0-0124, Standstill window
- S-0-0155, Friction compensation

Functional Principle

The principle of friction torque compensation is that the known friction component is pre-controlled (compensated) via an added torque/force command value and does not have to be compensated by the controller. This allows, especially when reversing the direction of movement, improving the control behavior (little lag error). Precision of drive control is thereby increased.



- S-0-0124 Standstill window
- S-0-0155 Friction compensation

Fig.8-9: Functional Principle of Friction Compensation



A hysteresis was implemented in the reversal point so that the compensation value is only added when the drive velocity is outside the standstill window (see S-0-0124).

## Notes on Commissioning

- Requirements** The following requirements must have been fulfilled for using this function:
- The friction torque of the axis must have a relevant value. With a friction torque component of less than 10 % of the nominal torque of the drive used, friction torque compensation won't have any important effect.
  - The friction torque to be compensated must be more approximately constant, independent of the current machining process.

- Preparations** Before activating the function, make the following preparations:
- Set velocity and position control loops according to the Notes on Commissioning.  
See "Commissioning and Parameterizing the Control Loops" for the respective operating mode
  - Connect the master; it must allow moving the drive (e.g. jog function).
  - Set and activate the travel range limits of the axis (cf. P-0-0090, S-0-0049, S-0-0050).
  - If the friction characteristic of the axis is highly temperature-dependent, bring the drive to operating temperature before determining the compensation value.
  - Set the torque limit to minimum value so that the drive cannot surmount the static friction and does not move in spite of command value input.



If the drive can only be moved in position control, the lag error monitor has to be switched off, as otherwise the error "F2028 Excessive deviation" can occur during determination of the compensation value!

### Determining the Compensation Value

Determine the compensation value (S-0-0155) in the following steps:

1. Preset a positive command value for the axis and increase "S-0-0092, Bipolar torque/force limit value" until the axis moves. The value then contained in S-0-0092 corresponds to the static friction component for positive direction (friction value\_positive).  
Repeat this procedure in the other direction of movement to determine the static friction component for negative direction (friction value\_negative).
2. Derive the setting value for friction torque compensation from the determined values (friction value\_positive and friction value\_negative). As there is no direction-dependent correction value, the average value has to be calculated from these two values and entered in "S-0-0155, Friction compensation".

$$S-0-0155 = \frac{|\text{friction value\_positive}| + |\text{friction value\_negative}|}{2}$$

Fig. 8-10: Generating the Average Value for the Entry in Parameter S-0-0155

## 8.5.2 Axis Error Correction

### Brief Description

The actual position value provided by the measuring system can differ from the real actual position value at the axis, e.g. at the point of chip removal in the case of metal-cutting machining, due to

- inaccuracy of the measuring system,

## Extended Axis Functions

- transmission inaccuracy in mechanical transmission elements such as gear, clutch, feed spindle etc.,
- thermal expansion of machine parts of the drive system.

For compensating the mechanically determined position error sources, IndraDrive controllers provide the following correction functions:

- Backlash on reversal correction
- Precision axis error correction
- Control-side axis error correction

The control-side axis error correction is always active. The correction value can be transmitted in the cyclic telegram or in the service channel. In addition, precision axis error correction or reversal clearance can be activated, precision axis error correction having higher priority.

Moreover, it is possible to activate the temperature error correction. IndraDrive controllers provide two possibilities of correcting temperature errors:

- Independent of axis position
  - Depending on axis position
- Pertinent Parameters**
- S-0-0058, Reversal clearance
  - S-0-0124, Standstill window
  - P-0-0400, Axis correction external correction value
  - P-0-0401, Axis correction active correction value
  - P-0-0402, Axis correction reference temperature
  - P-0-0403, Axis correction reference position for temp. corr.
  - P-0-0404, Axis correction actual temperature pos.-dependent
  - P-0-0405, Axis correction actual temperature pos.-independent
  - P-0-0406, Axis correction temperature factor pos.-dependent
  - P-0-0407, Axis correction temperature factor pos.-independent
  - P-0-0408, Axis correction start position
  - P-0-0409, Axis correction end position
  - P-0-0410, Axis correction support point distance
  - P-0-0411, Axis correction, correction table positive
  - P-0-0412, Axis correction, correction table negative
  - P-0-0413, Axis correction control word

## Selecting the Measuring System

### Measuring System to be Corrected

The actual position value system to be corrected is selected via the respective bit of "P-0-0413, Axis correction control word" It is only possible to select one of the actual position value systems!



All position-dependent correction functions only take effect after the position data reference was established for the respective encoder (see "Establishing the Position Data Reference").

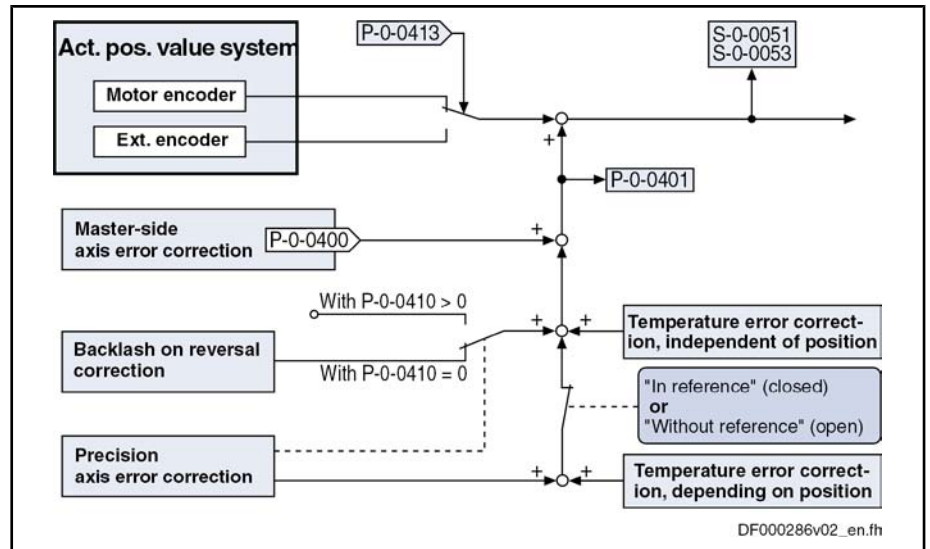
### Active Correction Value

The sum of active correction values is displayed in "P-0-0401, Axis correction active correction value". The value refers to the encoder selected in P-0-0413.

### How to Use the Functions of Axis Error Correction

It is possible to use several axis error corrections at the same time. The availability of the individual correction functions, however, depends on the functional package which has been activated.

The figure below illustrates the interaction of the subfunctions for axis error correction.



- S-0-0051 Position feedback 1 value
- S-0-0053 Position feedback 2 value
- P-0-0400 Axis correction external correction value
- P-0-0401 Axis correction active correction value
- P-0-0410 Axis correction support point distance
- P-0-0413 Axis correction Control word

Fig. 8-11: Overview of How to Use the Functions of Axis Error Correction

### Backlash on Reversal Correction



Assignment to functional firmware package, see chapter "Availability of the Extended Axis Functions".

By means of the backlash on reversal correction, it is easily possible to correct backlash in the mechanical axis system.

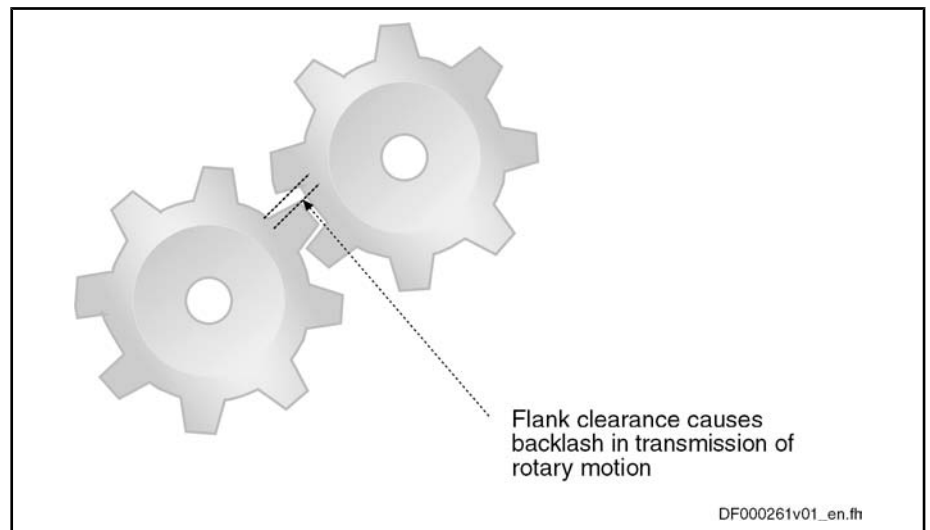


Fig. 8-12: Illustration of Backlash With Toothed Wheels

The function is activated by inputting the backlash in parameter "S-0-0058, Reversal clearance". The actual position values of the encoder selected via

Extended Axis Functions

**In Position Control**

P-0-0413 are corrected with the value from S-0-0058 (taking the direction of motion into account).

In position control, the direction of motion is recognized by the sign of the value of "P-0-0434, Position command value of controller", derived with respect to time.

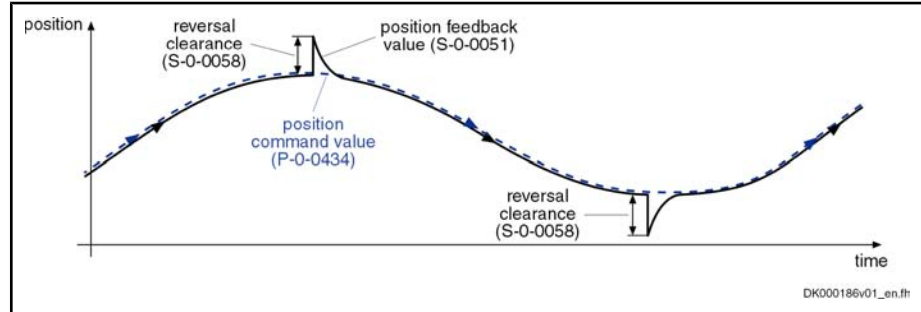


Fig.8-13: Operating Principle of Backlash on Reversal Correction in Position Control (Reversal Clearance Added in the Case of Negative Sign of the Value of P-0-0434)

**In Velocity Control**

In velocity control, reversal of the direction of motion is recognized when the velocity command value (S-0-0036) has exceeded the absolute value of the standstill window (S-0-0124) in positive or negative direction. The standstill window acts as hysteresis!

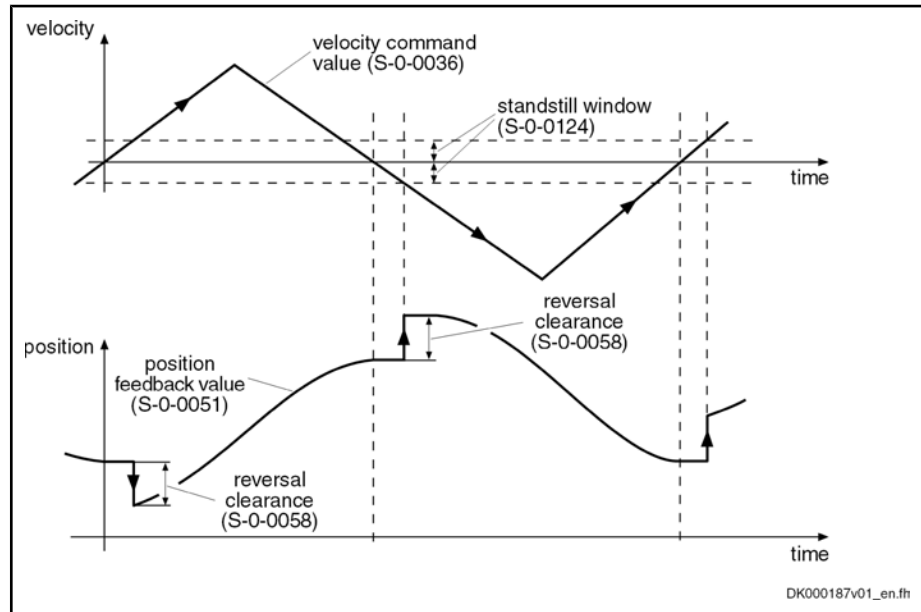


Fig.8-14: Operating Principle of Backlash on Reversal Correction in Velocity Control (Reversal Clearance Added When Velocity Command Value Leaves Standstill Window With Negative Velocity)

$$x_{act\_corr} = x_{act}$$

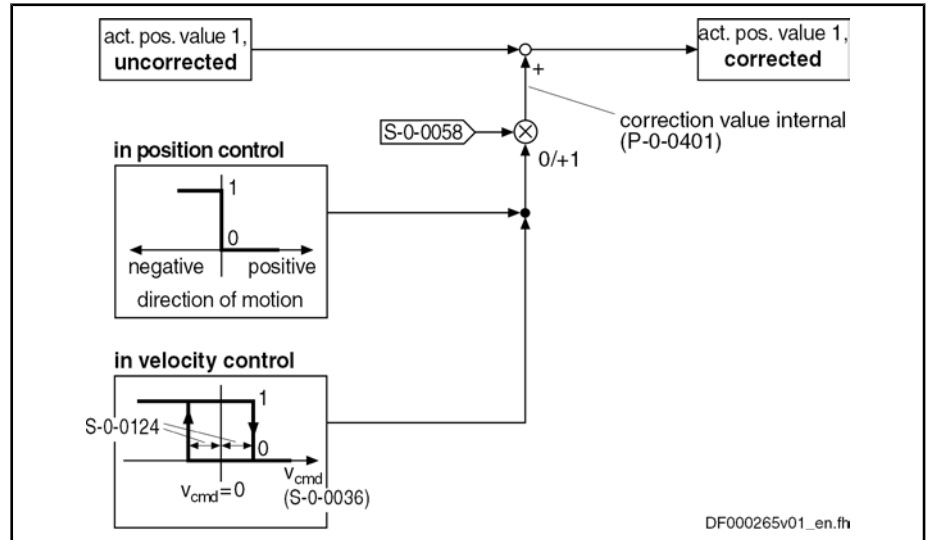
$x_{act\_corr}$  Corrected actual position value 1  
 $x_{act}$  Uncorrected actual position value 1

Fig.8-15: Corrected Actual Position Value for Positive Direction

$$x_{act\_corr} = x_{act} + \text{correction value}$$

$x_{act\_corr}$  Corrected actual position value 1  
 $x_{act}$  Uncorrected actual position value 1

Fig. 8-16: Corrected Actual Position Value for Negative Direction



S-0-0036 Velocity command value  
 S-0-0058 Reversal clearance  
 S-0-0124 Standstill window  
 P-0-0401 Axis correction active correction value

Fig. 8-17: Block Diagram of Backlash on Reversal Correction

**Determining the Reversal Clearance**

The following procedure is recommended for determining the value for "S-0-0058, Reversal clearance":

- By means of jog mode move axis in positive direction
- Place dial gauge at appropriate spot of mechanical axis system and set it to zero
- Jog axis in negative direction, until change in pointer deflection of dial gauge is visible

The reversal clearance then is determined according to the following calculation:

$$\text{Reversal clearance} = \Delta x_{control} - \Delta x_{dial\ gauge}$$

$\Delta x_{control}$  Distance traveled from zero position of dial gauge according to control display  
 $\Delta x_{dial\ gauge}$  Distance traveled according to dial gauge referring to its zero position

Fig. 8-18: Determining the Input Value for S-0-0058

**Precision Axis Error Correction**



Assignment to functional firmware package, see chapter "Availability of the Extended Axis Functions".

## Extended Axis Functions

The precision axis error correction is used for correcting non-linear encoder errors and non-linear errors of the mechanical system. The correction acts on the encoder selected by means of P-0-0413.

**Pertinent Parameters**

- P-0-0408, Axis correction start position
- P-0-0409, Axis correction end position
- P-0-0410, Axis correction support point distance
- P-0-0411, Axis correction, correction table positive
- P-0-0412, Axis correction, correction table negative

**Correction Values**

By means of the tables "P-0-0411, Axis correction, correction table positive" and "P-0-0412, Axis correction, correction table negative" it is possible to enter position- and direction-dependent correction values, so-called correction support points, within the correction range.

**Correction Range**

The correction range lies within the value range that is limited by the parameters "P-0-0408, Axis correction start position" and "P-0-0409, Axis correction end position". The start position (P-0-0408) is preset by the user, the end position (P-0-0409) is determined on the drive side from the maximum value of the correction table support points used (from P-0-0411 and P-0-0412) and the support point distance (P-0-0410).

**Correction Support Points**

The positions for which correction support points are entered, are determined via the parameters "P-0-0410, Axis correction support point distance" and "P-0-0408, Axis correction start position". Between the correction support points, the correction values are calculated by cubic spline interpolation.

The actual position values of the encoder selected via P-0-0413 are corrected with the interpolated values of "correction table positive" (P-0-0411) or "correction table negative" (P-0-0412), taking the direction of motion into account.

Depending on the operating mode, the direction of motion is recognized in different ways:

- **In position control**, by the sign of the value of "P-0-0434, Position command value of controller", derived with respect to time
- **In velocity control**, when the velocity command value (S-0-0036) exceeds the absolute value of the standstill window (S-0-0124) in positive/negative direction  
→ The standstill window acts as hysteresis!

**Activating the Precision Axis Error Correction**

The precision axis error correction is active, when a value greater than zero was entered in "P-0-0410, Axis correction support point distance" and the position data reference was established for the encoder the actual position value of which is to be corrected.



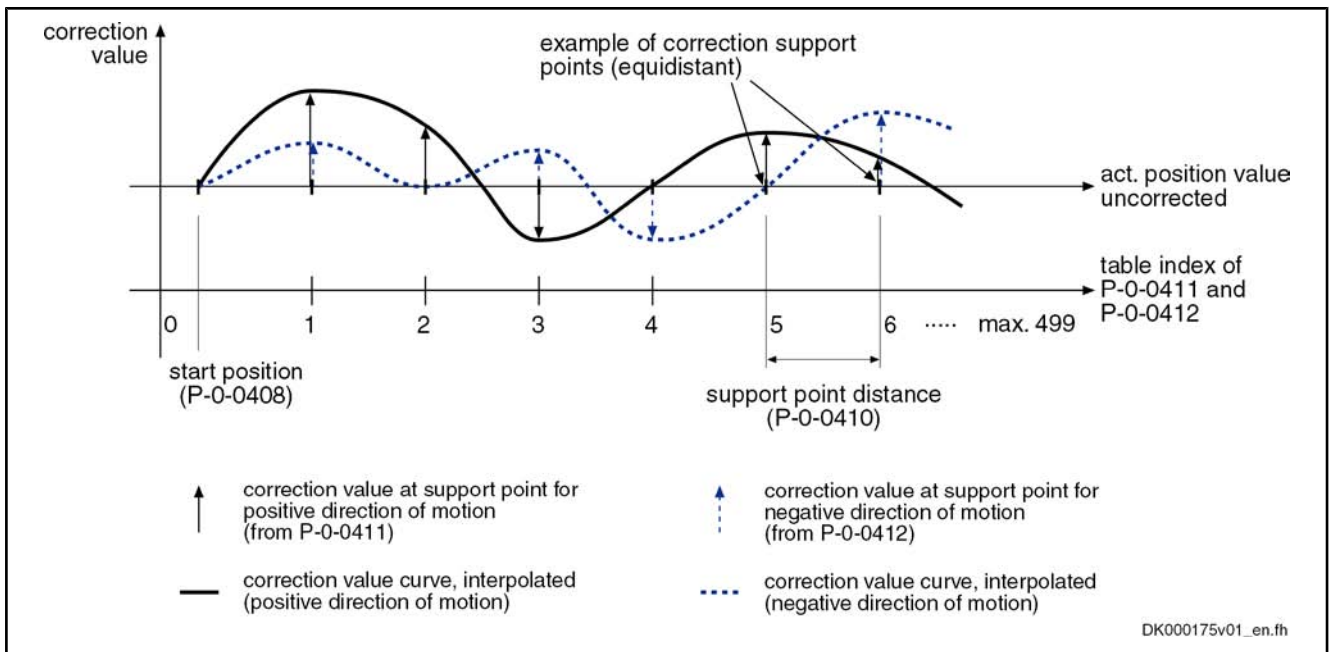


Fig. 8-19: Illustration of Correction Value Generation From the Entered Correction Support Points

Table index	P-0-0411 (positive direction)	P-0-0412 (negative direction)
0	0 (correction value at start position P-0-0408)	0 (correction value at start position P-0-0408)
1	Correction value support point 1	Correction value support point 1
2	Correction value support point 2	Correction value support point 2
3	Correction value support point 3	Correction value support point 3
....	....	....
498	Correction value support point 498	Correction value support point 498
499	0	0

Fig. 8-20: Assignment of Support Point Correction Values to Table Index of Correction Tables P-0-0411 and P-0-0412



At least 6, but not all of the 500 table values have to be used! It is recommended, however, to use the same number of correction support points for positive and negative directions of motion! The first and the last correction value of the table have to be zero in order to avoid discontinuity (abrupt changes) in the actual position value!

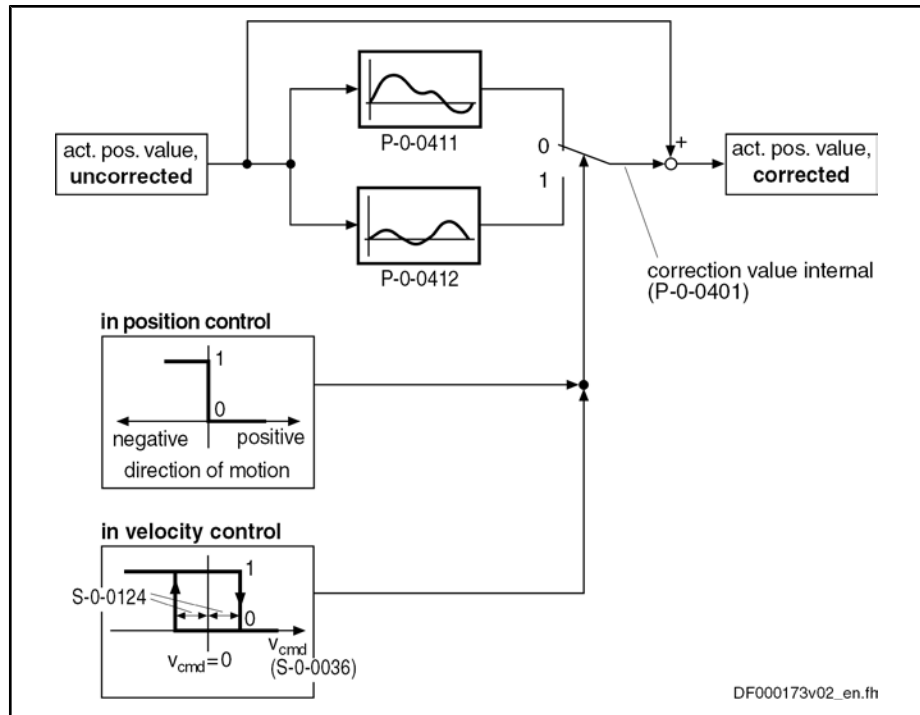


Different correction values for positive and negative directions of motion at the same support point cause discontinuity in the corresponding actual position value upon a change in direction and therefore are possibly causing abrupt control with regard to the command position!

**Operating Principle**

The figure below illustrates the operating principle of precision axis error correction:

Extended Axis Functions



- S-0-0036 Velocity command value
  - S-0-0124 Standstill window
  - P-0-0401 Axis correction active correction value
  - P-0-0411 Axis correction correction table positive
  - P-0-0412 Axis correction correction table negative
- Fig. 8-21: Block Diagram of Precision Axis Error Correction*

**Determining the Required Parameter Values**

The correction values are determined by means of a reference measuring system (e.g. laser interferometer). Within the desired correction range, the drive successively moves to the support points for the different directions and the corresponding position error is measured.

$$x_{corr} = x_{meas} - x_{display}$$


- $x_{korr}$  Correction value related to support point
  - $x_{meas}$  Measured position value at support point
  - $x_{display}$  Value of parameter S-0-0051 or S-0-0053
- Fig. 8-22: Determining Correction Value for Precision Axis Error Correction*

The correction values related to support point are entered in the list parameters P-0-0411 and P-0-0412.

The required length of the correction range and the maximum value of the number of support points determine the minimum support point distance. If a lower number of support points is selected, a bigger support point distance is required with a correction value of the same length. This, however, can reduce the precision of correction!

$$P-0-0410 = \frac{\text{length of correction range}}{\text{max. number of support points (P-0-0411;P-0-0412)}}$$

P-0-0410 Axis correction support point distance  
 P-0-0411 Axis correction correction table positive  
 P-0-0412 Axis correction correction table negative  
*Fig. 8-23: Determining the Support Point Distance*

 When the value in parameter P-0-0410 equals zero, the precision axis error correction is deactivated!

**Determining Start Position**

The start position for precision axis error correction defines the position of the first correction support point, the end position is determined by the controller and displayed in "P-0-0409, Axis correction end position".

**Control-Side Axis Error Correction**



Assignment to functional firmware package, see chapter "Availability of the Extended Axis Functions".

IndraDrive controllers provide the possibility of cyclically transmitting control-side correction values for the actual position value to the drive and using them for calculating the actual position value in the position control clock.

The control-side axis error correction is activated when "P-0-0400, Axis correction external correction value" has been included in the master data telegram. The correction values act on the encoder selected in "P-0-0413, Axis correction control word" .



For control-side axis error correction, it is not necessary to establish the position data reference drive-internally for the respective encoder!

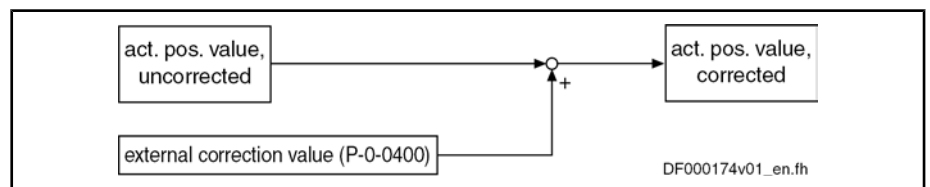


Fig. 8-24: Control-Side Axis Error Correction

**Temperature Error Correction**

**General Information**



Assignment to functional firmware package, see chapter "Availability of the Extended Axis Functions".

The temperature error correction is used to correct actual position value errors that can occur due to temperature-dependent linear expansion at servo axes.

**Dependencies of the Actual Position Value Errors of Thermal Cause**

According to the mechanical configuration of the axis and the arrangement of the workpiece or tool, the actual position value errors caused by the influence of temperature can

- only depend on temperature

- or -

Extended Axis Functions

- depend on temperature and on axis position.

IndraDrive controllers therefore provide two possibilities of temperature error correction:

- Independent of position
- Depending on position

**Measured Temperature Value**

The measured temperature value has to be made cyclically available by the control master via the master communication. Separate measured temperature values are used for position-dependent and position-independent temperature error correction!

**Reference Temperature**

The temperature-dependent correction functions are working relatively to a reference temperature at which there isn't any temperature-dependent actual position value error present. The reference temperature value has to be entered in "P-0-0402, Axis correction reference temperature".



When actual position reference values are measured, all machine parts have to have reference temperature!

**Scaling**

All temperature data are scaled with the temperature scaling (S-0-0208) set on the drive side. The factors for linear expansion (P-0-0406, P-0-0407) are scaled with the quotient "position data scaling/temperature scaling" (S-0-0076/S-0-0208).

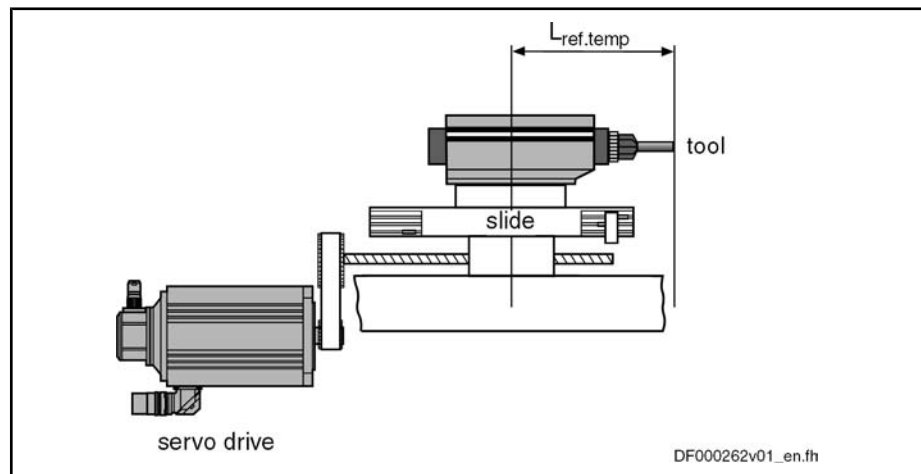
**Position-Independent Temperature Error Correction**

**Usage**

The position-independent temperature error correction is used to compensate the temperature-dependent linear expansion of tools, workpieces and slides. The expansion of these components of a servo axis only depends on the temperature difference compared to a reference temperature, the resulting actual position value error is the same at each position of the axis.

**Pertinent Parameters**

- P-0-0402, Axis correction reference temperature
- P-0-0405, Axis correction actual temperature pos.-independent
- P-0-0407, Axis correction temperature factor pos.-independent



$L_{ref.temp}$ . Material length the temperature expansion of which has to be compensated (at reference temperature)

Fig. 8-25: Example of Application for Position-Independent Temperature Error Correction



The actual position value system to be corrected is selected via the respective bit of "P-0-0413, Axis correction control word"

Operating principle of position-independent temperature error correction:

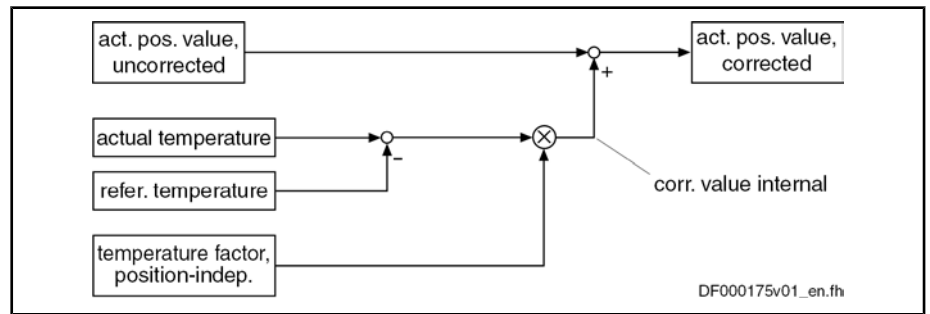


Fig. 8-26: Position-Independent Temperature Error Correction

Drive-internal determination of the correction value:

$$x_{\text{korr}} = P-0-0407 \times [(P-0-0405) - (P-0-0402)]$$

- $x_{\text{korr}}$  Correction value, temperature-dependent
- P-0-0407 Axis correction temperature factor pos.-independent
- P-0-0405 Axis correction actual temperature pos.-independent
- P-0-0402 Axis correction reference temperature

Fig. 8-27: Determining the Correction Value

**Position-Independent Temperature Factor**

**Calculating the Value**

The value for "P-0-0407, Axis correction temperature factor pos.-independent" can be determined by means of calculation or measurement.

If all data for the formula below can be unequivocally assigned due to the assembly of the mechanical system, the correction factor can be calculated.

$$P-0-0407 = \alpha \times L_{\text{ref. temp.}}$$

- P-0-0407 Axis correction temperature factor pos.-independent
- $\alpha$  Linear expansion coefficient of the material
- $L_{\text{ref. temp.}}$  Material length the temperature expansion of which has to be compensated (at reference temperature)

Fig. 8-28: Calculating the Value for P-0-0407

$$\begin{aligned}
 P-0-0407 &= \alpha \times L_{\text{ref. temp.}} \\
 &= 0,000018 \text{ 1/K} \times 100 \text{ mm} \\
 &= 0,00018\text{mm}/0,1\text{K}
 \end{aligned}$$

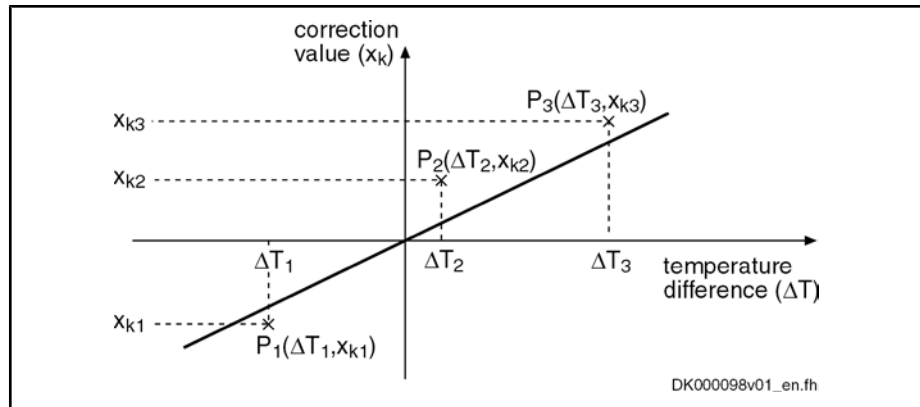
- P-0-0407 Axis correction temperature factor pos.-independent
- $\alpha$  For example, 0.000018 1/K, if temperature scaling °C (default scaling)
- $L_{\text{ref. temp.}}$  For example, 100 mm (preferred scaling)

Fig. 8-29: Example of How to Calculate the Value for P-0-0407

**Measuring the Value**

If it is impossible to calculate the value for P-0-0407 (e.g. if the object of correction consists of different materials), it has to be measured. A series of measurements determines the actual position value error of the object of correction at different temperatures. Depending on the temperature difference, a straight line can be approximated by means of the measuring points.

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$x_{kn}$  Correction value (measured position value – actual position value (S-0-0051/S-0-0053))  
 $\Delta T_n$  Temperature difference (measured temperature – reference temperature (P-0-0402))

Fig.8-30: *Approximated Straight Correction Line on the Basis of Measured Correction Values at Different  $\Delta T$*

Calculation by Means of Measured Values

The gradient of the approximated straight line is the value of the position-independent temperature factor. By means of the value from the series of measurements, it is possible to calculate the position-independent temperature factor:

$$P-0-0407 = \frac{n \times \sum (\Delta T_n \times x_{kn}) - \sum \Delta T_n \times \sum x_{kn}}{n \times \sum \Delta T_n^2 - (\sum \Delta T_n)^2}$$

P-0-0407 Axis correction temperature factor pos.-independent  
 n Number of measured values  
 $\Delta T_n$  Temperature difference at which the correction value  $x_{kn}$  was determined  
 $x_{kn}$  Correction value at the temperature difference  $\Delta T_n$

Fig.8-31: *Calculating the Position-Independent Temperature Factor From the Values of the Series of Measurements*

Activating the Function

The position-independent temperature error correction is activated, when the value of "P-0-0407, Axis correction temperature factor pos.-independent"



When the value in parameter P-0-0407 equals zero, the function of position-independent temperature error correction is deactivated. This correction function does not require position data reference for the measuring system to the corrected!

Position-Dependent Temperature Error Correction

Usage

The position-dependent temperature error correction is used to compensate for the temperature-dependent linear expansion of the mechanical transfer elements of a servo axis or the measuring system. Depending on the position of the axis slide, the temperature-dependent linear expansion causes actual position value errors of different extent over the travel range of the axis.

At a position of the axis, there is a non-temperature-dependent "dedicated point" available that is used as the reference position for the position-dependent temperature error correction.

Pertinent Parameters

- P-0-0402, Axis correction reference temperature

- P-0-0403, Axis correction reference position for temp. corr.
- P-0-0404, Axis correction actual temperature pos.-dependent
- P-0-0406, Axis correction temperature factor pos.-dependent

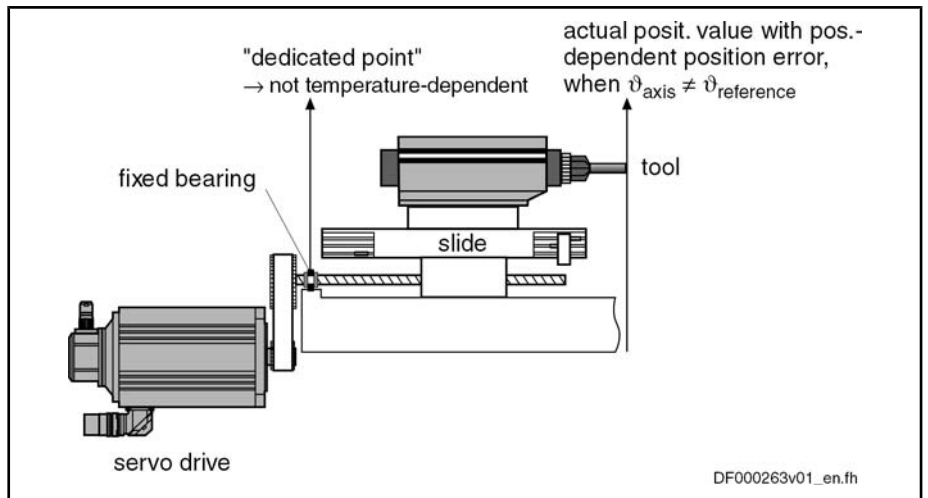


Fig. 8-32: Example of Application for Position-Dependent Temperature Error Correction



The actual position value system to be corrected is selected via the respective bit of "P-0-0413, Axis correction control word"

Operating principle of position-dependent temperature error correction:

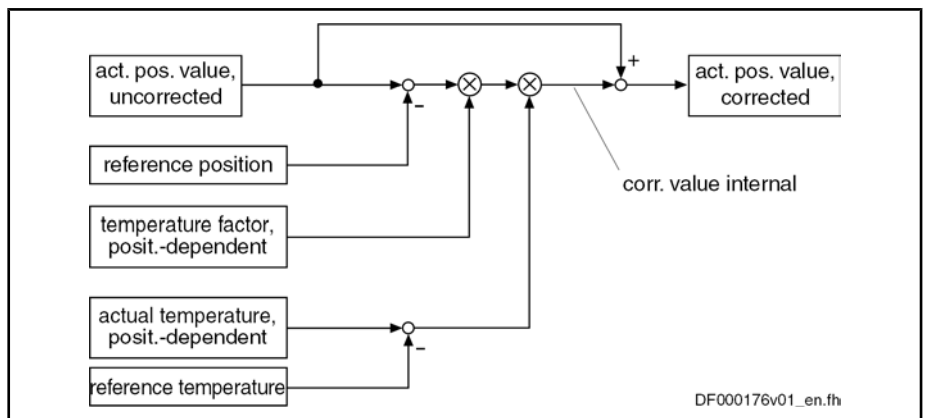


Fig. 8-33: Position-Dependent Temperature Error Correction

When the position data reference was established for the actual position value system, the correction value related to the current actual position value is drive-internally determined as follows:

$$x_{\text{korr}} = [(S-0-0051) - (P-0-0403)] \times [(S-0-0404) - (P-0-0402)] \times P-0-0406$$

- $x_{\text{korr}}$  Correction value, temperature- and position-dependent
- S-0-0051 Position feedback 1 value (or S-0-0053 for position feedback 2)
- P-0-0403 Axis correction dedicated position for temp. corr.
- P-0-0404 Axis correction actual temperature pos.-dependent
- P-0-0402 Axis correction reference temperature
- P-0-0406 Axis correction temperature factor pos.-dependent

Fig. 8-34: Determining the Correction Value, Temperature- and Position-Dependent

Extended Axis Functions

**Determining the Dedicated Position**

For position-dependent temperature error correction, there is an axis position that is not invalidated by variations of temperature. It is the reference position for position-dependent temperature error correction and is entered in "P-0-0403, Axis correction reference position for temp. corr."

Determine the dedicated position by:

- Direct measurement, if the arrangement of the mechanical transmission elements allows unequivocally recognizing the dedicated position
- or -
- A series of measurements with which the actual position value error is measured at axis positions clearly different from the dedicated position (at constant temperature that is clearly different from the reference temperature (P-0-0402))

**Dedicated Position by Means of Series of Measurements**

As in the majority of cases it is impossible to determine the dedicated point by direct measurement, determining the dedicated point by means of a series of measurements is of great importance.

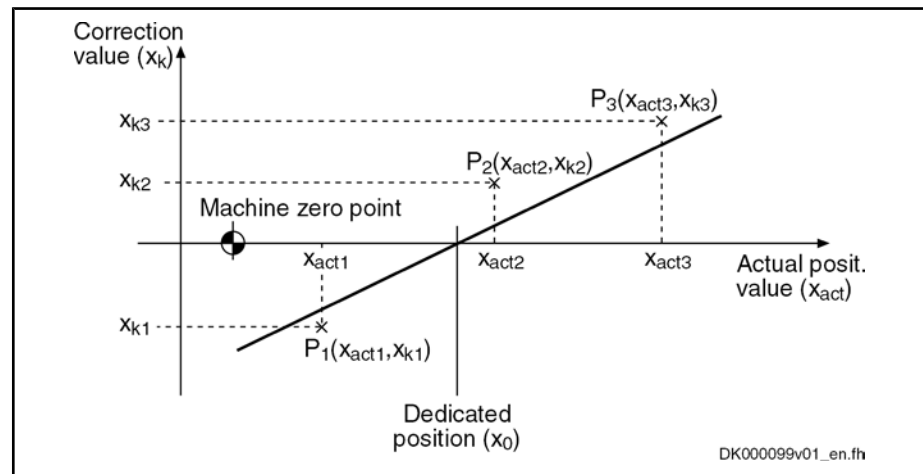


Fig.8-35: Illustration of the Dedicated Position

By means of the measuring points (P<sub>1</sub>, P<sub>2</sub>, P<sub>3</sub>), it is possible to determine the dedicated position by the equation of an approximated straight line:

$$x_0 = \frac{-b}{a}$$

- x<sub>0</sub> Dedicated Position
- b Intersection point of straight line and correction value axis (x<sub>k</sub>)
- a Gradient of the straight line

Fig.8-36: Determining the Dedicated Position

Gradient of the straight line:



$$a = \frac{n \times \sum(x_{act\_n} \times x_{kn}) - \sum x_{act\_n} \times \sum x_{kn}}{n \times \sum(x_{act\_n})^2 - (\sum x_{act\_n})^2}$$

a Gradient of the straight line  
 n Number of measured values  
 x<sub>act\_n</sub> Actual position at which a correction value x<sub>kn</sub> was measured  
 x<sub>kn</sub> Correction value at x<sub>act\_n</sub>

Fig. 8-37: Auxiliary Equation 1 for Determining Dedicated Point

Intersection point of straight line and correction value axis (x<sub>k</sub>):

$$b = \frac{\sum x_{kn} \times \sum(x_{act\_n})^2 - \sum x_{act\_n} \times \sum(x_{act\_n} \times x_{kn})}{n \times \sum(x_{act\_n})^2 - (\sum x_{act\_n})^2}$$

b Intersection point of straight line and correction value axis  
 n Number of measured values  
 x<sub>act\_n</sub> Actual position at which a correction value x<sub>kn</sub> was measured  
 x<sub>kn</sub> Correction value at x<sub>act\_n</sub>

Fig. 8-38: Auxiliary Equation 2 for Determining Dedicated Point

**Example** Measured errors at T<sub>act</sub> = 45°C (reference temperature T<sub>0</sub> = 23°C):

n	X <sub>act_n</sub> (actual pos. value 1) in mm	x <sub>kn</sub> (error) in mm
1	+ 10,0000	- 0,0300
2	+ 70,0000	+ 0,0100
3	+ 105,0000	+ 0,0250

Fig. 8-39: Example of a Series of Measurements for Temperature Error Correction

Resulting measuring points: P = [x = x<sub>act\_n</sub>; x = x<sub>kn</sub>]

- P1 = [+ 10.0 mm; - 0.03 mm]
- P2 = [+ 70.0 mm; + 0.01 mm]
- P3 = [+ 105.0 mm; + 0.025 mm]
- n = 3

Partial sums for auxiliary equations:

$$\begin{aligned} \sum x_{kn} &= (-0,03 + 0,01 + 0,025) \text{ mm} = + 0,005 \text{ mm} \\ \sum x_{act\_n} &= (10,0 + 70,0 + 105) \text{ mm} = 185,0 \text{ mm} \\ \sum(x_{act\_n})^2 &= (10^2 + 70^2 + 105^2) \text{ mm}^2 = 16025 \text{ mm}^2 \\ \sum x_{act\_n} \times x_{kn} &= (-0,3 + 0,7 + 2,625) \text{ mm}^2 = + 3,025 \text{ mm}^2 \end{aligned}$$

Fig. 8-40: Example: Partial Sums for Auxiliary Equations

Extended Axis Functions

$$a = \frac{3 \times 3,025\text{mm}^2 - 185,0\text{mm} \times 0,005\text{mm}}{3 \times 16025\text{mm}^2 - (185,0\text{mm})^2} = \frac{8,15\text{mm}^2}{13850\text{mm}^2} = 0,00058845$$

Fig.8-41: Example: Auxiliary Equation 1

$$b = \frac{0,005 \times 16025\text{mm}^2 - 185,0\text{mm} \times 3,025\text{mm}}{3 \times 16025\text{mm}^2 - (185,0\text{mm})^2} = \frac{-479,5\text{mm}^2}{13850\text{mm}^2} = -0,034621$$

Fig.8-42: Example: Auxiliary Equation 2

$$x_0 = \frac{-(-0,034621)}{0,00058845} = 58,83 \text{ mm}$$

$x_0$  Dedicated Position

Fig.8-43: Example: Determining the Dedicated Position

In order to be able to determine the dedicated position as exactly as possible, several series of measurements should be recorded at different temperatures for position-dependent temperature error correction.

The resulting dedicated position is determined by the arithmetic mean of the calculated dedicated positions.

Position-Dependent Temperature Factor

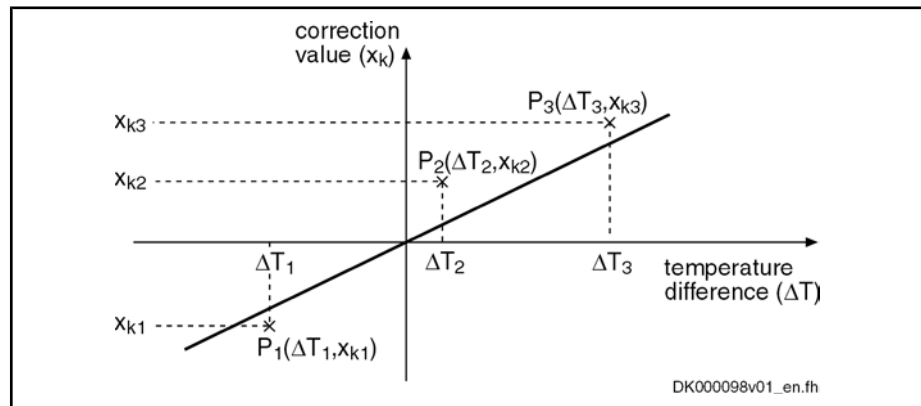
The value for "P-0-0406, Axis correction temperature factor pos.-dependent" is determined

- by means of the data of the mechanical transmission elements
- or -
- by means of series of measurements for actual position value error at different temperatures at an identical axis position.

Temperature Factor by Means of Series of Measurements

To determine the position-dependent temperature factor, it is necessary to record a series of measurements of correction values at different temperatures, at least at one position that clearly differs from the dedicated position.

Depending on the temperature difference, a straight line can be approximated through the measuring points.



$x_{kn}$  Correction value (measured position value – actual position value (S-0-0051/S-0-0053))

$\Delta T_n$  Temperature difference (measured temperature – reference temperature (P-0-0402))

Fig.8-44: Approximated Straight Correction Line on the Basis of Measured Correction Values at Different  $\Delta T$  With Identical Actual Position

The gradient of the approximated straight line is the value of the position-dependent temperature factor. By means of the value from the series of measurements, it is possible to calculate the position-dependent temperature factor:

$$P-0-0406 = \frac{n \times \sum (\Delta T_n \times x_{kn}) - \sum \Delta T_n \times \sum x_{kn}}{n \times \sum \Delta T_n^2 - (\sum \Delta T_n)^2}$$

P-0-0406	Axis correction temperature factor pos.-dependent
n	Number of measured values
$\Delta T_n$	Temperature difference at which the correction value $x_{kn}$ was determined
$x_{kn}$	Correction value at the temperature difference $\Delta T_n$

*Fig. 8-45: Calculating the Position-Dependent Temperature Factor From the Values of the Series of Measurements*

In order to determine the factor as precisely as possible, it is useful to record the series of measurements at several positions.

The resulting temperature factor is determined by the arithmetic mean of the calculated temperature factors.

#### Activating the Function

The position-independent temperature error correction is activated, when the value of "P-0-0406, Axis correction temperature factor pos.-dependent"



When the value in parameter P-0-0406 equals zero, the function of position-dependent temperature error correction is deactivated. This correction function requires position data reference for the measuring system to the corrected!

## 8.5.3 Quadrant Error Correction

### Brief Description



Assignment to functional firmware package, see chapter "Availability of the Extended Axis Functions".

In the case of axis drives that are controlled, for example, in circular interpolation, static friction at the reversal points of the direction of motion can cause distortion of the circular contour.

In order to compensate this contour error at the so-called "quadrant transitions" (velocity reversal), IndraDrive controllers provide the "quadrant error correction" function.

This correction function is useful for such cases when drives are operated in cyclic position control and in circular interpolation by the control master.

#### Pertinent Parameters

- P-0-0100, Position command value extension
- P-0-0435, Control word of position controller
- P-0-0436, Reference radius for quadrant error correction
- P-0-0437, Velocity time range for quadrant error correction
- P-0-0438, Velocity time range for quadrant error correction
- P-0-0439, Table of velocity pulse for quadrant error correction

### Functional Description

For quadrant error correction, static friction possibly occurring at the reversal points of the direction of motion is compensated by adding an additional, pulse-

Extended Axis Functions

**Sinusoidal Position Command Value Profile**

shaped command value to the velocity command value at the output of the position loop. By means of this velocity feedforward, the axis overcomes the static friction faster and with less lag error.

To use quadrant error correction for circular interpolation, it is required that the control master operates two drives in cyclic position control. In this case, the drives are controlled in an interpolating way with sinusoidal position command value profiles with an angular difference, related to the circle, of 90 angular degrees between them. The internally generated velocity command value profiles of the two drives are also sinusoidal and have an offset of 90°.

**Velocity Pulse with Reversal of Direction**

When the direction of motion changes, a triangular velocity pulse with a velocity time range to be set is added to the drive-internal velocity command value.

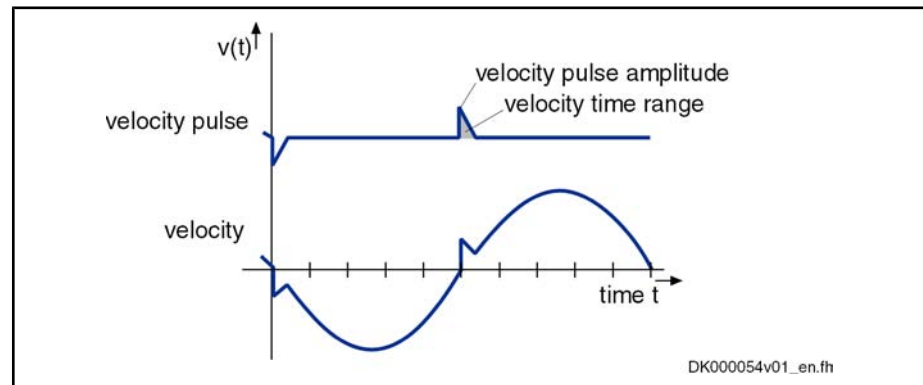


Fig.8-46: Schematic Curves of Velocity Pulse and Velocity Command Value With Quadrant Error Correction

The controller detects changes in the direction of motion by the time flow of the cyclic position command values.

**Reference Circle, Reference Radius**

The settings for quadrant error correction are made when a reference circle is processed (radius of reference circle in "P-0-0436, Reference radius for quadrant error correction"), e.g. the circle that is demanded for the reference piece.

The amplitude of the velocity pulse of quadrant error correction is preset depending on the circular velocity. The pulse is added abruptly and decreases in a ramp-like way.

The higher the path velocity, the higher the pulse and the steeper it approaches zero, because the velocity time range of the pulse is independent of the velocity. It corresponds to the value entered in "P-0-0437, Velocity time range for quadrant error correction".

**Estimation for the Velocity Time Range**

For the dimensioning of P-0-0437, it is recommended to estimate the required pulse amplitude and the duration of the pulse. This should be done with regard to the path velocity and the duration for processing the reference circle (P-0-0436):

$$P-0-0437 = \frac{1}{2} \times \frac{a}{100\%} \times v_{\text{path}} \times \frac{b}{100\%} \times T_{\text{circle}}$$

- P-0-0437 Velocity time range for quadrant error correction
- a percentage of path velocity
- $v_{\text{path}}$  path velocity
- b percentage of duration for processing of circle contour
- $T_{\text{circle}}$  duration for processing of circle contour

Fig.8-47: Estimation for Value of P-0-0437

By means of list parameters, the circular velocities and velocity pulse amplitudes are assigned to one another:

- P-0-0438, Velocity time range for quadrant error correction
- P-0-0439, Table of velocity pulse for quadrant error correction

It is possible to store 20 pairs of values for velocity and pulse amplitude in the mentioned parameters, the velocities have to be entered in ascending order.

#### Determining the Velocity Pulse Amplitude

The velocity pulse amplitude to be assigned to a current circular velocity is determined by means of the list parameter values:

- Between 2 pairs of values the pulse amplitude is interpolated in linear form, depending on the current path velocity.
- Below the lowest path velocity the pulse amplitude is set to zero.
- Above the highest path velocity the pulse amplitude assigned to the highest path velocity continues to take effect.

#### Determining the Current Circular Velocity

The controller calculates the current circular velocity by means of the current acceleration command value of the drive calculated from the position command values. The reference radius (P-0-0436) is the basis for calculating the path velocity.

If the drive-internal resolution of the calculated acceleration command value is low, quadrant error correction sometimes is without effect. For this case, it is recommended to integrate the extended position command value ("P-0-0100, Position command value extension") in the cyclic master communication. This extends the decimal places of the position command value.



Experience has shown that it is absolutely necessary to integrate the extended position command value (P-0-0100) in the cyclic master communication on the control side!

#### Activating the Quadrant Error Correction

The quadrant error correction is activated by the control master by setting the respective bit of "P-0-0435, Control word of position controller". It is only advantageous to use the function when a circular form is to be machined in the part program.

The correction should be activated at the earliest one clock after the start of circular interpolation so that the velocity pulse won't be added when the drive is starting. Otherwise high velocity pulses damaging the contour could be added, due to the mostly high starting accelerations, when the drive is starting.

For machining other contours, the quadrant error correction should be deactivated. To do this, the respective bit of P-0-0435 should be contained in the cyclic master communication and activated depending on the kind of machining.



The quadrant error correction remains without effect when the value "0" is contained in "P-0-0437, Velocity time range for quadrant error correction".

## Notes on Commissioning

For commissioning it is necessary to move the drive by the control master in cyclic circular interpolation. The quality of the circular form has to be determined, in the ideal case with measuring equipment for circular form testing.

#### Recommended Steps of Commissioning

The quadrant error correction should be commissioned in the following steps:

1. Make the following presettings:

## Extended Axis Functions

- Enter value for "P-0-0436, Reference radius for quadrant error correction"
  - Set quadrant error correction inactive in "P-0-0435, Control word of position controller"
  - Set "P-0-0437, Velocity time range for quadrant error correction" to "0"
  - Write 50% and 70% (list lines 1 and 2), for example, of maximum circular velocity to "P-0-0438, Velocity time range for quadrant error correction"
  - Write the value "0" to the first two list lines in "P-0-0439, Table of velocity pulse for quadrant error correction"
2. Move drive on control side in circular interpolation with 50% of maximum circular velocity and check quality of circular form with measuring equipment for circular form testing.
  3. Set quadrant error correction active in "P-0-0435, Control word of position controller"
  4. Write approx. 1% of current path velocity to list line 2 of "P-0-0439, Table of velocity pulse for quadrant error correction".
  5. Increase value in "P-0-0437, Velocity time range for quadrant error correction" starting with low values, observe quality of circular form with measuring equipment; increase values until maximum quality of circular form has been reached.  
  
If quality of circular form does not improve, write lower or higher value to list line 2 of P-0-0439, depending on tendency of improvement of circular form quality.
  6. After optimum value was written to P-0-0437, operate drive with other, different circular velocities in order to determine optimum values for P-0-0439.



Observe interpolation data (see above) for the velocity pulse amplitude depending on the current path velocities (P-0-0438 and P-0-0439)!

## 8.5.4 Cogging Torque Compensation

### Brief Description



Assignment to functional firmware package, see chapter "Availability of the Extended Axis Functions".

Motors for which the magnetic excitation is realized with permanent magnets (e.g. synchronous motors) in many cases show cogging torques or cogging forces. Cogging torques/cogging forces already act on the moving component of the motor in the de-energized state and aim at moving it to a stable position.

When the motor is put into motion by control, the cogging torques/cogging forces act on the motor in a decelerating or accelerating way, according to the position. For applications in which minimum lag error or very constant velocity is important, the position-dependent cogging torques/cogging forces can have a negative effect.

To improve the synchronous operation and lag error behavior of synchronous motors, IndraDrive controllers provide cogging torque and cogging force compensation for drives with high demands on lag error and synchronous operation

	quality. For this purpose, additive torque command values take effect in drive control in a position-dependent way.
<b>Hardware Requirements</b>	The compensation of cogging torque/cogging force is possible for the use of both measuring systems with absolute evaluation and measuring systems with relative evaluation. The following restriction applies to relative measuring systems: <ul style="list-style-type: none"> <li>• The position measuring range may have only <b>one</b> reference mark or it is equipped with distance-coded reference marks!</li> </ul>
<b>Pertinent Parameters</b>	<ul style="list-style-type: none"> <li>• P-0-0162, C1800 Command Drive optimization / command value box</li> <li>• P-0-0165, Drive optimization, control word</li> <li>• P-0-0170, Drive optimization, acceleration</li> <li>• P-0-0171, Drive optimization, velocity</li> <li>• P-0-1130, Table of cogging torque compensation values pos. Direction</li> <li>• P-0-1131, Control word of cogging torque compensation</li> <li>• P-0-1132, Table of cogging torque compensation values neg. direction</li> <li>• P-0-1133, Status word of cogging torque compensation</li> <li>• P-0-1134, Velocity threshold for attenuation of detent cogging compens</li> <li>• P-0-1135, Velocity threshold for switching off cogging torque compens.</li> <li>• P-0-1136, Lead time cogging torque compensation</li> <li>• P-0-1138, C4800 Command Determine cogging torque compensation table</li> </ul>
<b>Pertinent Diagnostic Messages</b>	<ul style="list-style-type: none"> <li>• C1808 Drive not homed</li> <li>• C4800 Command Determine cogging torque compensation table</li> <li>• C4801 Cogging torque compensation: Measuring vel. too high</li> <li>• C4802 Cogging torque compensation: Measuring vel. too low</li> <li>• C4803 Cogging torque compensation: Inadmissible acceleration</li> <li>• C4804 Cogging torque comp: Err. when storing corr. val table</li> <li>• C4805 Cogging torque comp.: Motor measuring system not homed</li> </ul>

## Functional Description

The compensation of cogging torque/cogging force through the IndraDrive firmware is carried out in two steps:

1. Recording and storing of the position-dependent cogging behavior via motor revolution or pole pair distance and generating position-dependent torque and force correction values for the compensation of the cogging behavior.

**Note:** In most cases, the travel range of linear motors covers several pole pair distances. It is assumed that the position-dependent cogging force curve is the same over all pole pair distances of the travel range!

2. Activation of the cogging torque compensation within a velocity range of the drive

<b>Recording of the Cogging Behavior</b>	The cogging behavior of a motor is recorded at constant velocity, once at initial commissioning. The torque/force command values currently generated by the velocity loop are recorded position-dependent within a measured value detection range.
--	--

For non-absolute motor measuring systems, the reference marker of the encoder must be identified once before starting the measured value recording.

## Extended Axis Functions

The command value for the motion for measured value detection must be generated by the control master.

The detection of the value tables for cogging torque compensation can be carried out internally through activation of parameter "P-0-0162, C1800 Command Drive optimization / command value box". In this case, the command value for the motion for measured value detection is generated internally. However, for mechanically connected axes the required velocity command value can also be set by the control master.

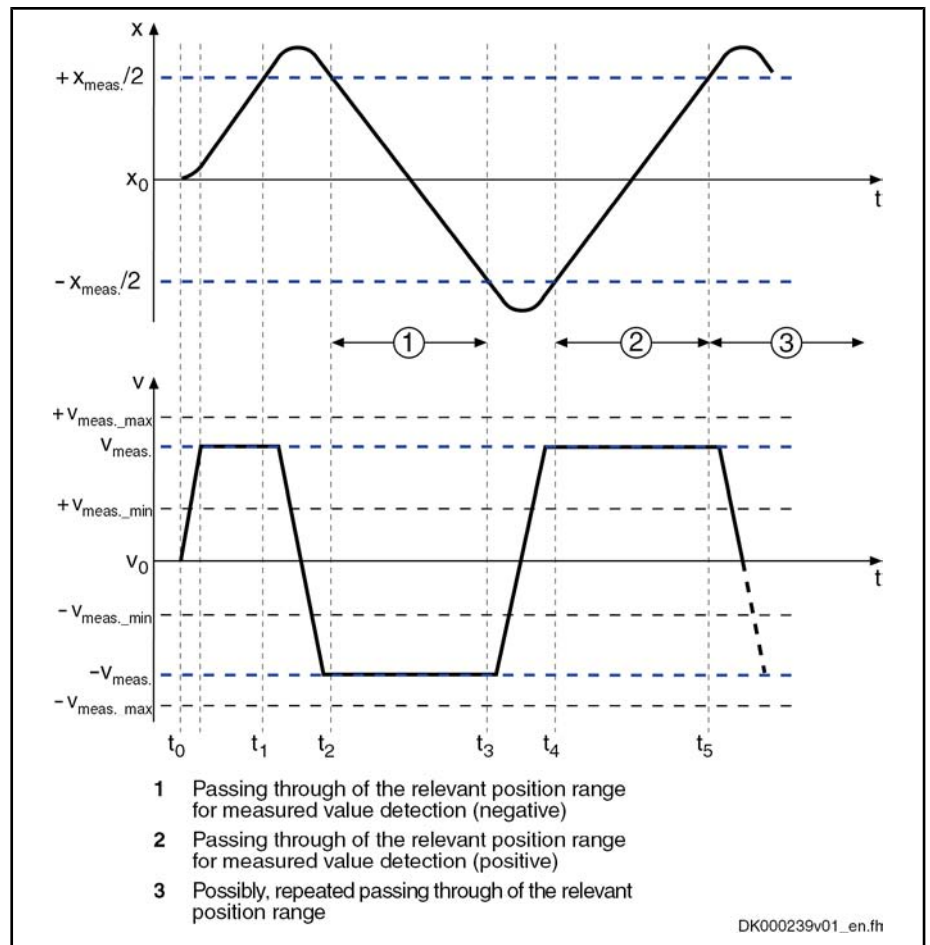
The command value must meet the following requirements:

- Rotary motor → Motion over minimum one motor revolution is required.
- Linear motor → Motion over minimum one pole pair distance is required.
- The measured value detection is only possible for constant velocity; the measured velocity must be selected within the permitted value range, dependent on the set performance (see below).
- If the drive must move both in positive and negative direction, it is necessary to include measured values for positive and negative direction of motion. For single-direction movement, only command values for the intended direction of movement are required.
- The controller divides the range of measured value detection (motor revolution or pole pair distance) into a position raster with 1024 sections. For every section of the raster, a compensation value is stored that has been determined via 40 measured values. Depending on the selected measured value velocity, the detection range must be passed maximum 40 times and minimum once in every required direction of motion.

**Command Value Curve for Bidirectional Measured Value Detection**


The figure below illustrates the position command value - to be preset by the control master - for measured value detection for cogging torque compensation in case that the drive must move in both directions.






$x_0$  position at starting point of time for the execution of the command  
 $x_{meas}$  measuring distance  
 $v_{meas}$  velocity during measuring value detection

Fig. 8-48: Position Command Value Curve for Bidirectional Detection of the Measured Values for Cogging Torque Compensation

 The position at the time of command start ( $x_0$ ) is automatically set to the middle of the position range for measured value detection! On activation of the command "C4800 Command Determine cogging torque compensation table" the axis must be located in sufficient distance to the limits of the travel range!

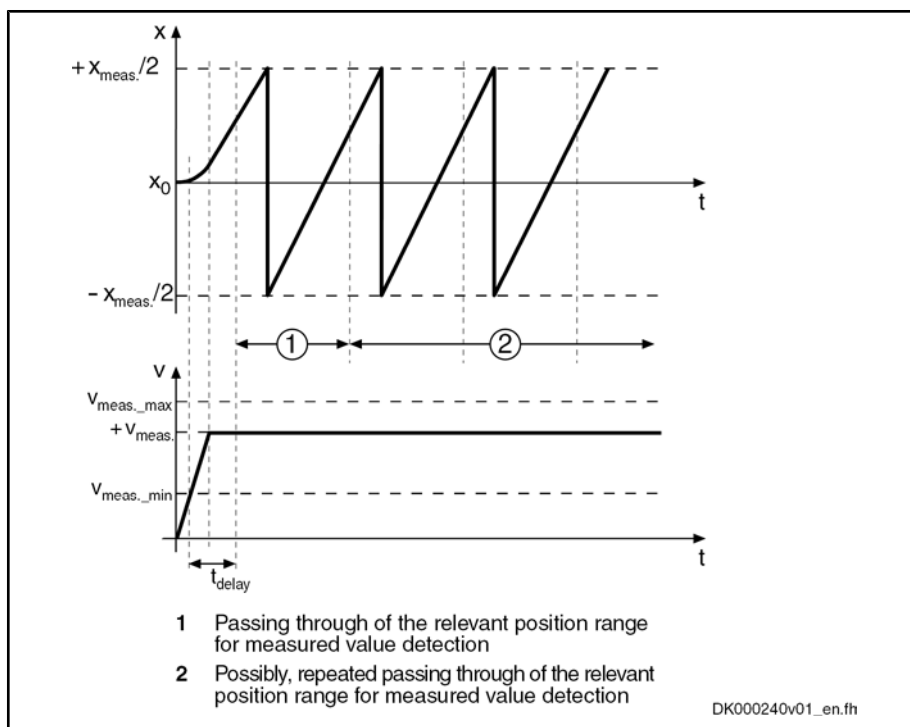
 Measured value detection in both directions must be carried out in compliance with the following requirements:

- Axis has **no** modulo scaling
- or -
- Axis with "modulo" scaling and command value mode "shortest distance" (see below "Notes on Commissioning")

**Command Value Curve for Unidirectional Measured Value Detection**

The figure below illustrates the position command value - to be preset by the control master - for measured value detection for cogging torque compensation in case that the drive is to move in one direction .

Extended Axis Functions



$x_0$  position at starting point of time for the execution of the command  
 $x_{meas}$  measuring distance  
 $v_{meas}$  velocity during measuring value detection  
 $t_{delay}$  delay period of 0.5 s before detection of the measured values

Fig. 8-49: Position Command Value Curve for Unidirectional Detection of the Measured Values for Cogging Torque Compensation



The unidirectional detection of the measured values for the table for cogging torque compensation is carried out in that direction which corresponds to the preceding sign of the command value, which has been recognized for the first time after activation of the command "C4800 Command Determine cogging torque compensation table".



Measured value detection can only be carried out in one direction in compliance with the following requirements:

- Axis with "modulo" and command value mode "positive direction" or "negative direction"

**Value Range of the Measured Value Velocity**

The measuring velocity refers to the motor output shaft or the slide of the linear motor. For load reference the command value input is to be selected such that the motor-side velocity lies in the permitted value range! The value range depends on the selected control performance.

Extended Axis Functions

	Minimum measuring velocity		Maximum measuring velocity	
	V <sub>meas_min</sub>		V <sub>meas_max</sub>	
Performance	Rotary (in 1/min)	Linear <sup>1)</sup> (in mm/min)	Rotary (in 1/min)	Linear <sup>1)</sup> (in mm/min)
<b>Economy</b>	0,47	35,16	58,6	4394,5
<b>Basic</b>	0,94	70,31	117,2	8789,1
<b>Advanced</b>	1,88	140,63	234,4	17578,1

1) Velocity for linear motors with a pole pair distance of 75 mm  
 Fig. 8-50: Value Range for the Measuring Velocity in Dependency of the set Performance



When the maximum measuring velocity is used, the range for the measuring value detection must be passed at least 40 times, for minimum measuring velocity at least once.

**Detection of the Correction Values**

Ideally, the cogging torque correction values of a motor should be determined when the machine has not yet been connected.

After recording the 40 required measured values within each position raster section, a torque/force correction value for each of these position sections is determined and stored in the cogging torque compensation tables. Every table has 1024 values and is stored in the parameters below:

- P-0-1130, Table of cogging torque compensation values pos. Direction
- P-0-1132, Table of cogging torque compensation values neg. direction



In "P-0-1133, Status word of cogging torque compensation" it is displayed whether the required number of measurings per position raster has been reached.

**Determination for Motor Axis Group**

If, for example, the cogging torques for a rotary synchronous kit motor are to be compensated, the recording of the values for the tables for cogging torque compensation is only possible in the motor axis group as the motor is only operational after it has been installed in the machine or the axis.

If a kit motor moves a shaft, which is not rotationally symmetrical (unbalanced), and its cogging torques are to be compensated, the influence of the rotor-position-dependent inertia can be drive-internally eliminated from the measured compensation tables by means of calculation. The settings required for this must be executed in "P-0-1131, Control word of cogging torque compensation".



The influence of an unbalanced mass can only be eliminated when the unbalance occurs periodically with reference to a rotor revolution!

For linear synchronous motors (kit motors), too, recording of the cogging torque compensation tables is only possible in the motor axis group, but eliminating axis-side influences does not make sense because the measured values of the compensation tables only refer to one pole pair, but the travel distance normally covers many pole pairs!

**Activation of the Cogging Torque Compensation**

The cogging torque compensation must be activated via the respective bit of "P-0-1131, Control word of cogging torque compensation". For absolute motor encoders, the compensation function is immediately active. For non-absolute

## Extended Axis Functions

motor encoders, the compensation function can only become active after the reference marker has been read.

Position-dependent adding of torque/force correction values, as is required for cogging torque compensation, is carried out below the adjustable velocity threshold in "P-0-1134, Velocity threshold for attenuation of detent cogging compensens" with full effectiveness of the correction values (100%).

Above the switch-off velocity threshold in "P-0-1135, Velocity threshold for switching off cogging torque compensens." which can be set, the compensation is totally ineffective (0%), because delays due to calculating time might possibly worsen the motor's cogging torque. Between the lower and the upper velocity threshold, the effectiveness of the correction values is linearly reduced from 100% to 0%, depending on the actual velocity value.

In the case of low speeds, intermediate values interpolated to the position are generated from neighboring correction values of the position raster in order to keep the changes of the additive torque/force command values as small as possible.

## Notes on Commissioning

## Initial Commissioning

## General Conditions

The values for the cogging torque compensation table are determined during first commissioning of the motor. If possible, the motor should not yet be connected to the machine for this!

If the motor, as is obligatory for kit motors, has already been mounted at or in the axis, it should preferably be able to move in a load-free way!



After or at replacement of the motor or the motor encoder, the values for the cogging torque compensation table must be re-determined!

The requirements below must be fulfilled before recording the measuring values for the cogging torque compensation table via the controller:

- With relative motor encoders with one reference marker, this reference marker has been read once.
- With relative motor encoders with distance-coded reference markers, two neighboring markers have been read.



With absolute motor encoders, no motion of the axis is required before measuring value detection.

## Notes on Commutation Setting

The commutation offset (for synchronous motors) must have been optimized and, for relative motor encoders, stored with relation to the reference point! The cogging torque compensation will only lead to an improvement of the motor characteristics if the commutation offset is the same so that it can be reproduced (Use "Optimum commutation setting with regard to reference point" for relative motor encoder!).

## Notes on Velocity and Position Loop Setting

In addition, the parameters of the velocity and position loop must have been optimized for the axis, in order for the determination of the correction values for the cogging torque compensation table to be carried out with the appropriate or required control loop gains or filter settings for the axis.

## Internal Determination of the Correction Values for the Cogging Torque Compensation

Through activation of "P-0-0162, C1800 Command Drive optimization / command value box" and with appropriate setting in "P-0-0165, Drive optimization, control word" the controller itself generates the curve of the velocity command value for the determination of the correction values.

Depending on the motor design (rotary or linear) the controller generates a velocity command value curve that causes a movement via motor revolution (rotary) or via a polar pair distance (linear) (see figures above). The travel velocity is preset by the user via "P-0-0171, Drive optimization, velocity" and must be set according to the permitted value range (see above). The maximum acceleration occurring in the command value range is preset via "P-0-0170, Drive optimization, acceleration" and can be limited by the user to a value permitted for the mechanical axis system.

**CAUTION**

**The axis performs independent movements → Property damage might occur on inobservance of the general conditions when starting the command C1800!**

→ Ensure that axis does not reach the collision area through internal command value by setting an appropriate initial position!

→ Select a high acceleration value, in order to reach a constant velocity command value over the shortest possible distance! This minimizes the travel distance if the motion is carried out in both directions.

---

**Master-Side Command Value Input  
for Determination of the Correction  
Values**

With mechanically connected axes, the command value curve for recording the cogging torque compensation tables can only be preset by the control master. For this purpose, a routine must be available at the control which provides the required velocity command value for the axes to travel.

**Determine Velocity for Measuring  
Value Detection**

The velocity for measuring value detection is to be determined according to the requirements of the above table ("Value Range for the Measuring Velocity"). With maximum velocity, passing the measuring value range up to 40 times may become necessary!

The minimum travel range of the motor is to be evaluated and a master-side command value profile is to be defined (programmed) such that the motor passes through the measuring value detection range an adequate number of times. The following applies to the direction of movement:

- Bidirectional for motion of the axis both positive and negative direction (starting position is the centre of the measuring value detection range)
- Unidirectional in the direction of axis movement with movement of the axis in only one direction

**Traveling the Command Value Profile**

For recording the values for the cogging torque compensation tables, "P-0-1138, C4800 Command Determine cogging torque compensation table" must be activated and the required command value profile must be set.



For recording the values for the cogging torque compensation table for axes with position scaling "modulo" (setting in S-0-0076) the following conditions must be taken into consideration:

- If in the parameter "S-0-0393, Command value mode" the option "shortest distance" has been set, the controller expects command values for both motion directions of the motor ("bidirectional").
- If in "S-0-0393, Command value mode" the option "positive direction" or "negative direction" has been set, the controller expects that the axis has only one permitted motion direction and therefore command values are only preset for one motion direction ("unidirectional").

---

During the motion according to the command value input, measuring values are recorded, from which the values for the correction tables are determined. In "P-0-1133, Status word of cogging torque compensation" it is displayed when

## Extended Axis Functions

enough measuring values have been recorded in order to complete the command value input.

After completion of the measuring value recording, the correction values for the cogging torque compensation table are automatically determined and appropriately stored in the position raster. Now the execution of the command C4800 can be terminated.



During the recording of measured values, "C48" flashes on the display. As soon as the measuring value recording is completed, the flashing is also stopped and "C48" is displayed continuously!

## Checking the Effectiveness

The effectiveness of the cogging torque compensation can be evaluated with the comparison of various status variables of the drive between active and non-active function. With low travel speeds the effect of the compensation can be recognised most clearly.

The values of the status variables relevant for the comparison are stored in the parameters below:

- S-0-0040, Velocity feedback value
- S-0-0189, Following distance
- P-0-0049, Effective torque/force command value

## Activating the Function

Cogging torque compensation is activated by setting the corresponding bit in "P-0-1131, Control word of cogging torque compensation"!

The velocity threshold for attenuation or for switching off of the cogging torque compensation are to be determined in the parameters below:

- P-0-1134, Velocity threshold for attenuation of detent cogging compens
- P-0-1135, Velocity threshold for switching off cogging torque compens.

For this purpose, the control master has to control the axis, e.g. in position control, with command value characteristics which result in constant axis velocities of different level. The amplitude of the above stated state variables must be evaluated without and with active cogging torque compensation. The values for P-0-1134 and P-0-1135 are to be determined such that the amplitudes have minimum values **with active compensation**.



The velocity range in which it is advantageous to use cogging torque compensation can be increased by adjusting the value "P-0-1136, Lead time cogging torque compensation", if necessary!

## Possible Problems During Measured Value Recording

In case the command value does not comply with the requirements (see above), measured value recording is stopped and the execution of the command is aborted with the corresponding error message:

- C4801 Cogging torque compensation: Measuring vel. too high
- C4802 Cogging torque compensation: Measuring vel. too low
- C4803 Cogging torque compensation: Inadmissible acceleration

If an error occurs when cogging torque compensation table is stored, the following message is generated:

- C4804 Cogging torque comp: Err. when storing corr. val table

If, with a relative motor encoder, the drive has not read the reference marker(s) on activation of the command C4800, the following message is generated:

- C1808 Drive not homed

### Activation

#### Operating the Drive with Cogging Torque Compensation

For the operation of the drive with active cogging torque compensation, the respective bit must be set in "P-0-1131, Control word of cogging torque compensation". Compensation only becomes active if the controller has read the reference marking of a relative motor encoder or two neighboring reference markings or a relative, distance-coded motor encoder. For absolute motor encoders, the compensation function is immediately active!

With synchronous motors with relative motor encoder the option "Optimum commutation setting with regard to reference point" is to be used for determining the commutation offset. Otherwise, the cogging torque compensation will not generate any position-dependent reproducible correction values, which results in a reduced quality of the cogging torque compensation!

## 8.6 Correction of the Torque/Force Constant

### 8.6.1 Brief Description

#### Fields of Application



**Base package** of all firmware versions in **closed-loop** characteristic

#### Displaying the Motor Load, Load Limit Values

With IndraDrive devices, the current motor load is determined on the drive side and displayed. The load can be limited via the controller.

You can select the unit of the load display and of the limit value input:

- Percentage-based, related to the continuous motor current or nominal motor current
- Physical, values in "Nm" (rotary) or "N" (linear)

The load of the motor is determined by means of the measured motor current; with physical scaling, the controller determines the motor torque or force by using the currently flowing current for calculating the motor-type-specific torque or force constant.

If torque/force precision up to approx. +/- 5% is required (e.g., for load limitation) due to the mechanical axis system or process technology, the controller provides the "correction of torque/force constant". In this case, the motor-type-specific value is corrected depending on the current motor current, the motor temperature and the average speed.



Due to the downward compatibility of the firmware and possibly unavailable parameter values (e.g., for third-party motors), this correction must be separately activated!

#### Pertinent Parameters

- P-0-0448, Temperature-dependent torque/force coefficient
- P-0-0449, Speed-dependent torque/force coefficient
- P-0-0450, Current torque/force constant
- P-0-0556, Config word of axis controller
- P-0-3055, Maximum motor torque/force, encoder memory
- P-0-3056, Nominal motor torque/force, encoder memory
- P-0-3057, Speed-dependent torque/force coefficient, encoder memory
- P-0-3058, Temperature-dependent torque/force coefficient, enc. memory

## Extended Axis Functions

- S-0-0533, Nominal torque/force of motor
- S-0-0534, Maximum torque/force of motor

## Pertinent Diagnostic Messages

- None -

## 8.6.2 Functional Description

## Determining the Torque/Force

The torque or force generated by a motor is determined on the drive side by means of the measured motor current and a so-called "torque/force constant":

$\text{Rotary motor: } M_i = K_M * I_q; \quad K_M = f(I_q, \theta)$ $\text{Linear motor: } F_i = K_F * I_q; \quad K_F = f(I_q, \theta)$
---

$M_i$	Inner torque of the rotary motor
$K_M$	Torque constant, current-dependent and temperature-dependent
$I_q$	Motor current, torque-/force-generating component
$F_i$	Inner force of the linear motor
$K_F$	Force constant, current-dependent and temperature-dependent
$\theta$	Motor temperature

*Fig. 8-51: Current Dependence and Temperature Dependence of the Motor Torque or Force*

The so-called "torque or force constant" is not a physically static value, it depends on:

- Value of currently flowing motor current: Reduced when currents are greater than  $I_{\text{nominal}}$
- Temperature of motor winding and rotor: Reduced when temperature rises

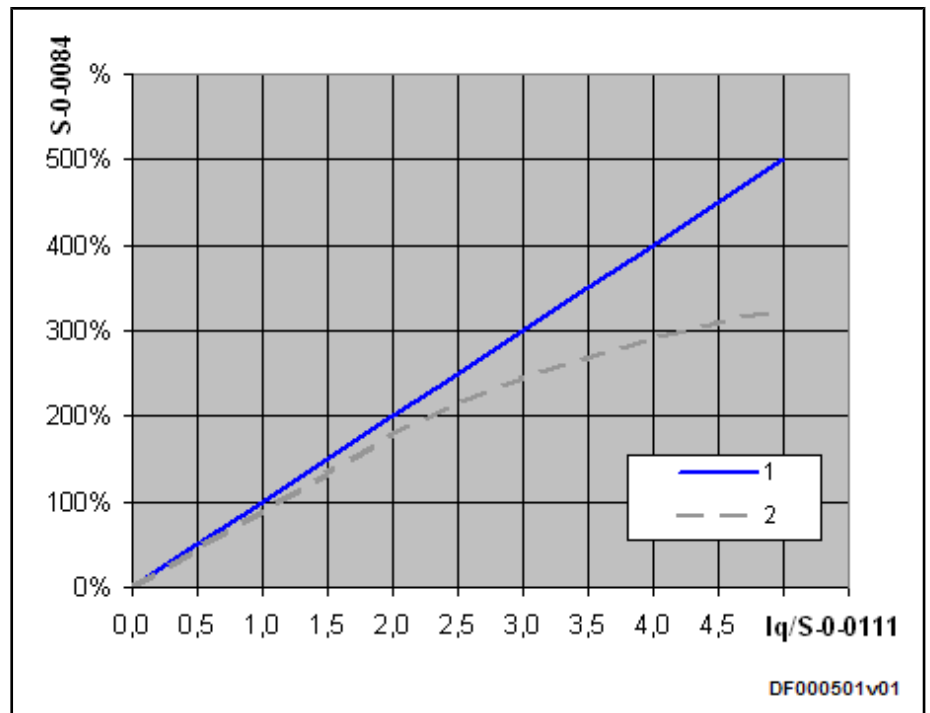
## Percentage-Based Scaling

The percentage-based scaling of torque/force data is the default setting for reasons of compatibility with existing firmware. The percentage value of the drive load and percentage-based limit values are current-related and relate to "S-0-0111, Motor current at standstill".



With percentage-based scaling of the torque/force data, the values are current-related as a matter of principle, the reference value is "S-0-0111, Motor current at standstill" \* "P-0-0051, Torque/force constant".





Graph 1 Current-dependent load, determined on drive side (default, without  $K_M$  correction)  
 Graph 2 Effective, current-dependent load at motor (basic curve shape)  
 $I_q$  Motor current, torque-generating component  
 S-0-0111 Motor current at standstill  
 S-0-0084 Torque/force feedback value in percent  
 Fig. 8-52: Comparison of Torque/Force Curves, on Drive Side and Motor Side, Percentage-Based Scaling, 100%-Value= $P-0-0051 \cdot S-0-0111$

**Physical Scaling**

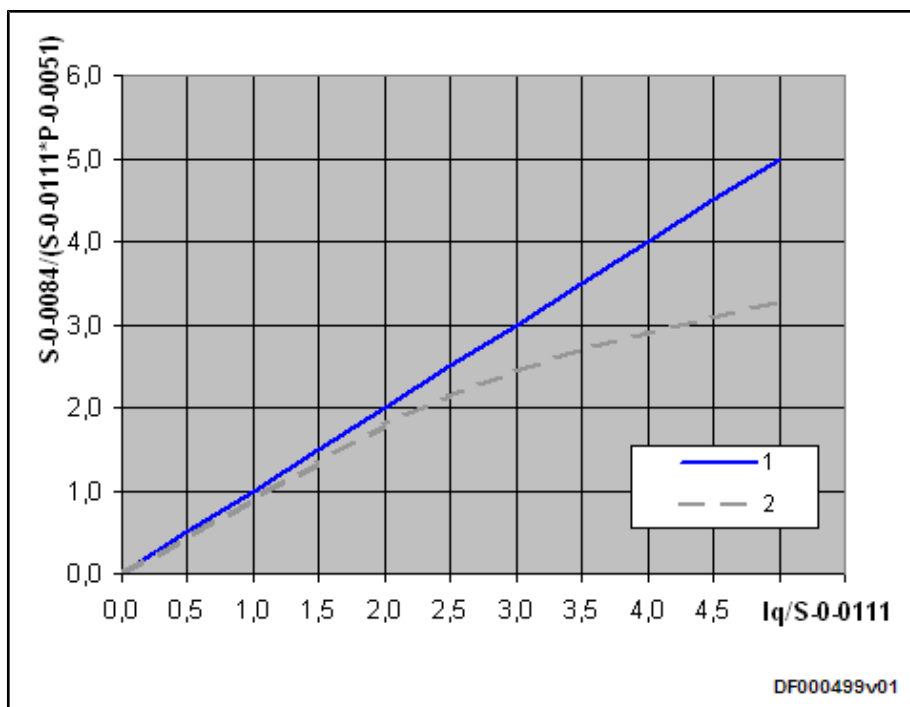
If physical scaling (rotary: Nm; linear: N) is selected due to the setting of load limit values, for example, you have to observe that the load is drive-internally determined in the default status with:

Actual value:	$M_i$ or, $F_i = P-0-0051 \cdot P-0-0043$
Command value:	$M_i$ or, $F_i = P-0-0051 \cdot P-0-0038$

$M_i, F_i$  Inner torque or force of the motor  
 P-0-0051 Nominal value of the torque/force constant, static value, specific to motor type  
 P-0-0043 Torque-generating current, actual value  
 P-0-0038 Torque-generating current, command value  
 Fig. 8-53: Drive-Internal Calculation of Motor Torque or Force (Default)

This drive-internal calculation leads to deviations from the torque or force action at the motor. This has a particularly negative effect when entering torque/force limit values, because the value which the limit value causes at the motor can strongly deviate; this might possibly worsen the drive performance considerably:

Extended Axis Functions

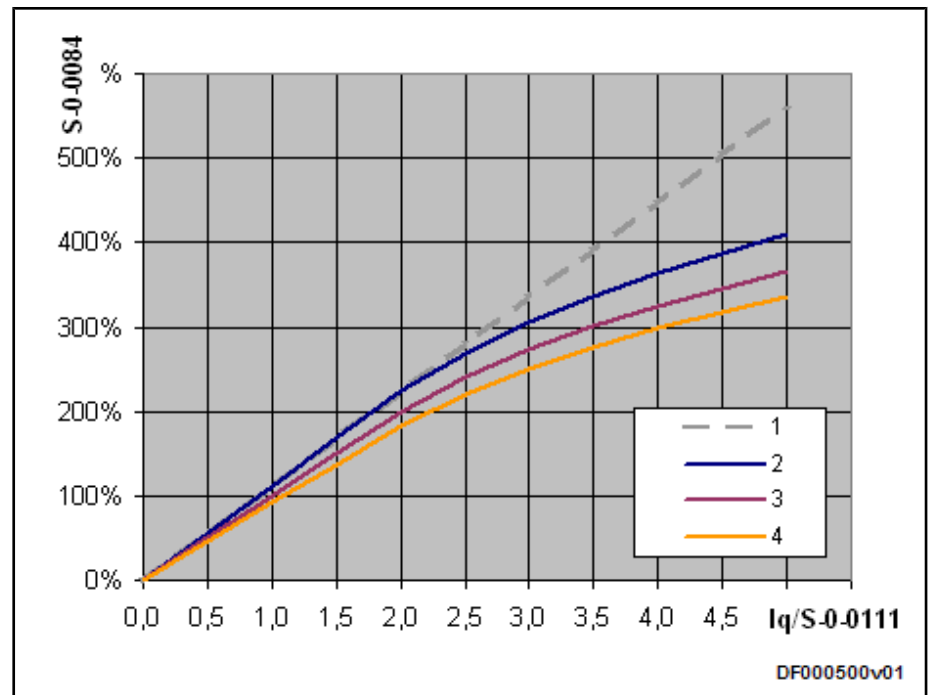


Graph 1 Current-dependent load, determined on drive side (default, without  $K_M$  correction)  
 Graph 2 Effective load at motor (basic curve shape)  
 Iq Motor current, torque-generating component  
 S-0-0111 Motor current at standstill  
 S-0-0084 Torque/force feedback value in Nm or N  
 P-0-0051 Torque/force constant  
 Fig. 8-54: Comparison of Torque/Force Curves, Physical Scaling

**Correction Function**

The "correction of the torque/force constant" can be activated to improve the torque/force precision. The following influences on the torque/force constant are taken into account:

- Magnetic field weakening by magnetic saturation due to increased motor current as compared to nominal current
- Magnetic field weakening by increased motor winding temperature
- Magnetic field weakening by increased rotor temperature depending on the average speed



Graph 1	Load curve without $K_M$ correction (linearly current-dependent with P-0-0051)
Graph 2	Load curve with $K_M$ correction (magnetic saturation taken into account)
Graph 3	Like graph 2, measured winding temperature additionally taken into account (in this case, nominal overtemperature at "S-0-0111, Motor current at standstill")
Graph 4	Like graph 3, speed-dependent motor temperature rise additionally taken into account
S-0-0084	Torque/force feedback value in percent
$I_q$	Motor current, torque-generating component
S-0-0111	Motor current at standstill
Fig. 8-55:	<i>Torque/Force Curves With <math>K_M</math> Correction, Percentage-Based Scaling, 100%-Value=S-0-0533, Nominal Torque/Force of Motor</i>



With percentage-based scaling and active "correction of the torque/force constant", the displayed percentage value, or the percentage-based limitation which was set, relates to "S-0-0533, Nominal torque/force of motor".

The magnetic saturation is taken into account by entering, in "S-0-0534, Maximum torque/force of motor", the maximum torque caused by "S-0-0109, Motor peak current".

The change in the torque/force constant which is due to temperature rise is corrected by:

- Measured winding temperature ("S-0-0383, Motor temperature") and motor-type-dependent value of "P-0-0448, Temperature-dependent torque/force coefficient"
- Dynamically averaged speed (average absolute value) and motor-type-dependent value of "P-0-0449, Speed-dependent torque/force coefficient"



The correction of the torque/force constant only works correctly, when the value of "P-0-0051, Torque/force constant" relates to the ambient temperature 20°C.

## Extended Axis Functions

The value of the currently effective torque/force constant is displayed in

- P-0-0450, Current torque/force constant

**Rexroth Motors**

For the synchronous MSK motors by Rexroth, the parameter values for the correction are defined by the manufacturer and will be made available in the motor encoder memory. For older motors, the values for manual input can be taken from the manufacturer-side "DriveBase" database.

**Third-Party Motors**

The torque/force constant can be corrected for third-party motors, too. It is not obligatory to correct all of the mentioned influences. However, it is recommended that you correct the magnetic saturation, because in most of the cases it considerably improves the torque precision. For this purpose, enter the following parameters correctly:

Maximum data:

- "S-0-0109, Motor peak current" and
- "S-0-0534, Maximum torque/force of motor"

Nominal data:

- "S-0-0111, Motor current at standstill" and
- "S-0-0533, Nominal torque/force of motor"

It only makes sense to use the temperature-dependent and speed-dependent correction, when correct values are available or were determined for the required coefficients:

- P-0-0448, Temperature-dependent torque/force coefficient
- P-0-0449, Speed-dependent torque/force coefficient



Depending on the respective precision requirements, it can be necessary to make complex series of measurements at the respective motor while checking the torque at the motor shaft!

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### 8.6.3 Notes on Commissioning

**Activation** You can access the dialogs for activating the correction of the torque/force constant via the "Project Explorer" of "IndraWorks Ds/D/MLD":

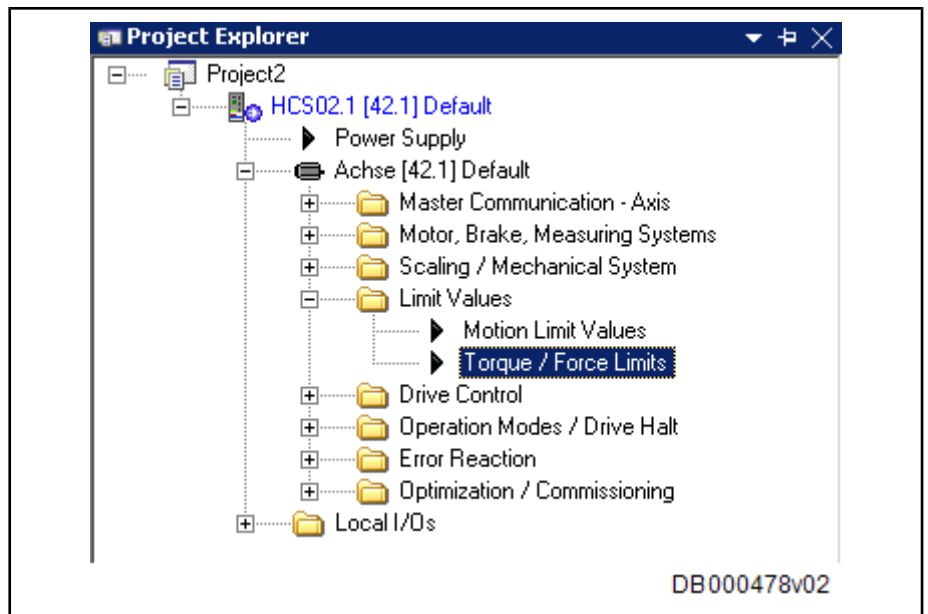


Fig. 8-56: Accessing the Dialog "Torque/Force Limits" in Which You Can Activate the "Correction of the Torque/Force Constant"

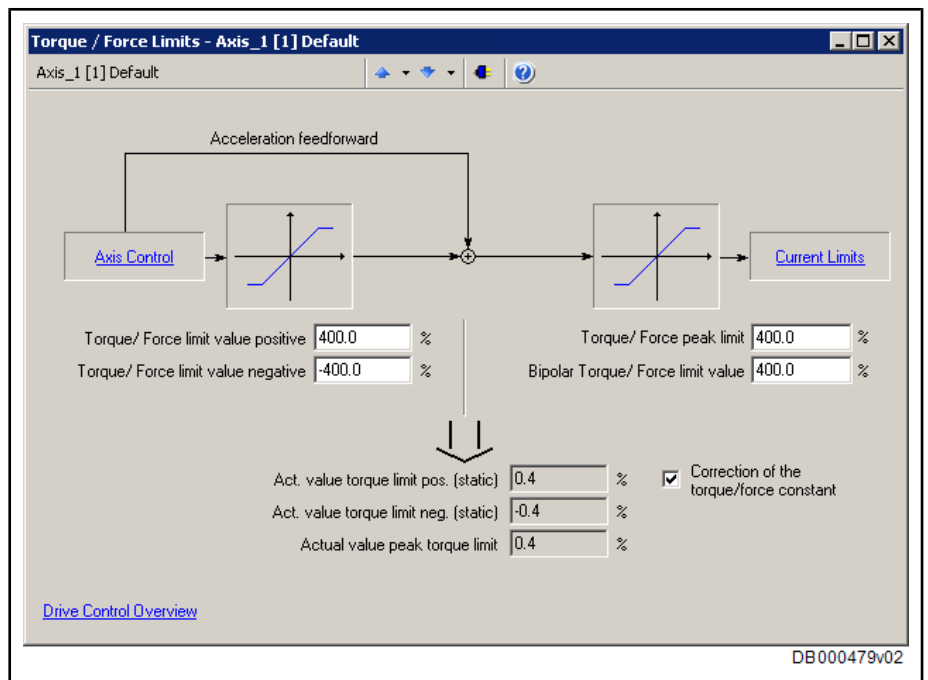


Fig. 8-57: Activating the "Correction of the Torque/Force Constant" in the Torque/Force Limits Dialog (Ticking the Check Box Sets Corresponding Bit of "P-0-0556, Config word of axis controller")

**Parameter Display or Parameter Input**

The corresponding parameters are motor-type-related values. They are displayed in the "Motor" dialog or entered for third-party motors, if necessary:

Extended Axis Functions

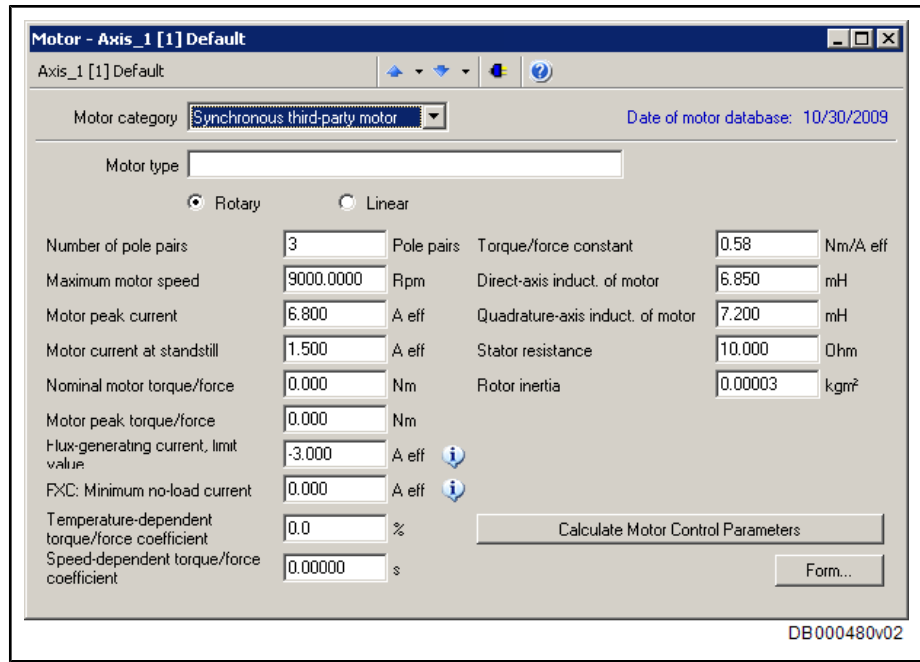


Fig.8-58: Display or Input of Motor-Type-Specific Parameters, Such as Parameters for Correcting the Torque/Force Constant "S-0-0533, Nominal Torque/Force of Motor", "S-0-0534, Maximum Torque/Force of Motor", "P-0-0448, Temperature-Dependent Torque/Force Coefficient" and "P-0-0449, Speed-Dependent Torque/Force Coefficient"

Diagnosis, Status Message

With active correction, the torque/force constant is adjusted in accordance with the current influences and displayed:

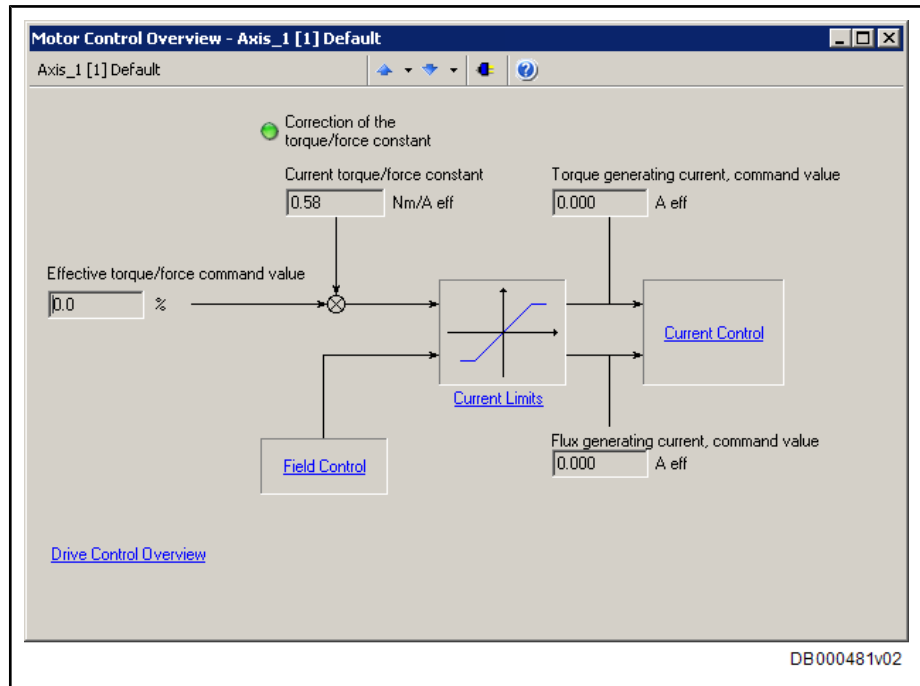


Fig.8-59: Display of Activated Correction of the Torque/Force Constant by Green Marking and Display of Value of Current Torque/Force Constant (P-0-0450, Current Torque/Force Constant)

## 8.7 Measuring Wheel Mode

### 8.7.1 Brief Description



Assignment to functional firmware package, see chapter "Availability of the Extended Axis Functions".

The measuring wheel mode is used for material feed axes, e.g. in sheet-metal machining. For direct measurement of the infeed of moved material, a rotary encoder that is detecting the infeed length is driven via a measuring wheel with frictionally engaged contact to the material surface.

The position control loop is closed via motor encoder and measuring wheel encoder, possible slip between motor and material does not cause incorrect measured values of material length.



The measuring wheel mode may only be activated when contact has been established between measuring wheel and material surface.

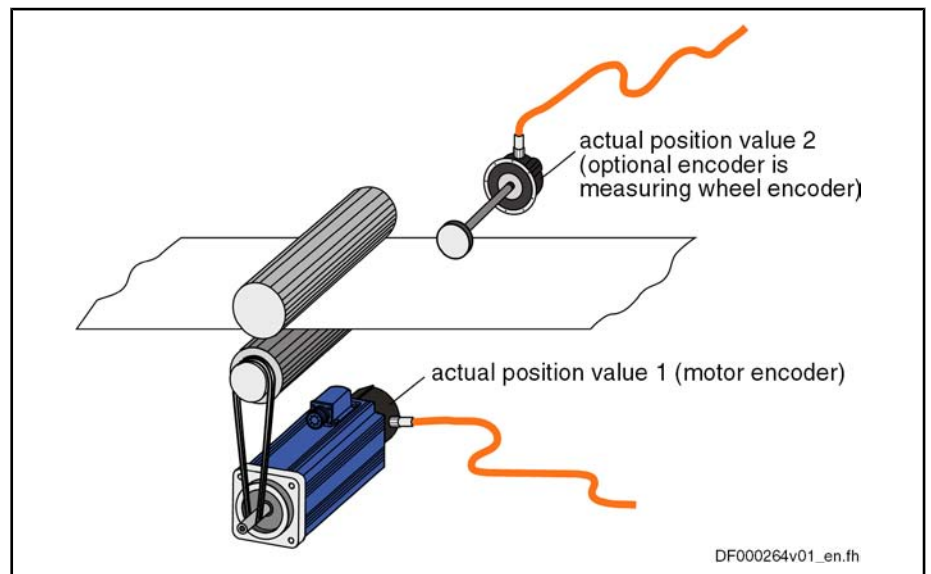


Fig. 8-60: Typical Arrangement of Drive for Material Infeed With Measuring Wheel Encoder

#### Hardware Requirements

The measuring wheel encoder is an optional (external) encoder that is connected according to the connection diagram contained in the "Drive Controllers, Control Sections; Project Planning Manual" separate documentation.

See also Measuring Systems

#### Pertinent Parameters

The following parameters are used to parameterize this function:

- S-0-0520, Control word of axis controller
- S-0-0521, Status word of position loop
- P-0-0241, Actual pos. smoothing time constant for hybrid pos. control
- P-0-0242, Current actual slip value in %
- P-0-0243, Maximum occurred actual slip value in %
- P-0-0244, Monitoring window of slip in %

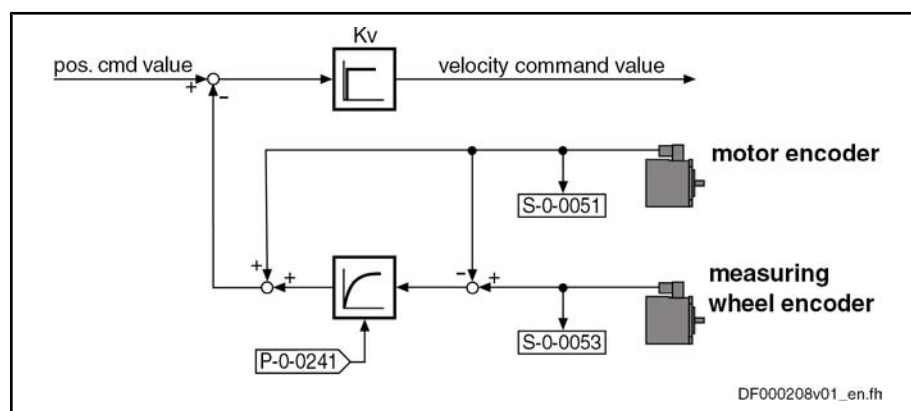
## Extended Axis Functions

The following parameters are used to parameterize the measuring wheel encoder:

- S-0-0115, Position feedback 2 type
  - S-0-0117, Resolution of feedback 2
  - P-0-0123, Feed constant 2 (optional encoder)
  - P-0-0124, Gear 2 load-side (optional encoder)
  - P-0-0125, Gear 2 encoder-side (optional encoder)
  - P-0-0185, Control word of encoder 2 (optional encoder)
- Pertinent Diagnostic Messages
- F2036 Excessive position feedback difference

## 8.7.2 Functional Description

The measuring wheel mode can only be used in operating modes in which the drive is in position control. The actual position value detected by the measuring wheel encoder is added to the actual position value of the motor encoder and is used as "hybrid actual position value" for position control. The difference of both actual position values (by mechanical slip, elasticity, ...) is smoothed via a filter to be set and compensated by addition to the actual position value of the motor encoder.



- S-0-0051 Position feedback 1 value  
 S-0-0053 Position feedback 2 value  
 P-0-0241 Actual pos. smoothing time constant for hybrid pos. control

Fig.8-61: Generating the "Hybrid Actual Position Value" With Measuring Wheel Mode

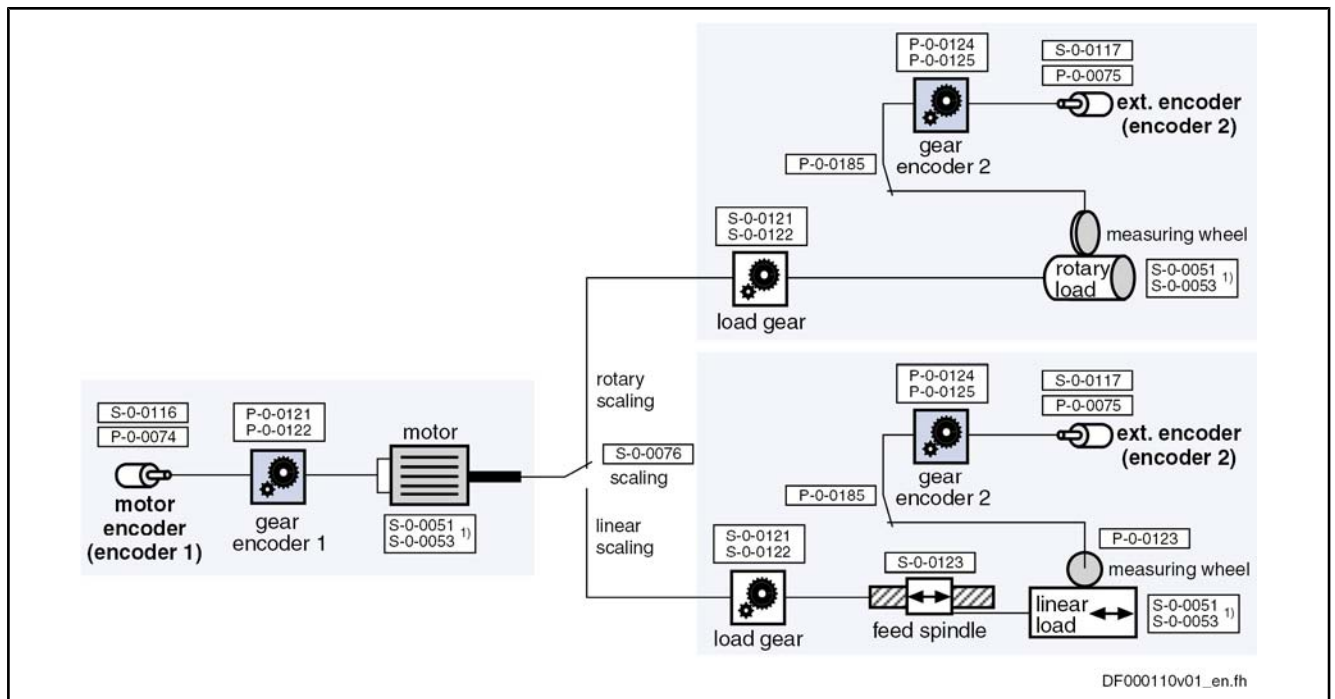
For measuring wheel mode you have to activate the optional encoder in "P-0-0185, Control word of encoder 2 (optional encoder)" as measuring wheel encoder (presetting). The measuring wheel mode itself is switched on by activating the "hybrid actual position value" in "S-0-0520, Control word of axis controller".



By the value "0" in "P-0-0241, Actual pos. smoothing time constant for hybrid pos. control", the actual position value of the motor encoder is ignored and only the actual position value of the measuring wheel encode is used for position control.

The mechanical arrangement of the measuring wheel encoder in the mechanical drive system is illustrated in the figure below:





- 1) S-0-0051/S-0-0053; depending on scaling (S-0-0076)
- S-0-0051 Position feedback 1 value
- S-0-0053 Position feedback 2 value
- S-0-0076 Position data scaling type
- S-0-0116 Feedback 1 Resolution
- S-0-0117 Feedback 2 Resolution
- S-0-0121 Input revolutions of load gear
- S-0-0122 Output revolutions of load gear
- S-0-0123 Feed constant
- P-0-0074 Encoder type 1 (motor encoder)
- P-0-0075 Encoder type 2 (optional encoder)
- P-0-0121 Gear 1 motor-side (motor encoder)
- P-0-0122 Gear 1 encoder-side (motor encoder)
- P-0-0123 Feed constant 2 (optional encoder)
- P-0-0124 Gear 2 load-side (optional encoder)
- P-0-0125 Gear 2 encoder-side (optional encoder)
- P-0-0185 Control word of encoder 2 (optional encoder)

Fig. 8-62: Arrangement of the Measuring Wheel Encoder in the Mechanical Drive System

**Operating Modes and Measuring Wheel Mode**

The measuring wheel mode can only be used in position-controlled operating modes.

**Position Data Reference**

Activating the measuring wheel mode clears a possibly existing position data reference to the axis for both encoders. In measuring wheel mode, the axis can only be moved in a relative way, the control master itself has to establish the position data reference to the material to be fed!

After the measuring wheel mode has been deactivated, the position data reference to the axis, if necessary, has to be established again for relative and absolute encoders.

It is also possible to maintain an existing position data reference of the encoders. For this purpose the relevant bit is to be set in "P-0-0185, Control word of encoder 2 (optional encoder)". The option to maintain the position data reference when activating/deactivating/ the measuring wheel mode can be used only if it is ensured that the mechanical reference of the actual position value

## Extended Axis Functions

from the measuring wheel encoder to the motor encoder or the material to be measured is not shifted.



Risk of machine damage or rejects if the material position is not reflected correctly due to slip effects between material and motor encoder!

As in the position-controlled measuring wheel mode the actual position value of the additional measuring wheel encoder becomes active for control it is required to initialize this actual position value with an appropriate value. The initialization method can be set in "P-0-0185, Control word of encoder 2 (optional encoder)".

- Encoder Initialization Depending on Operation Mode
- Encoder Initialization via Last Encoder Active in Position Control

#### Encoder Initialization Depending on Operation Mode

Depending on the relevant bit of P-0-0185, in position-controlled operation modes, the actual position value of the motor encoder is applied to the actual position value of the measuring wheel encoder when the measuring wheel mode is activated ("S-0-0051, Position feedback value 1" → "S-0-0053, Position feedback value 2").

When switching to a non-position-controlled operation mode while the measuring wheel mode has been activated, the actual position value of the measuring wheel encoder is applied to the actual position value of the motor encoder ("S-0-0053, Position feedback value 2" → "S-0-0051, Position feedback value 1").

In non-position-controlled operating modes control, as a basic principle, takes place with regard to the motor encoder. If first the measuring wheel mode is activated and only then the drive is switched to a position-controlled operation mode, the actual position value of the motor encoder is applied to the actual position value of the measuring wheel encoder ("S-0-0051, Position feedback value 1" → "S-0-0053, Position feedback value 2"), **when the drive is switched to the position-controlled operation mode.**

In non-position-controlled operating modes, it is possible, with active measuring wheel mode, to lift the feed rolls off the material (discharge the feed rolls), for example.

#### Encoder Initialization via Last Encoder Active in Position Control

Depending on the relevant bit of P-0-0185 the actual position values of the motor encoder and the measuring wheel encoder are initialized with the actual position value of the last encoder active in position control, if the position control between the motor encoder and the hybrid actual position value of the two encoders is switched (Switching in S-0-0520, Bit 0). If the hybrid actual position value is not switched to the actual position value of the motor encoder the original initialization of the measuring wheel encoder is maintained.

#### Monitoring the Slip

Due to the measuring wheel mode, slip that can occur between material and drive motor is compensated via the position control. But slip also implies wear in the mechanical drive system and at the material. The controller supports reducing wear by allowing the monitoring of the occurring slip with regard to a maximum allowed value to be set.

The current actual slip value is displayed in "P-0-0242, Current actual slip value in %". It refers to

- One measuring wheel revolution, if the "feed constant 2" is active in P-0-0185 (typical case: measuring wheel is measuring linear infeed)
- or -
- one revolution of the external encoder, if "feed constant 2" is not active in P-0-0185 (encoder is measuring rotary infeed).

If the calculated slip exceeds the value in "P-0-0244, Monitoring window of slip in %" (value unequal

"0"), the slip monitoring function triggers with the error message "F2036 Excessive position feedback difference" and the drive reacts with the error reaction that has been set.

To determine the monitoring window, the maximum occurring slip, e.g. during a machining cycle, is stored in "P-0-0243, Maximum occurred actual slip value in %".



The slip monitor is deactivated with the value "0" in parameter P-0-0244!

### 8.7.3 Notes on Commissioning

#### Presettings

First set the parameter values relevant to the mechanical arrangement of motor, motor encoder, axis and measuring wheel (see fig. "Arrangement of the Measuring Wheel Encoder in the Mechanical Drive System"). In addition, configure "P-0-0185, Control word of encoder 2 (optional encoder)" in such a way that the external (optional) encoder is used as "measuring wheel encoder".

#### Activating the Measuring Wheel

Mode



CAUTION

**Property damage caused by uncontrolled drive motion if measuring wheel encoder or feed motor do not have contact to the material!**

→ Only activate measuring wheel mode, if the measuring wheel is moved by the material in a frictionally engaged way!

The measuring wheel mode is switched on by activating the "hybrid actual position value" in "S-0-0520, Control word of axis controller". As a prerequisite, the drive has to be in a position-controlled operating mode.

As the possibly existing position data reference of both encoders to the axis gets lost, the control master can only move the drive with relative (material-related) position command value. The position data reference to the material has to be established on the control side by means of the actual position value of motor encoder or measuring wheel encoder transmitted by the drive and an installation-side signal!

#### Deactivating the Measuring Wheel

Mode

The measuring wheel mode can be deactivated by

- Deactivating the "hybrid actual position value" in "S-0-0520, Control word of axis controller"
- switching to communication phase P2 (or parameter mode),
- switching the drive off.

If position data reference of the encoders to the axis should be required, it must be established again after the measuring wheel mode has been deactivated!

#### Setting the Jerk Attenuation

Jerky slip phenomena can be attenuated by entering a value greater than zero in "P-0-0241, Actual pos. smoothing time constant for hybrid pos. control".



The value "0" in P-0-0241 switches off the attenuation and causes only the actual position value of the optional measuring wheel encoder to be effective.

#### Procedure:

1. Enter value "0" in P-0-0241 and move axis at low infeed velocity.
2. Increase infeed velocity up to maximum velocity.

## Extended Axis Functions

While increasing the velocity also increase the value of P-0-0241, if necessary, in order to achieve a satisfactory compromise of smoothness of running and positioning velocity (e.g. for cutting material into sections) (watch "P-0-0038, Torque-generating current, command value").

**Slip Monitoring with Measuring Wheel Mode**

The slip monitor with active measuring wheel mode is activated by entering a value greater zero in "P-0-0244, Monitoring window of slip in %".



The value "0" in parameter P-0-0244 causes the slip monitor to be switched off! The value in "P-0-0242, Current actual slip value in %" is then is no longer reset after each revolution of measuring wheel or external encoder, but the total slip since the deactivation of the slip monitor is displayed (possibly continuously increasing value).

**Procedure:**

1. First enter high value in "P-0-0244, Monitoring window of slip in %" so that slip monitor cannot be triggered.
2. Enter value "0" in "P-0-0243, Maximum occurred actual slip value in %" and run complete positioning cycle of axis with maximum infeed velocity several times, if necessary.
3. After having cyclically moved axis, read parameter P-0-0243 and enter value, multiplied by a safety factor (e.g. "2"), in "P-0-0244, Monitoring window of slip in %".

If the value in "P-0-0242, Current actual slip value in %" exceeds the value of P-0-0244, the controller generates the error message "F2036 Excessive position feedback difference" and the drive reacts with the error reaction that has been set.

## 8.8 Positive Stop Drive Procedure

### 8.8.1 Brief Description



Assignment to functional firmware package, see chapter "Availability of the Extended Axis Functions".

For special applications, it is required to move machine axes operated in position or velocity control up to a limit stop in order to generate forces of pressure.

When an axis in the standard situation has moved up to a limit stop, the drive should signal a drive error by the monitoring facilities of the position or velocity control loop and react with shutdown.

But if the drive can detect the special case of operation "positive stop drive procedure", it can ignore the messages of the position and motions monitors and generate the required force of pressure, if necessary.

The control master signals this special case to the controller of IndraDrive devices via a command. Upon this command, the drive switches off the respective monitors and acknowledges axis standstill to have been detected and a parameterizable force or torque threshold to have been exceeded.

**Pertinent Parameters**

- S-0-0082, Torque/force limit value positive
- S-0-0083, Torque/force limit value negative
- S-0-0092, Bipolar torque/force limit value
- S-0-0124, Standstill window
- S-0-0149, C1300 Positive stop drive procedure command

- Pertinent Diagnostic Messages**
- C1300 Positive stop drive procedure command
  - C1301 Class 1 diagnostics error at command start

## 8.8.2 Functional Description

Moving a machine axis to a limit stop in a position-controlled way, e.g. for generating a force of pressure, is a process specifically provoked on the master side. To do this, the master inputs a command value for the drive that the axis cannot reach because the mechanical limit stop is situated before it.

In order to avoid error messages and reactions with the drive having been blocked, the execution of "C1300 Positive stop drive procedure command" (S-0-0149) is started before the limit stop is reached. This switches off the following monitors that would cause class 1 diagnostic errors:

- Monitor "drive does not follow command value"
  - F2028 Excessive deviation
- Velocity command value monitor
  - "F2037 Excessive position command difference"
- Acceleration command value monitor
  - "F2039 Maximum acceleration exceeded"
- Velocity control loop monitor
  - "F8078 Speed loop error"

The command is acknowledged on the following conditions:

- The axis has stopped, i.e. the actual velocity value (S-0-0040) has fallen below the velocity threshold in "S-0-0124, Standstill window".
  - and -
- The generated torque or force has exceeded a threshold value, i.e. the actual torque/force value (S-0-0084) is greater than the value in one of the parameters S-0-0082, Torque/force limit value positive, "S-0-0083, Torque/force limit value negative" or "S-0-0092, Bipolar torque/force limit value".

The two criteria for command acknowledgment can be set axis-specifically.

By resetting the command C1300, the monitors are switched on again!



**CAUTION**

**Property damage can be caused by moving to positive stop too rapidly!**

→ Reduce moving velocity and torque/force limit value (S-0-0092) to values that are not causing damage to the mechanical system!



If the drive already signals a class 1 diagnostics error (e.g. has already reached positive stop), the command "positive stop drive procedure" cannot be started!

## 8.8.3 Notes on Commissioning

For acknowledgment of command C1300 it is necessary to set:

- Threshold value for detection of axis standstill in parameter
  - S-0-0124, Standstill window
- Torque/force threshold in the parameters
  - S-0-0082, Torque/force limit value positive
  - S-0-0083, Torque/force limit value negative

## Extended Axis Functions

- S-0-0092, Bipolar torque/force limit value



The parameters S-0-0124, S-0-0082, S-0-0083 and S-0-0092 are used for other functions, too. Specific changes of values made for the function "positive stop drive procedure" have to be reset, if necessary!

Before positive stop is reached, start:

- S-0-0149, C1300 Positive stop drive procedure command

After drive has moved away from positive stop, reset the command, if necessary!

**Diagnosis**

The command has been executed when the "commands change bit" is set in "S-0-0135, Drive status word" and no command error is present.

If a class 1 diagnostics error is present at the start of command C1300 (e.g. because the axis has already reached positive stop), the command is not executed. The following message is displayed:

- C1301 Class 1 diagnostics error at command start

## 8.9 Redundant Motor Encoder

### 8.9.1 Brief Description



Assignment to functional firmware package, see chapter "Availability of the Extended Axis Functions".

Motor control of synchronous motors requires a position measuring system that measures the position of the moving part of the motor as opposed to the static part. If there is malfunction or defect in the position measuring system (motor encoder), a synchronous motor can no longer be decelerated in a controlled way.

Depending on the requirements, position control can require an external measuring system at the axis which detects the position at the load with the required precision.

For axis control, the entire mechanical drive system between motor encoder and load position of the external encoder is mapped via parameters. This allows calculating the position of the motor encoder from the position of the external encoder or determining the load position from the motor encoder position, if the mechanical drive system is without slip.

If there is a defect in the motor encoder, the motor position, when an external encoder is used, can be determined via the position of the external encoder and the synchronous motor can be decelerated in a controlled way.

For asynchronous motors with motor encoder, it is also possible to use an external measuring system for controlled deceleration, if there is a defect in the motor encoder. But if the asynchronous motor, depending on the drive task, is operated without encoder, controlled deceleration via external encoder in the case of error is not possible!



You can only use measuring systems with  $U_{pp} = 1V$  or resolvers as redundant motor encoders!

**Pertinent Parameters**

- P-0-0185, Control word of encoder 2 (optional encoder)

- Pertinent Diagnostic Messages**
- F2031 Encoder 1 error: Signal amplitude incorrect
  - F2042 Encoder 2: Encoder signals incorrect
  - F8022 Enc. 1: Enc. signals incorr. (can be cleared in ph. 2)
  - F8042 Encoder 2 error: Signal amplitude incorrect

## 8.9.2 Functional Description

**Relevance of the Function** By means of the function "redundant motor encoder", the axis can be shut down, even if the motor encoder is defective, with the error reaction that has been set. For this purpose, the position data of the motor encoder required for motor control are replaced by the position data of the external (optional) measuring system derived from the motor shaft position or primary part position.

**Requirements** To use the function "redundant motor encoder", the axis must be equipped with an external (optional) measuring system ( $U_{pp} = 1V$  or resolver) and the mechanical connection between the measuring systems must be without slip. In addition, the optional encoder must be activated as redundant motor encoder in "P-0-0185, Control word of encoder 2 (optional encoder)".



The function "Redundant motor encoder" can be used for axes with linear motor, too, if an external measuring system is available.

---

**Operating Principle** When the redundant motor encoder has been activated, the error message "F2031 Encoder 1 error: Signal amplitude incorrect" is triggered and a possibly existing position data reference is cleared, if the motor encoder is defective. The controller switches the internal signal paths of the encoder evaluation so that both parameter "S-0-0051, Position feedback value 1" and parameter "S-0-0053, Position feedback value 2" receive the signals of the external encoder (activated as redundant motor encoder). The signal path for the commutation of the motor is switched, too.

Extended Axis Functions

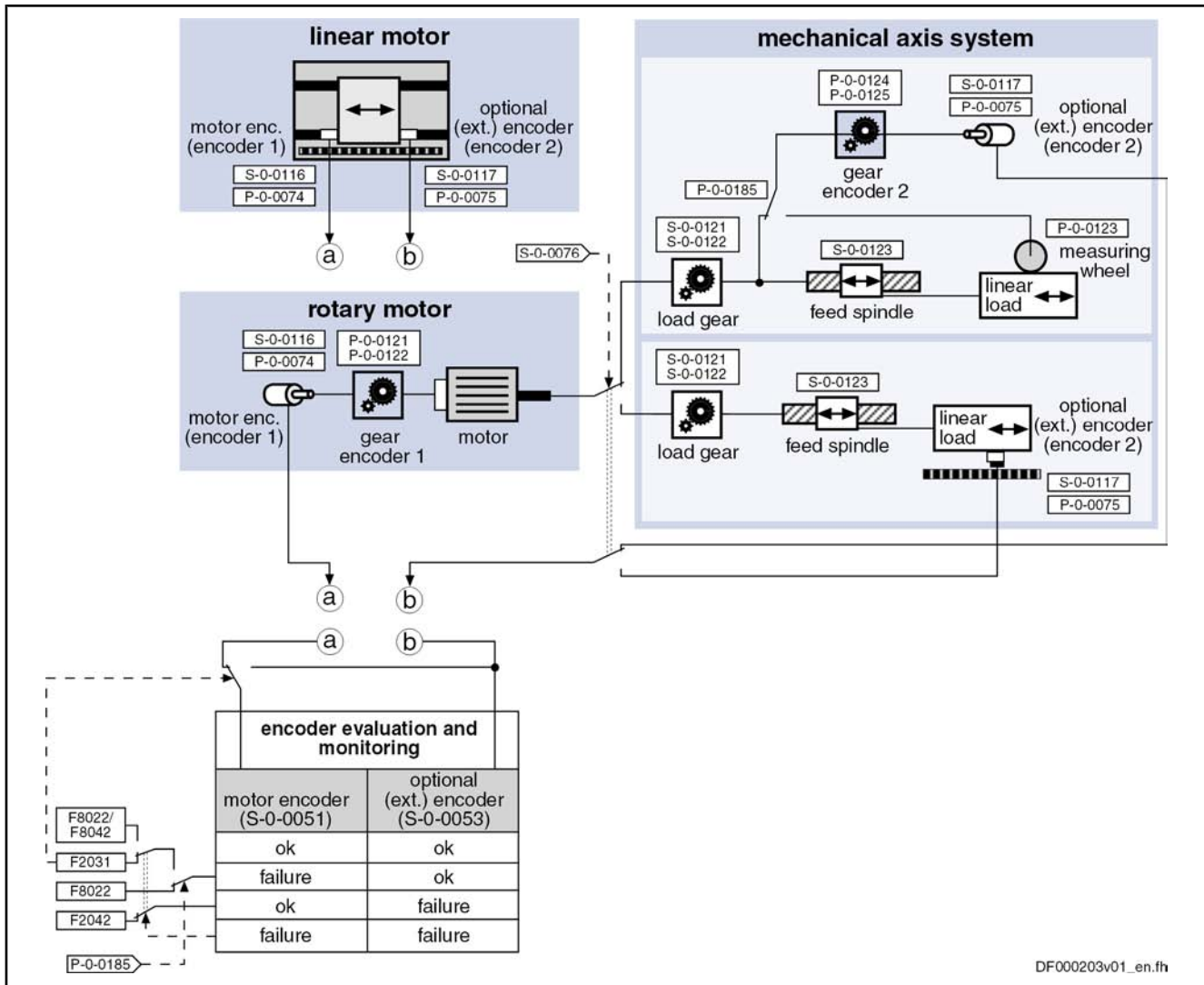


Fig. 8-63: Redundant Encoder Evaluation for Axes With Rotary Motors and Linear Motors

Reactions if Motor Encoder Defective

Due to the intact position data of the external encoder derived from the motor position, it is possible to carry out master-controlled deceleration ("P-0-0117, Activation of control unit reaction on error") or the error reaction of the axis set in "P-0-0119, Best possible deceleration".

Without redundant motor encoder it would only have been possible to disable the motor torque!

Reactions if External Encoder Defective

If a defect occurs in the redundant motor encoder with the motor encoder being intact, the error message "F2042 Encoder 2: Encoder signals incorrect" is triggered and the axis is shut down with master-side NC reaction or according to the error reaction that was set.

Reactions if Both Encoders Defective

If a defect occurs simultaneously in the motor encoder and the redundant encoder, the message of a fatal F8xxx error is triggered:

- "F8042 Encoder 2 error: Signal amplitude incorrect" if motor encoder was defective first,
- "F8022 Enc. 1: Enc. signals incorr. (can be cleared in ph. 2)" if redundant motor encoder was defective first.

The drive torque is disabled and the drive coasts to stop.



**Resetting F2 Errors of Motor Encoder and External Encoder**

The message of a motor encoder defect (F2031) or a defect of the external encoder (F2042) cannot be cleared in communication phase 4, it is necessary to switch to communication phase 2 or to the parameter mode. If for removing the cause of the error it is necessary to replace the motor encoder or dismount and mount it again, check the commutation setting and carry it out again, if necessary.

If the external encoder is a relative measuring system, the position data reference has to be established again, if necessary. If the external encoder is an absolute measuring system and was replaced or dismounted and mounted again, the position data reference has to be established again, if necessary.

**8.9.3 Notes on Commissioning****Presettings**

First make basic settings:

- Set parameter values for mechanical axis system (see "Mechanical Axis System and Arrangement of Measuring Systems")
- Set parameter values for motor encoder and external encoder (see Measuring Systems)
- Determine behavior of drive in the case of error (see "Error Reactions")

**Setting Parameters for Velocity and Position Control Loop**

Make sure that the axis runs steadily in the velocity and position control loop, both with the motor encoder and with the redundant motor encoder:

- Optimize the parameters of the velocity and position control loop with active motor encoder at a value of "P-0-1119, Velocity mix factor feedback 1 & 2" of 0% (see "Closed-Loop Axis Control (Closed-Loop Operation)")
- With P-0-1119 = 100%, test settings of velocity and position control loop made with P-0-1119 = 0%
  - Velocity and position control loop is only closed via redundant motor encoder (see "Closed-Loop Axis Control (Closed-Loop Operation)")

Make the setting for velocity and position control loop such that the axis shows steady behavior in operation both with motor encoder and with redundant motor encoder.

**8.10 Spindle Positioning****8.10.1 Brief Description**

Assignment to functional firmware package, see chapter "Availability of the Extended Axis Functions".

With the drive function "spindle positioning", the drive, at a command of the master, aligns the spindle independently with regard to the spindle zero position. The command position is transmitted to the drive controller via parameter and can be preset as absolute or relative position.

By means of the "position spindle" command the spindle can be positioned in a position-controlled way (e.g. within the "velocity control" mode) without having to switch the operation mode from velocity to position control.

How to use the drive function "spindle positioning":

- For **milling and drilling spindles**
  - To prepare tool change → spindle remains at a defined position to allow changing the tool
- For **turning machine main spindles**
  - To change the workpiece (if required)

## Extended Axis Functions

- To place balancing drillings for workpieces to be balanced
- To index the workpiece for further machining
- For **revolving transfer machines**
  - To advance the turntable in order to bring workpieces to a defined machining position at the different stations

**Hardware Requirements** The use of a home switch may be required.  
See "Establishing Position Data Reference for Relative Measuring Systems"

- Pertinent Parameters**
- S-0-0152, C0900 Position spindle procedure command
  - S-0-0153, Spindle angle position
  - S-0-0154, Spindle positioning parameter
  - S-0-0180, Spindle relative offset
  - S-0-0222, Spindle positioning speed
  - S-0-0372, Drive Halt acceleration bipolar
  - S-0-0417, Positioning velocity threshold in modulo mode
  - S-0-0418, Target position window in modulo mode
  - S-0-0437, Positioning status
  - S-0-0041, Homing velocity
  - S-0-0042, Homing acceleration
  - P-0-1201, Ramp 1 pitch
  - P-0-1202, Final speed ramp 1
  - P-0-1203, Ramp 2 pitch
  - P-0-1211, Deceleration ramp 1
  - P-0-1213, Deceleration ramp 2

- Pertinent Diagnostic Messages**
- C0900 Position spindle command
  - C0902 Spindle positioning requires drive enable
  - C0903 Error during initialization
  - C0906 Error during search for zero pulse

## 8.10.2 Functional Description


### Basic Sequence of the Function

Spindle positioning is started via "S-0-0152, C0900 Position spindle procedure command". During the execution of the command, the controller ignores the current command value of the active operating mode.

The presetting for the kind of positioning and motion of the spindle towards the target position is made in "S-0-0152, C0900 Position spindle procedure command".

**Sequence of Spindle Positioning** The process of spindle positioning takes place in several steps (see figure below):

1. First the spindle is decelerated in velocity control with the deceleration ramps of this control mode (P-0-1202, P-0-1211 and P-0-1213).
2. At the end of the deceleration process, the drive switches to position control and moves to the target position with the inputs from the parameters "S-0-0222, Spindle positioning speed" and "S-0-0372, Drive Halt acceleration bipolar".

	3. If the spindle has not yet been in reference, homing is carried out using the inputs from the parameters "S-0-0042, Homing acceleration" and "S-0-0041, Homing velocity", before the drive moves to the target position according to step 2.
<b>Kind of Positioning</b>	<p>The spindle can be positioned at</p> <ul style="list-style-type: none"> <li>• absolute target position</li> </ul> <p>- or -</p> <ul style="list-style-type: none"> <li>• relative target position.</li> </ul> <p>When "absolute target position" was set, the value from parameter "S-0-0153, Spindle angle position" is applied, at the start of spindle positioning, as the target position effective in the drive ("S-0-0430, Effective target position").</p> <p>When "relative target position" was set, the target position (S-0-0430) effective in the drive at the start of spindle positioning is generated by addition of the current actual position value and the value from "S-0-0180, Spindle relative offset".</p>
<b>Direction of Motion During Positioning</b>	<p>In the case of modulo scaling of position data, it is possible to choose between the following directions of motion for spindle positioning:</p> <ul style="list-style-type: none"> <li>• Clockwise rotation</li> <li>• Counter-clockwise rotation</li> <li>• Shortest distance</li> </ul>
<b>Positioning Velocity</b>	The allowed maximum velocity during the spindle positioning process is entered in parameter "S-0-0222, Spindle positioning speed".
<b>Acceleration/Deceleration</b>	The maximum acceleration or deceleration during the spindle positioning process is determined by parameter "S-0-0372, Drive Halt acceleration bipolar".
<b>Control Encoder</b>	For spindle positioning, the position control loop can be closed via the motor encoder or the optional encoder.
	<hr/> <p> In the case of a mechanical system with slip (e.g. V-belt) between motor and spindle, an optional encoder is obligatory!</p> <hr/>
<b>Spindle Positioning with Non-Homed Control Encoder</b>	<p>The encoder used for spindle positioning is defined by the bit for encoder selection in "S-0-0147, Signal status word".</p> <p>If the encoder selected for spindle positioning does not yet have the position data reference to the spindle (see "S-0-0403, Position feedback value status"), the position data reference is automatically established during the execution of spindle positioning!</p> <p>See also "Establishing the Position Data Reference"</p> <p>The figure below illustrates the basic sequence of the drive function "spindle positioning".</p>

Extended Axis Functions

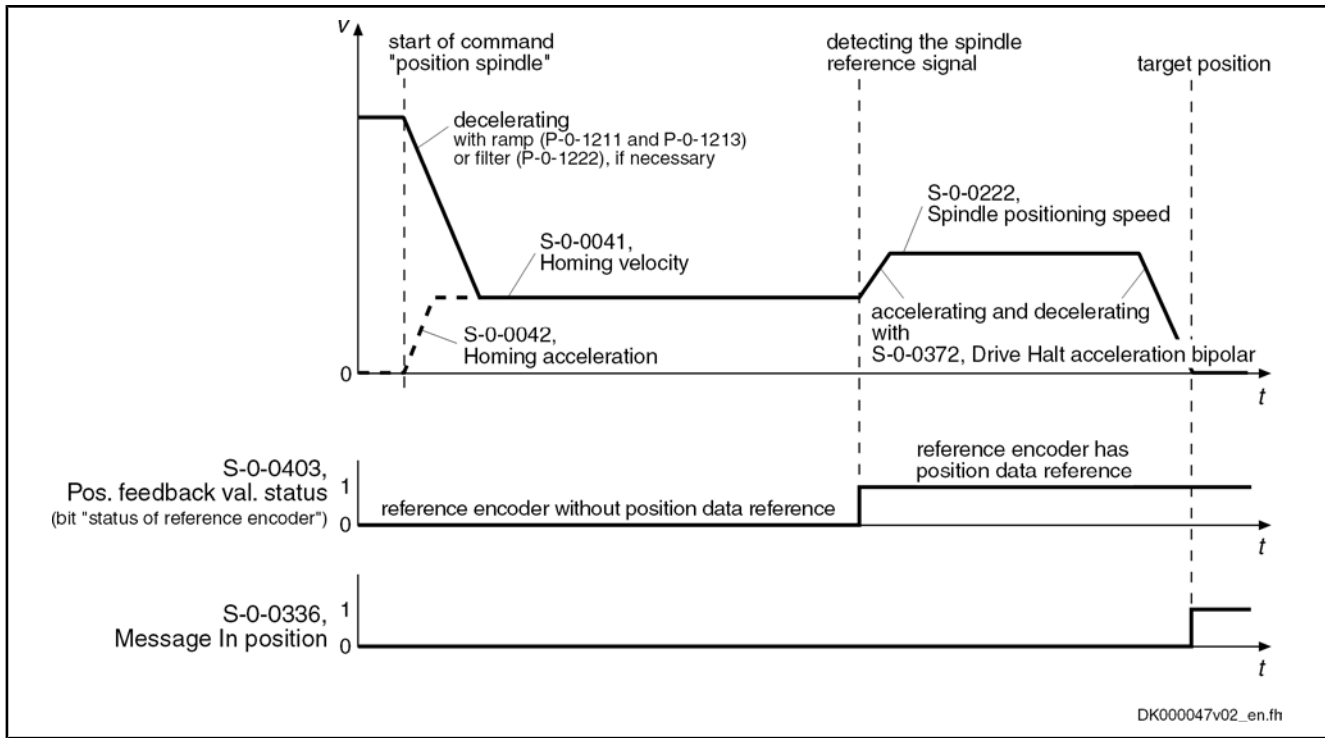


Fig. 8-64: Basic Sequence of Spindle Positioning (Including Establishing the Position Data Reference)

**Message "Target Position Reached"**

The following parameters signal that the target position for spindle positioning has been reached:

- S-0-0336, Message In position
- and -
- S-0-0013, Class 3 diagnostics

The target position is signaled to have been reached when

- Velocity command value and actual velocity value are lower than the threshold value in parameter "S-0-0124, Standstill window"
- and -
- The distance to target position is smaller than the value in parameter S"S-0-0057, Position window".



See also Parameter Description "S-0-0013, Class 3 diagnostics"

**Specific Features With "Modulo" Position Data Format**

**Infinitely Turning Axis**

Spindles for machine tools or rotary axes mostly are infinitely turning axes, their required position being within one revolution (0...360 dgr). For those axes it is recommended to use the "modulo" position data format because it allows displaying the actual position values with reference to one axis revolution only.

**Ambiguity of Target Position**

With modulo scaling, the target position is ambiguous because it occurs within every spindle revolution. Depending on the direction of motion ("clockwise/counter-clockwise" or "shortest distance") preset for spindle positioning and the velocity at which spindle positioning is started, the positioning distance can be of different length. In addition, one or several additional revolutions can be required until the target position has been reached!

**Spindle Positioning Out of Standstill**

Out of standstill the spindle or rotary axis positions as determined in "S-0-0154, Spindle positioning parameter":

- With the selected direction of motion ("clockwise" or "counter-clockwise")
  - or -
  - with the direction of motion in which the target position can be reached over the shortest possible distance ("shortest distance")
- Spindle Positioning Out of Motion** Apart from the determined direction of motion (in parameter S-0-0154), decelerating and positioning the spindle out of motion depends on
- the absolute value of the current velocity
  - and -
  - the distance between current axis position and target position
- at the start of spindle positioning.
- The actual sequences of the positioning process of a turning axis can differ in spite of the determined direction of positioning motion.
- In order to improve the reproduction of the positioning process, further limiting conditions are taken into account for the drive behavior:
- S-0-0417, Positioning velocity threshold in modulo mode
  - S-0-0418, Target position window in modulo mode

Current direction of rotation at start of spindle positioning	Start position of spindle positioning ...	
	... within target position window (S-0-0418)	... outside of target position window (S-0-0418)
As selected direction of positioning motion ("clockwise" or "counter-clockwise")	Positioning takes place over shortest distance, if values do not leave target position window during deceleration.  If values leave target position window during deceleration, drive positions according to selected direction of positioning motion at next target position to be reached.	Positioning takes place to the next target position that can be reached, while maintaining the velocity direction.  If "braking distance > distance start position-target position", the positioning process can require one to several revolutions, depending on the velocity at the start of the positioning process.
Opposite selected direction of positioning motion ("clockwise" or "counter-clockwise")	If "braking distance < distance start position-target position", drive moves to target position over shortest distance.  If "braking distance > distance start position-target position", positioning takes place after deceleration of motor, with reversion of velocity direction, at next target position to be reached.	The motor is decelerated to standstill. The positioning process then takes place at next target position to be reached, according to the determined direction of positioning motion.


Fig. 8-65: Dependence of the Positioning Process on the Start Position With Determined Direction of Positioning Movement "Clockwise" or "Counter-Clockwise"

## Extended Axis Functions

Current velocity at start of spindle positioning ...	
... higher than value of S-0-0417 (velocity threshold)	... lower than value of S-0-0417 (velocity threshold)
Positioning takes place at next target position to be reached, while maintaining the velocity direction. If "braking distance > distance start position-target position", the positioning process can require one to several revolutions, depending on the velocity at the start of the positioning process.	If "braking distance < distance start position-target position", positioning takes place at next target position to be reached, while maintaining the velocity direction. If "braking distance > distance start position-target position", positioning takes place after deceleration of motor, with reversion of velocity direction, at next target position to be reached.

Fig.8-66: *Dependence of the Positioning Process on the Velocity at the Start of Spindle Positioning With Determined Direction of Positioning Motion "Shortest Distance"*

### 8.10.3 Notes on Commissioning

<b>Presettings</b>	<p>Determining kind of positioning and direction of positioning motion:</p> <ul style="list-style-type: none"> <li>• S-0-0154, Spindle positioning parameter</li> </ul> <p>Determining maximum velocity for spindle positioning:</p> <ul style="list-style-type: none"> <li>• S-0-0222, Spindle positioning speed</li> </ul> <p>Determining threshold values for "in position" message:</p> <ul style="list-style-type: none"> <li>• S-0-0057, Position window</li> <li>• S-0-0124, Standstill window</li> </ul> <p> See also Parameter Description "S-0-0013, Class 3 diagnostics"</p> <p>If the position data are scaled in modulo format, it is possible to specify limiting conditions that improve the reproduction of the positioning process:</p> <ul style="list-style-type: none"> <li>• S-0-0417, Positioning velocity threshold in modulo mode</li> <li>• S-0-0418, Target position window in modulo mode</li> </ul>
<b>Presetting Target Position</b>	<p>The target position of the spindle is preset via</p> <ul style="list-style-type: none"> <li>• S-0-0153, Spindle angle position (absolute positioning)</li> </ul> <p>- or -</p> <ul style="list-style-type: none"> <li>• S-0-0180, Spindle relative offset (relative positioning).</li> </ul>
<b>Starting Spindle Positioning</b>	<p>Spindle positioning is started by starting the command</p> <ul style="list-style-type: none"> <li>• S-0-0152, C0900 Position spindle procedure command</li> </ul>
<b>Diagnosing Spindle Positioning</b>	<p>The target position effective for the positioning process is displayed in</p> <ul style="list-style-type: none"> <li>• S-0-0430, Effective target position.</li> </ul>
<b>End of Spindle Positioning</b>	<p>When the target position has been reached, this is displayed in</p> <ul style="list-style-type: none"> <li>• S-0-0336, Status "In position"</li> </ul> <p>- and -</p> <ul style="list-style-type: none"> <li>• S-0-0013, Class 3 diagnostics.</li> </ul> <p>The respective message bit changes from "0" to "1" when the conditions for the message have been fulfilled. The execution of the "position spindle" command is thereby acknowledged as having been "completed without error".</p>

## 8.10.4 Diagnostic Messages

The execution of spindle positioning required drive enable (AF). Diagnostic message in the case of error:

- C0902 Spindle positioning requires drive enable

If an absolute encoder is used as control encoder, the position data reference of the encoder must have been established before the first-time start of spindle positioning. Diagnostic message in the case of error:

- C0903 Error during initialization

If a relative encoder is used as control encoder and a home switch is to be evaluated, the position data reference is established with the first-time spindle positioning (unless already done). If the drive does not recognize the home switch signal, the following diagnostic message is generated:

- C0903 Error during initialization

If a relative encoder is used as control encoder, the position data reference is established with the first-time spindle positioning (unless already done). If the drive does not recognize any reference mark signal, the following diagnostic message is generated:

- C0906 Error during search for zero pulse

## 8.11 Parameter Set Switching

### 8.11.1 Brief Description



Assignment to functional firmware package, see chapter "Availability of the Extended Axis Functions".

IndraDrive devices have been equipped with eight parameter sets; it is possible to switch between these sets in operation. One of the switchable parameter sets is always active. Switching takes place upon command of the control master.

#### Notes on Applications

With the possibility of adjusting the values of different parameters to different operating phases or machining processes by switching parameter sets, if necessary during operation, the IndraDrive firmware supports the work flow in flexible production facilities.

Examples of application:

- Changing from C-axis to roughing or finishing operation in the case of spindles
- Positioning mode for tool change with different gear ratios
- Changing motor spindles for different machining phases
- Adjusting the control loop gains to different load inertia or load masses (e.g. with very different workpieces)
- Star-delta switching of motors with switchable winding to increase the torque in short-time operation

#### Classification of Switchable Parameters

Under the application-related point of view, the parameters to be switched are divided into the following groups:

- Application Parameters
- Control Loop Parameters
- Load gear parameters, only in alternative functional package main spindle function

## Extended Axis Functions

- Winding parameters, only in alternative functional package main spindle function
  - Motor control and motor encoder parameters, only in alternative functional package main spindle function
- Pertinent Parameters**
- S-0-0216, C4100 Switch parameter set command
  - S-0-0217, Preselect parameter set command
  - S-0-0219, IDN-list of parameter set
- Note:** List parameter S-0-0219 to S-7-0219 contain parameter sets no. 0 to no. 7
- S-0-0254, Current parameter set
  - P-0-2216, Parameter set switching, configuration
  - P-0-2217, Parameter set switching, preselection range
  - P-0-2218, Parameter set switching, delay time
- Pertinent Diagnostic Messages**
- C0273 Modulo value for motor encoder cannot be displayed
  - C0278 Modulo value for optional encoder cannot be displayed
  - C0280 Maximum travel range cannot be displayed internally
  - C4100 Switch parameter set command
  - C4101 Switching only possible without AF
  - C4103 Preselect parameter set forbidden value
  - C4104 Error during parameter set switching (->S-0-0423)

## 8.11.2 Functional Description

### General Information

Parameter set switching is activated

- By triggering command "C4100 Switch parameter set command" (S-0-0216) via control master

- or -

- "Drive-controlled" by changing "S-0-0217, Preselect parameter set command"

The triggering of parameter set switching is set in "P-0-2216, Parameter set switching, configuration".

The drive firmware then activates the parameter set determined by the value of "S-0-0217, Preselect parameter set command". The active value is displayed in "S-0-0254, Current parameter set". After switching on it is always set 0 that is active.

To minimize the times required for switching and storing or loading the parameter sets of a drive, the switchable parameters are permanently assigned to the following groups:

- **Application** (e.g. parameters for limit values for torque/force, position, velocity, etc.)
- **Control loop** (e.g. parameters for gain factors of position and velocity loop, etc.)
- **Load gear** (parameters for load gear input and load gear output revolutions, load inertia, etc.), only in alternative functional package main spindle function



- **Winding** (current loop parameters for winding switching, start-delta switching, etc.), only in alternative functional package main spindle function
- **Motor control and motor encoder parameters** (changes in the control process, motor switching, etc.), only in alternative functional package main spindle function

"P-0-2216, Parameter set switching, configuration" determines which of the mentioned parameter groups are to be switchable. In addition, "P-0-2217, Parameter set switching, preselection range" determines how many of the eight parameter sets are to be used. The parameters intended for parameter set switching can be seen in the list parameters S-0-0219 to S-7-0219 (IDN list of the respective parameter set). These list parameters are generated by the drive depending on the settings in the parameters P-0-2216 and P-0-2217.

Parameters are addressed via their IDNs. In the case of the switchable parameters, it is necessary to observe the number for the respective parameter set.

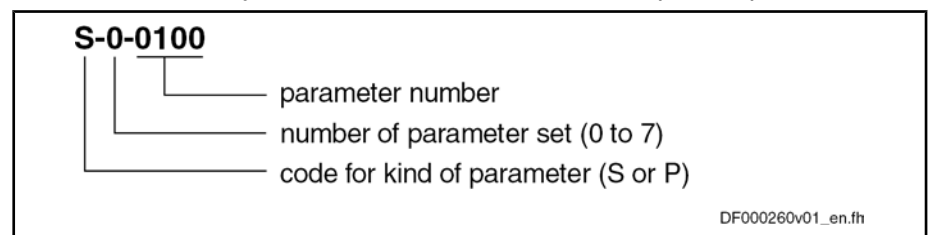


Fig. 8-67: Structure of the IDN of a Switchable Parameter (Example)

## Defining the Parameter Groups

### Application Parameters

The following switchable parameters are permanently assigned to the "application" group (only in the alternative functional packages servo function, main spindle function, synchronization):

- S-0-0038, Positive velocity limit value
- S-0-0039, Negative velocity limit value
- S-0-0057, Position window
- S-0-0082, Torque/force limit value positive
- S-0-0083, Torque/force limit value negative
- S-0-0091, Bipolar velocity limit value
- S-0-0092, Bipolar torque/force limit value
- S-0-0124, Standstill window
- S-0-0125, Velocity threshold nx
- S-0-0126, Torque threshold Tx
- S-0-0138, Bipolar acceleration limit value
- S-0-0157, Velocity window
- S-0-0158, Power threshold Px
- S-0-0193, Positioning Jerk
- S-0-0222, Spindle positioning speed
- S-0-0261, Coarse position window
- S-0-0349, Bipolar jerk limit
- S-0-0372, Drive Halt acceleration bipolar
- S-0-0822, Torque/force ramp
- S-0-0823, Torque/force ramp time

## Extended Axis Functions

- P-0-0041, Position command average value filter time constant
- P-0-0214, Analog input, assignment A, scaling per 10V full scale
- P-0-0215, Analog input, assignment A, signal value at 0V
- P-0-0216, Analog input, assignment A, dead zone
- P-0-0217, Analog input 1, time constant input filter
- P-0-0237, Analog input, assignment B, scaling per 10V full scale
- P-0-0238, Analog input, assignment B, signal value at 0V
- P-0-0239, Analog input, assignment B, dead zone
- P-0-1201, Ramp 1 pitch
- P-0-1202, Final speed ramp 1
- P-0-1203, Ramp 2 pitch
- P-0-1211, Deceleration ramp 1
- P-0-1213, Deceleration ramp 2
- P-0-1222, Velocity command filter
- P-0-4010, Load inertia

**Control Loop Parameters** The following switchable parameters are permanently assigned to the "control loop" group (only in the alternative functional packages servo function, main spindle function, synchronization):

- S-0-0100, Velocity loop proportional gain
- S-0-0101, Velocity loop integral action time
- S-0-0104, Position loop Kv-factor
- S-0-0348, Acceleration feedforward gain
- S-0-0826, Torque/force window
- P-0-0004, Velocity loop smoothing time constant
- P-0-0040, Velocity feedforward evaluation
- P-0-0180, Acceleration feedforward smoothing time constant
- P-0-1119, Velocity mix factor feedback 1 & 2
- P-0-1120, Velocity control loop filter: filter type
- P-0-1121, Velocity control loop filter: limit frequency of low pass
- P-0-1122, Velocity control loop filter: bandwidth of band-stop filter
- P-0-1123, Vel. cont. loop filter: center frequency of band-stop filter
- P-0-1126, Velocity control loop: acceleration feedforward

**Load Gear Parameters** The following switchable parameters are permanently assigned to the "load gear" group (only in alternative functional package main spindle function):

- S-0-0041, Homing velocity
- S-0-0042, Homing acceleration
- S-0-0052, Reference distance 1
- S-0-0121, Input revolutions of load gear
- S-0-0122, Output revolutions of load gear
- S-0-0299, Home switch offset
- P-0-0109, Torque/force peak limit



If load-related position, velocity or acceleration parameters exist, switching of the parameters of the "load gears" group is not allowed while the safety technology is active with the configuration "scaling of safety parameters according to setting of scaling system" (P-0-3210, bit14 = "0") and "gear independence with safety technology encoder mounted on the load side not active" (P-0-3210, bit 15 = "0"),

**Winding Parameters**

The following switchable parameters are permanently assigned to the "winding" group (only in alternative functional package main spindle function):

- S-0-0106, Current loop proportional gain 1
- S-0-0107, Current loop integral action time 1
- S-0-0109, Motor peak current
- S-0-0111, Motor current at standstill
- S-0-0113, Maximum motor speed
- S-0-0141, Motor type
- S-0-0201, Motor warning temperature
- S-0-0204, Motor shutdown temperature
- P-0-0018, Number of pole pairs/pole pair distance
- P-0-0051, Torque/force constant
- P-0-0528, Flux control loop proportional gain
- P-0-0529, Scaling of stall current limit
- P-0-0530, Slip increase
- P-0-0532, Premagnetization factor
- P-0-0533, Voltage loop proportional gain
- P-0-0534, Voltage loop integral action time
- P-0-0535, Motor voltage at no load
- P-0-0536, Maximum motor voltage
- P-0-0568, Voltage boost
- P-0-0569, Maximum stator frequency slope
- P-0-0570, Stall protection loop proportional gain
- P-0-0571, Stall protection loop integral action time
- P-0-0572, Slip compensation factor
- P-0-0573, IxR boost factor
- P-0-0574, Oscillation damping factor
- P-0-0577, Square characteristic: lowering factor
- P-0-0578, Current for deceleration, absolute value
- P-0-0579, Current for deceleration, time period
- P-0-0590, Motor model frequency loop proportional gain
- P-0-0591, Motor model frequency loop integral action time
- P-0-0592, Motor model adjustment factor
- P-0-0593, FXC: Total flux loop proportional gain
- P-0-0594, FXC: Total flux loop integral action time
- P-0-0595, FXC: Frequency loop proportional gain

## Extended Axis Functions

- P-0-0596, FXC: Frequency loop scaling factor of inertia
- P-0-0597, FXC: Current loop proportional gain
- P-0-0598, FXC: Current loop integral action time
- P-0-0599, FXC: Slip frequency filter time constant
- P-0-0600, FXC: Rated slip frequency
- P-0-4002, Charact. of quadrature-axis induct. of motor, inductances
- P-0-4003, Charact. of quadrature-axis inductance of motor, currents
- P-0-4004, Magnetizing current
- P-0-4005, Flux-generating current, limit value
- P-0-4013, Current limit value of demagnetization
- P-0-4016, Direct-axis inductance of motor
- P-0-4017, Quadrature-axis inductance of motor
- P-0-4032, Motor type plate data
- P-0-4036, Rated motor speed
- P-0-4039, Stator leakage inductance
- P-0-4040, Rotor leakage inductance
- P-0-4041, Motor magnetizing inductance
- P-0-4042, Characteristic of motor magnetizing inductance
- P-0-4043, Rotor time constant
- P-0-4048, Stator resistance

**Motor control and motor encoder parameters**

The following switchable parameters are permanently assigned to the "motor control and motor encoder parameters" group (only in alternative functional package main spindle function):

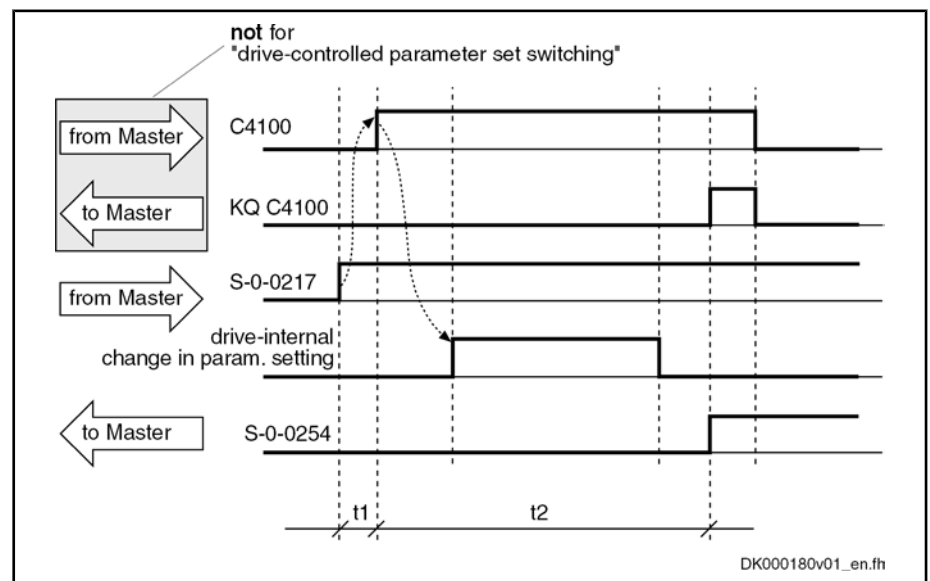
- S-0-0116, Resolution of feedback 1
- S-0-0206, Drive on delay time
- S-0-0207, Drive off delay time
- S-0-0277, Position feedback 1 type
- P-0-0045, Control word of current controller
- P-0-0074, Encoder type 1 (motor encoder)
- P-0-0077, Assignment motor encoder->optional slot
- P-0-0121, Gear 1 motor-side (motor encoder)
- P-0-0122, Gear 1 encoder-side (motor encoder)
- P-0-0124, Gear 2 load-side (optional encoder)
- P-0-0125, Gear 2 encoder-side (optional encoder)
- P-0-0506, Amplitude for angle acquisition
- P-0-0507, Test frequency for angle acquisition
- P-0-0508, Commutation offset
- P-0-0510, Rotor inertia
- P-0-0512, Temperature sensor
- P-0-0513, Temperature sensor characteristic
- P-0-0517, Commutation: required harmonics component
- P-0-0522, Control word for commutation setting
- P-0-0540, Torque of holding brake

- P-0-0575, Search mode: search current factor
- P-0-0576, Search mode: finding point slip factor
- P-0-0601, Configuration motor data identification
- P-0-0640, Cooling type
- P-0-4014, Type of construction of motor
- P-0-4034, Thermal time constant of winding
- P-0-4035, Thermal time constant of motor
- P-0-4037, Thermal short-time overload of winding

## Conditions and Timing for Parameter Set Switching

Parameter Groups "Application", "Control Loop" and "Load Gear"

Parameter set switching of application, control loop and load gear parameters can take place in operation, i.e. with drive enable ("AF"). For "drive-controlled parameter set switching", the timing is as follows:



C4100	Switch parameter set command
KQ C4100	Switch parameter set command acknowledgment
S-0-0217	Preselect parameter set command
S-0-0254	Current parameter set
t1	Approx. 6 ms (drive-controlled parameter set switching)
t2	Approx. 5...30 ms

Fig. 8-68: Sequence Diagram for Switching Application, Control Loop and Load Gear Parameters

Parameter Group "Load Gear" and Safety Technology

If for load-related position, velocity and/or acceleration data the "load gears" parameter group is included in the switching, "fixed format related to motor" or "gear independence with safety technology encoder mounted on the load side" has to be set for the scaling of the SI parameters (P-0-3210, Safety technology configuration), otherwise the transition command error "C0256 Safety technology configuration error" will be generated when changing from parameter mode to operating mode with safety technology activated.

If the gear ratio of the load gear is changed through parameter set switching, the position data reference will be maintained ("homed" in "S-0-0403, Position feedback value status"), if the position data directly refer to an encoder:

- Data reference to load with position control on an external encoder
- Data reference to motor shaft with position control on the motor encoder

## Extended Axis Functions

Otherwise, the reference of the position data will be lost through the changes in the gear ratio of the load gear and the position data reference has to be established again.

The following command errors might occur:

- C0273 Modulo value for motor encoder cannot be displayed
- C0278 Modulo value for optional encoder cannot be displayed
- C0280 Maximum travel range cannot be displayed internally

For remedy in case of an error, see Troubleshooting Guide for the respective error message!



**CAUTION**

**By parameter set switching with "AF", the command values can change internally. This can cause accidental axis motion!**

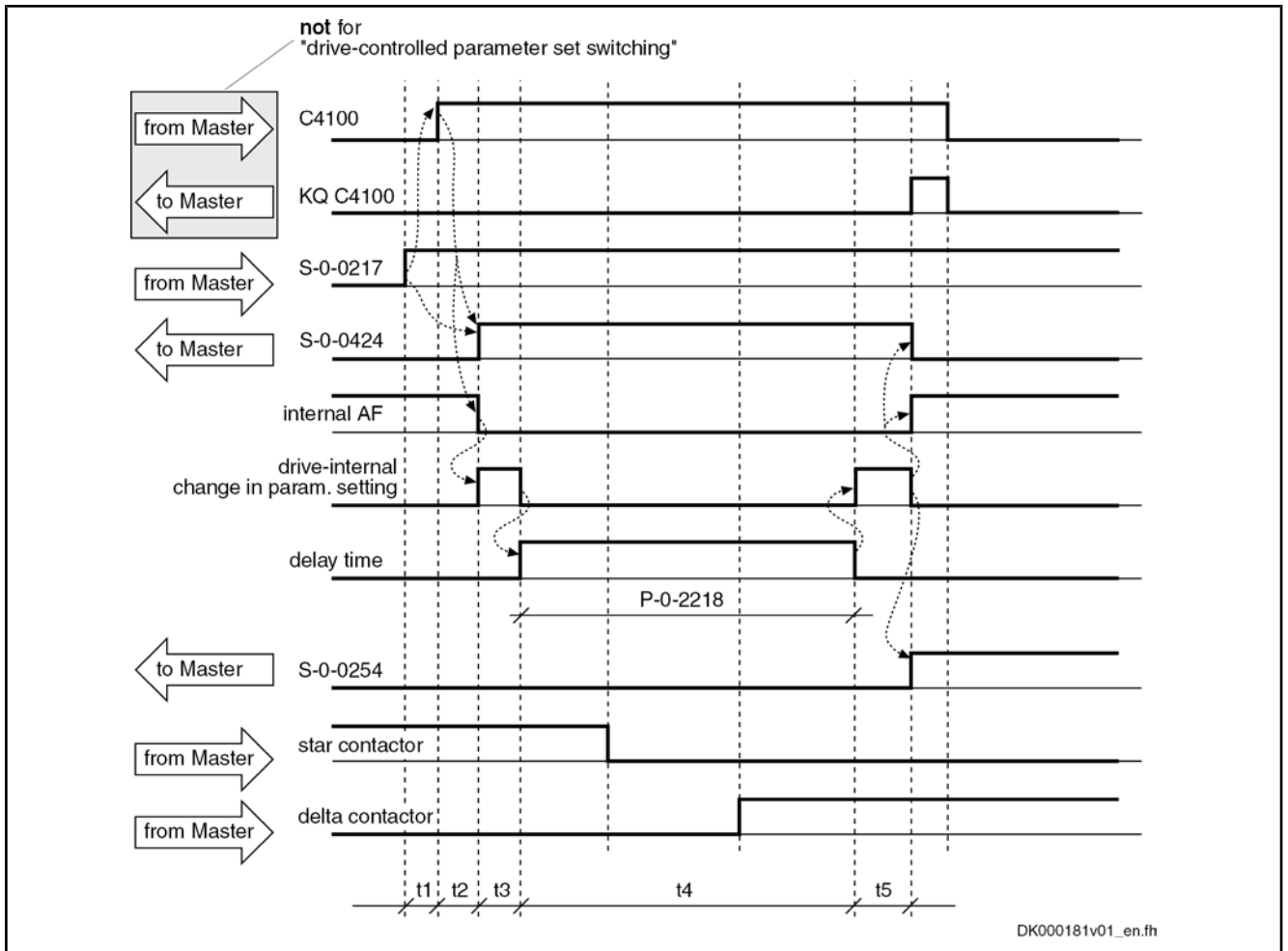
→ Via the control master make sure that the changes in the controlled system really took place (query the feedbacks)!

---

### Parameter Group "Winding"

The parameter group "winding", too, can be switched in operation, i.e. with drive enable ("AF"). During the switching process, drive enable is internally deactivated and activated again in the controller after the delay time which can be set (see P-0-2218) is over (see sequence diagram below).

Winding switching thereby takes place in the shortest possible time. By the appropriate setting in P-0-2218, you have sufficient delay until switching times of contactors, relays etc. are over.



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- C4100 Switch parameter set command
- KQ C4100 Switch parameter set command acknowledgment
- S-0-0217 Preselect parameter set command
- S-0-0254 Current parameter set
- S-0-0424 Status parameterization level
- P-0-2218 Parameter set switching, delay time
- t1 Approx. 6 ms (drive-controlled parameter set switching)
- t2 Approx. 5...30 ms
- t3 Approx. 10...20 ms
- t4 According to the value of P-0-2218
- t5 Approx. 10...20 ms

Fig. 8-69: Sequence Diagram for Switching the Winding Parameters

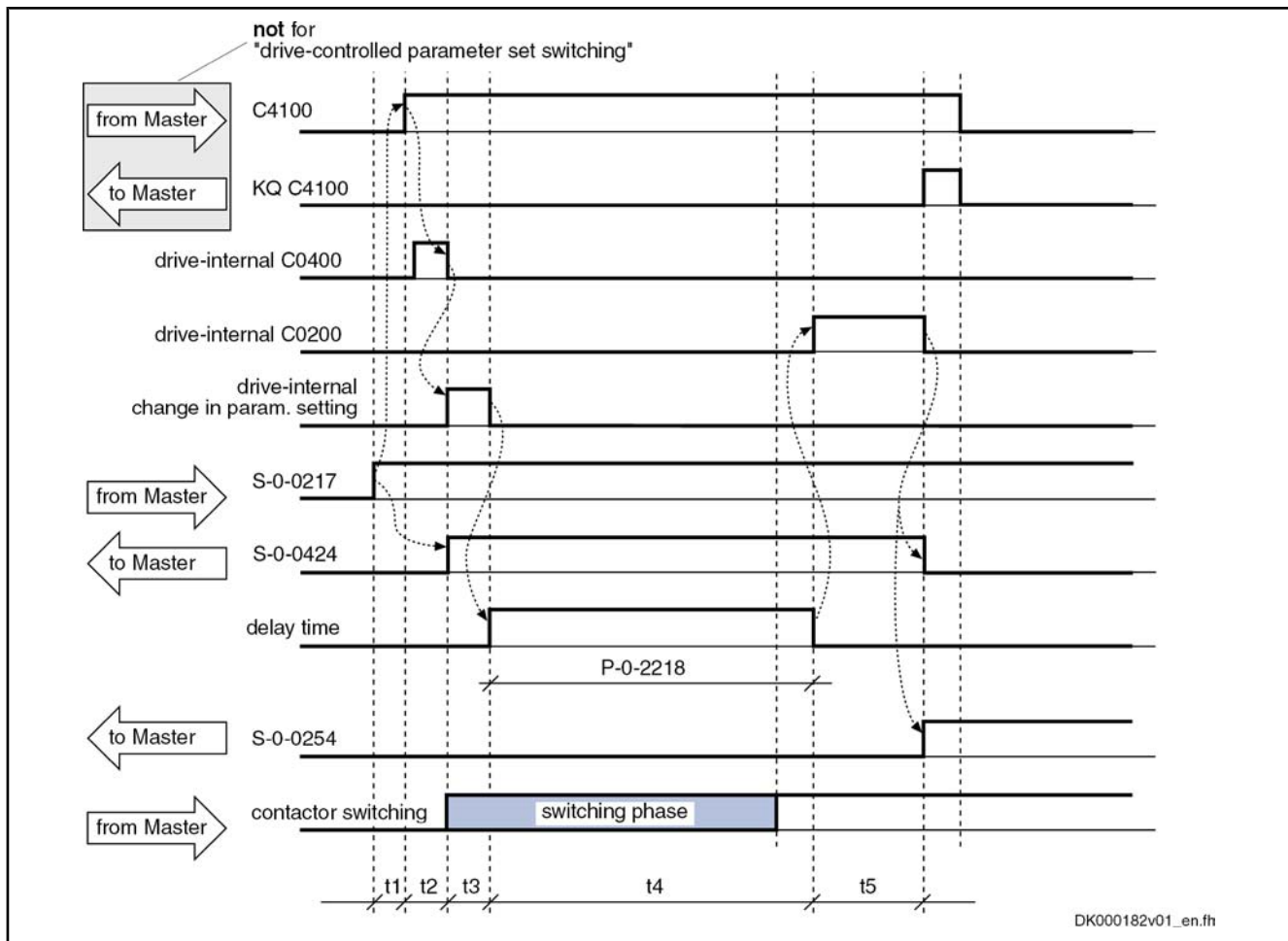
**"Motor Control and Motor Encoder Parameters" Parameter Group**

If the drive, at the start of parameter set switching, is in operating mode ("bb" or "Ab") and drive enable ("AF") has not been set, it switches internally to parameter mode ("C0400 Activate parameterization level 1 procedure command"), carries out parameter set switching and automatically goes back to operating mode ("C0200 Exit parameterization level procedure command"). Switching is impossible in "AF"!

For switching the encoder parameters it is possible, by means of "P-0-2218, Parameter set switching, delay time"

to delay the return to operating mode via "C0200 Exit parameterization level procedure command" to have sufficient delay until switching times of contactors, relays etc. are over.

Extended Axis Functions



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- C4100 Switch parameter set command
- KQ C4100 Switch parameter set command acknowledgment
- C0400 Activate parameterization level 1 procedure command
- C0200 Exit parameterization level procedure command
- S-0-0217 Preselect parameter set command
- S-0-0254 Current parameter set
- S-0-0424 Status parameterization level
- P-0-2218 Parameter set switching, delay time
- t1 Approx. 6 ms (drive-controlled parameter set switching)
- t2 Approx. 50 ms, for resolver measuring system approx. 250 ms
- t3 Approx. 6 ms
- t4 According to the value of P-0-2218
- t5 approx. 1...15s

Fig.8-70: Sequence Diagram for Switching the Motor Control and Motor Encoder Parameters




During the execution of "C4100 Switch parameter set command", command error messages C02xx might possibly occur, if inadmissible states (e.g. switching times) are still present before switching back to operating mode takes place!

### 8.11.3 Notes on Commissioning

- Presettings** Preselect parameter groups to be switched in:
- P-0-2216, Parameter set switching, configuration
- Determine number of switchable parameter sets in:



	<ul style="list-style-type: none"> <li>• P-0-2217, Parameter set switching, preselection range</li> </ul>
	If desired, activate "drive-controlled parameter set switching" in P-0-2216, too.
<b>Writing Switchable Parameters</b>	Depending on the selected presettings, those parameters can be written in communication phase 4 the IDNs of which are displayed in parameters S-0-0219 to S-7-0219 (IDN list of respective parameter set).
	<hr/>  All other parameters that could be included in the parameter set switching (S-1-xxxx to S-7-xxxx or P-1-xxxx to P-7-xxxx) but are not listed, cannot be written in communication phase 4! <hr/>
<b>Initial State</b>	After switching on, it is always "parameter set 0" that is active first. "S-0-0254, Current parameter set" displays "0".
<b>Carry Out Parameter Set Switching</b>	<p>Before the function is activated, the number of the parameter set to which switching is to take place must be entered in parameter "S-0-0217, Preselect parameter set command".</p> <p>Sequence of the function:</p> <ul style="list-style-type: none"> <li>• Command "C4100 Switch parameter set command" (S-0-0216) is started via control master</li> <li>• Successful parameter set switching is checked in parameter "S-0-0254, Current parameter set" (new parameter set number must have been acknowledged in this parameter)</li> <li>• Command C4100 is cleared by control master</li> </ul>
<b>Diagnostic Messages</b>	<p>During execution of the command, the message "C41" appears on the display of the controller.</p> <p>Possible failures are displayed by the following diagnostic messages:</p> <ul style="list-style-type: none"> <li>• C4101 Switching only possible without AF</li> <li>• C4103 Preselect parameter set forbidden value</li> <li>• C4104 Error during parameter set switching (-&gt;S-0-0423)</li> </ul> <p>In connection with the gear switching the following diagnosis messages are possible:</p> <ul style="list-style-type: none"> <li>• C0273 Modulo value for motor encoder cannot be displayed</li> <li>• C0278 Modulo value for optional encoder cannot be displayed</li> <li>• C0280 Maximum travel range cannot be displayed internally</li> </ul>

## 8.12 Drive-Controlled Oscillation

### 8.12.1 Brief Description



Assignment to functional firmware package, see chapter "Availability of the Extended Axis Functions".

Upon a command of the control master, the drive ignores the cyclic command value input and independently turns alternately in positive and negative direction (speed oscillation). The cyclic speed characteristic can be set via parameters and can be realized symmetrically or asymmetrically.

**Notes on Applications** With speed oscillation the main drive supports the following applications, for example:

- Meshing the toothed wheels when switching a gear train
- Engaging positive clutches (e.g. connecting i.c. engine equipment under test to test stands)

Extended Axis Functions

- Pertinent Parameters**
- S-0-0213, Oscillation speed
  - S-0-0214, Oscillation offset speed
  - S-0-0215, Oscillation cycle time

- Pertinent Diagnostic Messages**
- C4200 Drive-controlled oscillation command
  - C4201 Oscillation requires drive enable
  - C4202 Oscillation command speed cannot be reached

### 8.12.2 Functional Description

Drive-controlled oscillation is adjusted to the individual requirements of the meshing/engaging procedure via parameters. Oscillation cycle time, oscillation speed and oscillation offset speed can be set.

By means of the oscillation offset speed, oscillation can be asymmetrically configured in order to overcome tooth-to-tooth positions during the meshing procedure.

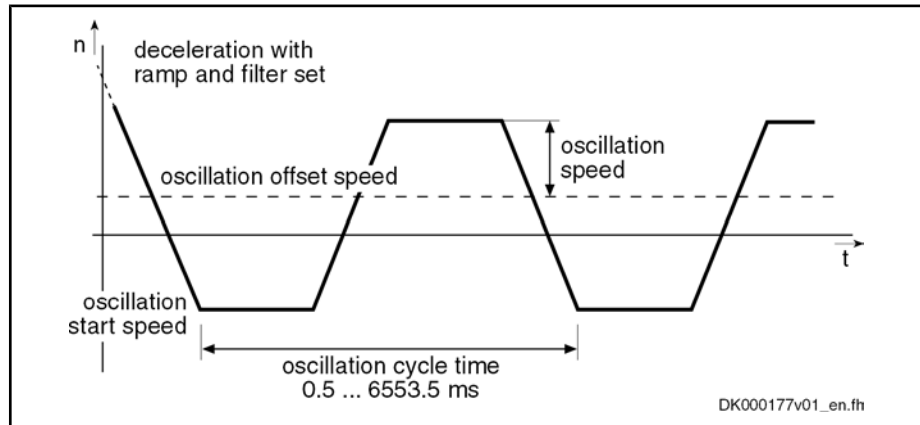


Fig.8-71: Speed Characteristic With Drive-Controlled Oscillation

**Start "Drive-Controlled Oscillation"**

Triggering of command "C4200 Drive-controlled oscillation command" causes the following reaction:

- When the motor is turning, the velocity is decelerated to the oscillation start speed, taking possibly activated ramps and filters into account.
- When the motor has stopped, acceleration to the oscillation start speed takes place.

**Acknowledgment**

If within 5 s after start of command the deviation of the actual velocity value from the oscillation start speed is smaller than the value of "S-0-0157, Velocity window", the execution of the command is acknowledged and the command value curve for speed oscillation is internally generated.

**Command Value Generation**

The drive-internal command value for oscillation is cyclically generated from oscillation offset speed +/- oscillation speed. Drive-internal ramps and command value filters that were set then aren't active.

The parameter values for drive-controlled oscillation can be changed during the oscillation process. At the latest after the oscillation cycle time is over, the drive reacts to the new values.

After execution of command C4200 has been completed, the drive follows the currently present command value.

### 8.12.3 Notes on Commissioning

**Presettings/Checks**

Before activating the function "drive-controlled oscillation" the following presettings or checks have to be made:

- Value in parameter ""S-0-0215, Oscillation cycle time"" has to be unequal zero.
  - Values of parameters "S-0-0215, Oscillation cycle time", "S-0-0213, Oscillation speed" and "S-0-0214, Oscillation offset speed" have to be checked and values allowed for the spindle mechanics entered, if necessary.  
Value in parameter "S-0-0215, Oscillation cycle time" has to be between 0.5ms and 6553.5ms (steps of 0.5ms)!
- Activate Oscillation** The function is activated by starting command "C4200 Drive-controlled oscillation command" (S-0-0190) via the control master.
- Complete Oscillation** The function is completed by clearing command C4200 by the control master, when the master has detected the meshing of the gear shaft to have been carried out.
- Diagnostic Messages** During execution of the command, the message "C42" appears on the display of the controller.  
Possible failures are displayed by the following diagnostic messages:
- C4201 Oscillation requires drive enable
  - C4202 Oscillation command speed cannot be reached

## 8.13 Parking Axis

### 8.13.1 Brief Description



Assignment to functional firmware package, see chapter "Availability of the Extended Axis Functions".

If individual axes within a master communication group (e.g. SERCOS ring, PROFIBUS) are to be temporarily deactivated, without taking them out of the axis group on the hardware and communication side, the function "parking axis" can be activated via command.

When a drive has been put into the status "parking axis", it behaves "neutrally" with regard to hardware and master communication. Errors possibly detected by the drive are suppressed and have no effect on the axes in operation. This allows, for example, uncoupling the motor and the motor encoder in the status "parking axis" without errors being signaled.

The axis that has been "parked" behaves as if it would not exist!

**Pertinent Parameters**

- S-0-0139, C1600 Parking axis procedure command

**Pertinent Diagnostic Messages**

- C1600 Parking axis command

### 8.13.2 Functional Description

The parameter "S-0-0139, C1600 Parking axis procedure command" can only be activated in parameter mode (communication phase "P2" or "P3"). Executing the command causes the following actions:

- Monitoring functions of measuring systems are deactivated
- Motor temperature monitoring is deactivated
- Reference bits in "position feedback value status" are disabled
- Drive initializations are not carried out when "S-0-0128, C5200 Communication phase 4 transition check" is executed
- "PA" is displayed on control panel and in diagnostic system

## Extended Axis Functions

- Master-side drive enable is ignored



The execution of command C1600 is not acknowledged as completed on the drive side, in order to keep the command change bit of parameter "S-0-0135, Drive status word" free for diagnosis of other commands!

The command C1600 can only be cleared in communication phase "P2" or "P3" or by switching back to "P0". Completing the execution of command C1600 causes the following actions:

- Monitoring functions of measuring systems are activated
- Motor temperature monitoring is activated
- Standard diagnostic messages appear again on display and in diagnostic system
- Drive enable is possible again in communication phase "P4"



As the position data reference of relative measuring systems gets lost when command C1600 is started, the position data reference for these measuring systems has to be established again (homing procedure) after drive enable has been set!



To activate the function "parking axis", there is an alternative to switching to communication phase "P2"; you can switch to the parameter mode from the operating states "bb" or "Ab" via "S-0-0420, C0400 Activate parameterization level 1 procedure command". By activating "S-0-0422, C0200 Exit parameterization level procedure command", the drive returns to the operating mode.

## 8.14 Integrated Safety Technology

### 8.14.1 General Information



The section below contains an overview of the integrated safety functions of the IndraDrive hardware and the IndraDrive firmware. Details concerning function, notes on commissioning and examples of application are described in the separate documentation "Rexroth IndraDrive: Integrated Safety Technology According to IEC61508" (DOK-INDRV\*-SI2-\*\*VRS\*\*-FK\*\*-EN-P; part no. R911327664).

### 8.14.2 Product Presentation

#### What is "Integrated Safety Technology"?

The control sections of the IndraDrive range can be equipped with one of the following optional modules:

- One optional module "Safe Torque Off" ("L2") or
- One optional module "Safe Motion" ("S2")

By the mentioned optional modules, IndraDrive is equipped with integrated safety technology which provides the user with an electronic starting lockout, as well as with universally programmable safe motion and standstill monitoring.

**Definition** "Safe Motion" means application-related safety functions which are applicable for personal protection at machines according to EN ISO 13849-1 Category 3 PL d and IEC EN 62061 SIL 2.  
"Safe Torque Off" means application-related safety functions which are applicable for personal protection at machines according to EN ISO 13849-1 Category 3 PL e and IEC EN 62061 SIL 3.

**Selecting the Function** The safety functions can be alternatively selected via

- 24 V inputs at the drive controller or
- 24 V inputs at the drive controller and master communication (one channel each) or
- The safe channel in PROFIBUS (PROFIsafe)

**Certification** The safety technology was certified by TÜV Rheinland® and has been listed by TÜV Rheinland of North America (NRTL listing) (see (<http://www.tuv.com/de/index.html> or <http://www.us.tuv.com/> under "ID-Zertifikate" or "ID-Certificate") [US+Canada NRTL-Certificate, certificate no. 72071176 (L2) and certificate no. 72071177 (S2)]. "NRTL" means **N**ationally **R**ecognized **T**esting **L**aboratory; products listed by such a testing laboratory may be used in the US in the appropriate way (according to NFPA 79).



Certificates are available on the Internet/Extranet.

**Requirements That Can Be Realized** The integrated safety technology is independent of the type of master communication, the higher-level control units and the supply modules. It is available as an optional module for the standard drive system. The requirements below can be realized in the machine or in the installation:

- Measures according to EN ISO 12100-2, if accessing the danger zone is required, for example, for equipping, teaching or material withdrawal.
- Requirements for safety-related parts of control units according to EN ISO 13849-1 Category 3 PL d and IEC EN 62061 SIL 2 (when using "Safe Motion") or EN ISO 13849-1 Category 3 PL d/PL e and IEC EN 62061 SIL 2/SIL 3 (when using "Safe Torque Off"), as required in EN 1010-1 (printing and paper converting machines), EN 12415 (turning machines) and EN 12417 (machining centres).
- Control functions in the case of error according to EN 60204-1 (see "Using Diversity" in EN 60204-1).

### Integrated Safety Technology as IndraDrive Platform Solution

The different characteristics (e.g. PROFIsafe) require different hardware:

Control section type	Description	Characteristics of integrated safety technology		
		Safe Torque Off (optional module "L2")	Safe Motion (optional module "S2")	
			Digital I/Os	PROFIsafe
CSH01.1C	ADVANCED	X	X	X
CSH01.3C	ADVANCED	X	X	X
CSB01.1C	BASIC UNIVERSAL (single-axis)	X		
CDB01.1C	BASIC UNIVERSAL (double-axis)	X	X	X
CSB01.1N-FC	BASIC OPENLOOP			
CSB01.1N-AN	BASIC ANALOG	X		

Extended Axis Functions

Control section type	Description	Characteristics of integrated safety technology		
		Safe Torque Off (optional module "L2")	Safe Motion (optional module "S2")	
			Digital I/Os	PROFIsafe
CSB01.1N-SE	BASIC SERCOS	X		
CSB01.1N-PB	BASIC PROFIBUS	X		

Fig.8-72: Overview of the Hardware Requirements for the Integrated Safety Technology



For using the integrated safety technology "Safe Motion" or "Safe Torque Off" according to IEC EN 61508 or EN ISO 13849-1, at least the firmware version MP\*07VRS or higher must be used in the drive. In addition to the optional module "S2", using PROFIsafe requires the master communication module "PROFIBUS" (PB) together with the respective firmware version (as of MP\*07VRS)!

### Characteristics and Classification of Safety Technology

**Functionality Levels** The available integrated safety functions can be divided into 2 levels:

- Level 1: Purely hardware-based safety technology, "Safe torque off" is part of it (optional safety technology module "L2" required)
- Level 2: Extensive integrated safety technology including all other safety functions, such as "Safely-limited speed", "Safely-monitored position",... (optional safety technology module "S2" required)

**Characteristics Regarding the Interfaces** Apart from the classification of the safety functions, we distinguish the kinds of control (e.g. digital I/Os or PROFIBUS). The following characteristics are supported:

- Digital I/Os
- PROFIsafe

### 8.14.3 Safe Torque Off (STO)

#### Brief Description



Using the function "Safe torque off" requires the optional safety technology module "L2".

The energy supply to the drive is safely interrupted with the safety function "Safe torque off". The drive cannot generate any torque/force and, as a consequence, it cannot generate any dangerous motions, either.



Before activating the safety function "Safe torque off", the drive system must be decelerated via the command value input; there is no drive-controlled deceleration!



#### Lethal injury and/or property damage caused by unintended axis motion!

⇒ If external force influences are to be expected with the safety function "Safe torque off", e.g. in the case of a vertical axis, this motion has to be safely prevented by additional measures, e.g. a mechanical brake or a weight compensation; for such axes, Bosch Rexroth recommends that you use the safe braking and holding system.

**Features** The safety function "Safe torque off" has the following features:

## Extended Axis Functions

- Corresponds to stop category 0 according to EN 60204-1
- Is suited for safety-relevant applications up to Category 1 PL c and Category 3 PL d/PL e according to EN ISO 13849-1 or up to SIL 1/SIL 2/SIL 3 according to IEC EN 62061.
- The energy supply to the motor is safely interrupted via two channels.
- The **selection** is made via two channels using either an N/C-N/O or an N/C-N/C combination.  
To attain SIL 3/PL e, selection must take place via a higher-level safety master.
- The safe state is **acknowledged** by an N/C-N/O contact; the acknowledgment must be evaluated until SIL 2/PL d and SIL 3/PL e have been reached.
- For **dynamization of the safety function selection**, the function must be activated at least every 168 hours (SIL 2/PL d) or 24 hours (SIL 3/PL e). For this reason, the operating hours of the power section at which the safety function "Safe torque off" was selected the last time are stored in the parameter "P-0-0102, Oper. hours power section at last activation of STO".  
Dynamization of the safety function selection is not required for reaching SIL 1/PL c.
- Monitoring the validity of the selection: 100 ms after selection was changed.
- The time intervals for activating the safety function "Safe torque off" have to be set via "P-0-0103, Time interval of forced dynamization".
- The history of the time intervals that were set is displayed in the parameter "P-0-0104, Change history time interval of forced dynamization".
- The status of the safety function "Safe torque off" is displayed via the parameter "P-0-0106, Operating status of STO".

**Pertinent Parameters**

The following parameters are used in conjunction with the safety function "Safe torque off":

- P-0-0101, Configuration for STO selector
- P-0-0102, Oper. hours power section at last activation of STO
- P-0-0103, Time interval of forced dynamization
- P-0-0104, Change history time interval of forced dynamization
- P-0-0106, Operating status of STO

**Pertinent Diagnostic Messages**

The following diagnostic messages can be generated in conjunction with the safety function "Safe torque off":

- F8027 Safe torque off while drive enabled
- F7043 Error of output stage interlock
- F3130 Error when checking input signals
- F3131 Error when checking acknowledgement signal
- E3110 Time interval of forced dynamization exceeded
- E8027 Safe torque off while drive enabled
- With the safety function "Safe torque off" activated, "STO" is shown on the display of the IndraDrive control panel.

## Extended Axis Functions

## 8.14.4 Integrated Safety Technology

- Features**
- Dual-channel selection on safety functions via digital inputs/outputs (24 V) or digital inputs/outputs (24 V) and master communication or a safe process data channel for PROFIBUS-DP (PROFIsafe)
  - **Integrated functionality for detecting "sleeping" errors:**
    - Dual-channel data processing with structure by diversity
    - Cross comparison of the safety-relevant data
    - Dynamization of static states
  - Password protection for all safety technology parameters
  - Safety functions in normal operation and special mode
    - "Safe maximum speed", "Safe direction", "Safely-limited position"
  - Safety functions of safety technology function category "Safe standstill"
    - "Safe stop 1 (Emergency stop)", "Safe stop 1", "Safe stop 2", "Safe braking and holding system"
  - Safety functions of safety technology function category "Safe motion"
    - "Safely-limited speed", "Safe direction", "Safely-limited increment", "Safely-monitored position"
  - Auxiliary functions
    - "Safely-monitored stopping process", "Safe homing procedure", "Safe brake check", "Safe parking axis"
  - Safety functions for "Safe feedback"
    - "Safe diagnostic outputs", "Safe door locking device", "Safe inputs/outputs" [only available via master communication "PROFIBUS" (PROFIsafe)]

**Pertinent Parameters** The parameters for safety technology are assigned to the IDN range from P-0-3200 to P-0-3399. For information on the pertinent parameters, see separate documentations "Integrated Safety Technology; Functional and Application Description" and "Parameter Description".

**Pertinent Diagnostic Messages** For the pertinent diagnostic messages in conjunction with integrated safety technology, see separate documentation "Integrated Safety Technology According to IEC61508; Functional Description" under the corresponding safety function.

## 8.14.5 Functions of the Integrated Safety Technology

### Overview

We distinguish the following operating states of integrated safety technology:



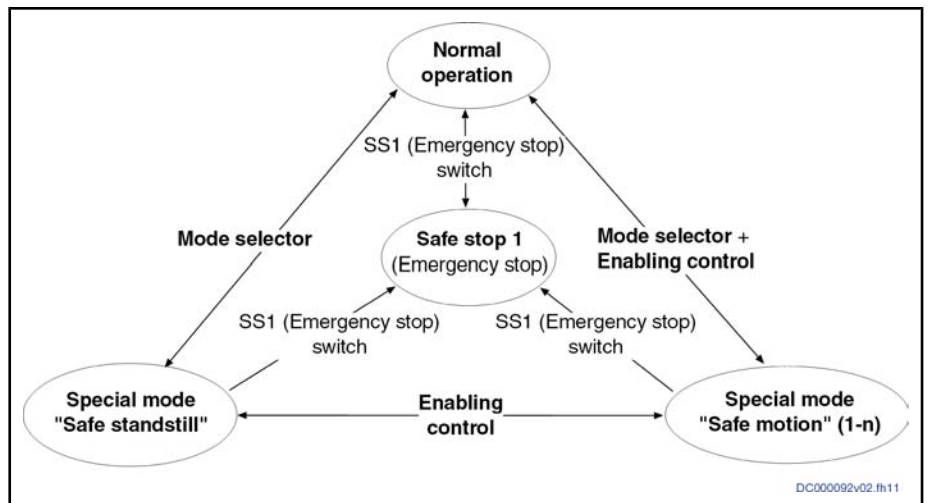


Fig. 8-73: Operating States of the Integrated Safety Technology

**Principles for Error Detection**

In order to prevent danger for persons in the danger zone of a machine motion in the case of temporary errors, precautions for minimizing motion due to errors have to be taken.

During operation, the safety functions are monitored by the drive system. For this purpose, three principles for discovering static error states, so-called sleeping errors, were realized in the system:

- **Dual-channel data processing** with structure by diversity
- **Cross comparison** of the safety-relevant data
- **Dynamization** of static states

These measures guarantee that a single error cannot cause the safety functions to get lost.

The installation or machine manufacturer has to determine in how far this is sufficient for an existing installation or machine by a risk analysis according to annex I of Directive 98/37/EWG.



After 2009-12-31, the new Machinery Directive 2006/42/EG must be applied.

**States of Integrated Safety Technology**

**Normal Operation and Special Mode**

The status "normal operation/special mode" supports the following safety functions:

- **Safe maximum speed**  
→ Defines a safe maximum speed in normal operation/special mode
- **Safely-limited position**  
→ Defines a positive and a negative safe position in normal operation/special mode  
**Note:** The safely-limited position requires establishing the safe reference!
- **Safe direction**  
→ 2-channel monitoring for allowed direction of motion

**Safe Standstill**

The status "safe standstill" supports the following safety functions:

- **Safe stop 1**  
→ Corresponds to stop category 1 according to EN 60204-1; with drive-controlled best possible deceleration and time monitoring

## Extended Axis Functions

- As an alternative -

- **Safe stop 2**

→ Corresponds to stop category 2 according to EN 60204-1; i.e. the drive control remains active, transition to standstill is carried out by the NC; drive monitors reaching of standstill within preset tolerance time via two channels

- Additionally -

- **Safe stop 1 (Emergency stop)**

→ Like "safe stop 1", but switching to "safe motion" by actuating the enabling control device not possible



Selection of "safe stop 1"/"safe stop 2" is made via the safety switches S1/S2; selection of "safe stop 1 (Emergency stop)" is made via dedicated switches

---

- **Safe braking and holding system**

→ It is safely prevented that gravity-loaded axes move down accidentally

**Safe Motion**

In the status "safe motion", the following safety functions are supported by "Safety on Board":

- **Safely-limited speed**

→ 2-channel monitoring for exceeding a speed threshold

- **Safe direction**

→ 2-channel monitoring for allowed direction of motion

- **Safely-limited increment**

→ 2-channel monitoring for allowed travel distance

- **Safely-monitored position**

→ 2-channel monitoring for monitored position

**Note:** The safely-monitored position requires establishing the safe reference!

**Auxiliary Functions**

The following auxiliary functions are provided:

- **Safely-monitored stopping process**

→ 2-channel monitoring of transition to safe standstill or safe motion

- **Safe homing procedure**

→ To establish the reference for channel 1 and channel 2

**Note:** The safe reference is a prerequisite for the "safely-limited position" and the "safely-monitored position"!

- **Safe brake check**

→ Cyclic test for both holding brakes (is required for the safe braking and holding system)

- **Safe parking axis**

→ Safe parking of the axis by safe locking of the output stage and acknowledgment of safety, although no encoder is available

**Safety Functions "Safe Feedback"**

The following safety functions are provided for "safe feedback":

- **Safe diagnostic outputs**

→ To transmit the "safe state" to additional system components

- **Safe door locking device** (not with PROFIsafe)

→ A drive that acts as the diagnostic master can summarize the safe state of several axes within a protective zone and control a safety door.

- **Safe inputs/outputs (for PROFIsafe)**

→ Safe inputs/outputs of the drive are used for connecting sensors and actuators which the higher-level master controls via PROFIsafe.

## 8.14.6 Notes on Commissioning

### Safe Torque Off

The use of the optional safety technology module "Safe Torque Off" (L2) does not require any special kind of commissioning; the corresponding wiring is sufficient.



For detailed descriptions and information, see separate documentation "Rexroth IndraDrive: Integrated Safety Technology According to IEC 61508"

### Safe Motion

Commissioning of the optional safety technology module "Safe Motion" (S2) is made through menu prompts via the commissioning tool "IndraWorks Ds/D/MLD".



For detailed descriptions and information, see separate documentation "Rexroth IndraDrive: Integrated Safety Technology According to IEC 61508"



## 9 Optional Device Functions

### 9.1 Availability of the Optional Device Functions

The following overview illustrates by which basic or functional packages the respective optional device function is supported (if not stated otherwise, this applies to all 4 firmware variants, MPB, MPD, MPH and MPC).

Optional device function	In base package (characteristic)	In functional package ... (on the basis of a base package with the following characteristics)		
		Servo function	Synchronization	Main spindle
Cross communication (CCD)	Only available with the corresponding hardware configuration			
IndraMotion MLD	Independent extension packages (ML, MA or TF)			
Digital inputs/outputs <sup>1)</sup>	OL/CL	–	–	–
Analog inputs <sup>1)</sup>	OL/CL	–	–	–
Analog outputs <sup>1)</sup>	OL/CL	–	–	–
Virtual master axis generator	–	–	OL/CL	–
Command value generator	OL/CL	–	–	–
Command value box	OL/CL	–	–	–
Encoder emulation	CL	–	–	–
Programmable Position switch	–	CL	CL	–
Probe	CL	–	OL/CL	–
Measuring encoder	–	OL/CL	OL/CL	–

OL Open-loop characteristic

CL Closed-loop characteristic

1) Depending on hardware configuration

*Fig. 9-1: Availability of the Optional Device Functions*

To use a functional package, it must have been activated (enabled). The currently enabled functional packages are displayed in "P-0-2004, Active functional packages".

See also "Enabling of Functional Packages"

## 9.2 Cross Communication (CCD)

### 9.2.1 Brief Description

**Overview** The IndraDrive "cross communication" device function (Cross Communication Drives → CCD) allows electronic (digital) coupling of axes and the connection of I/O modules for IndraMotion MLD.

Optional Device Functions

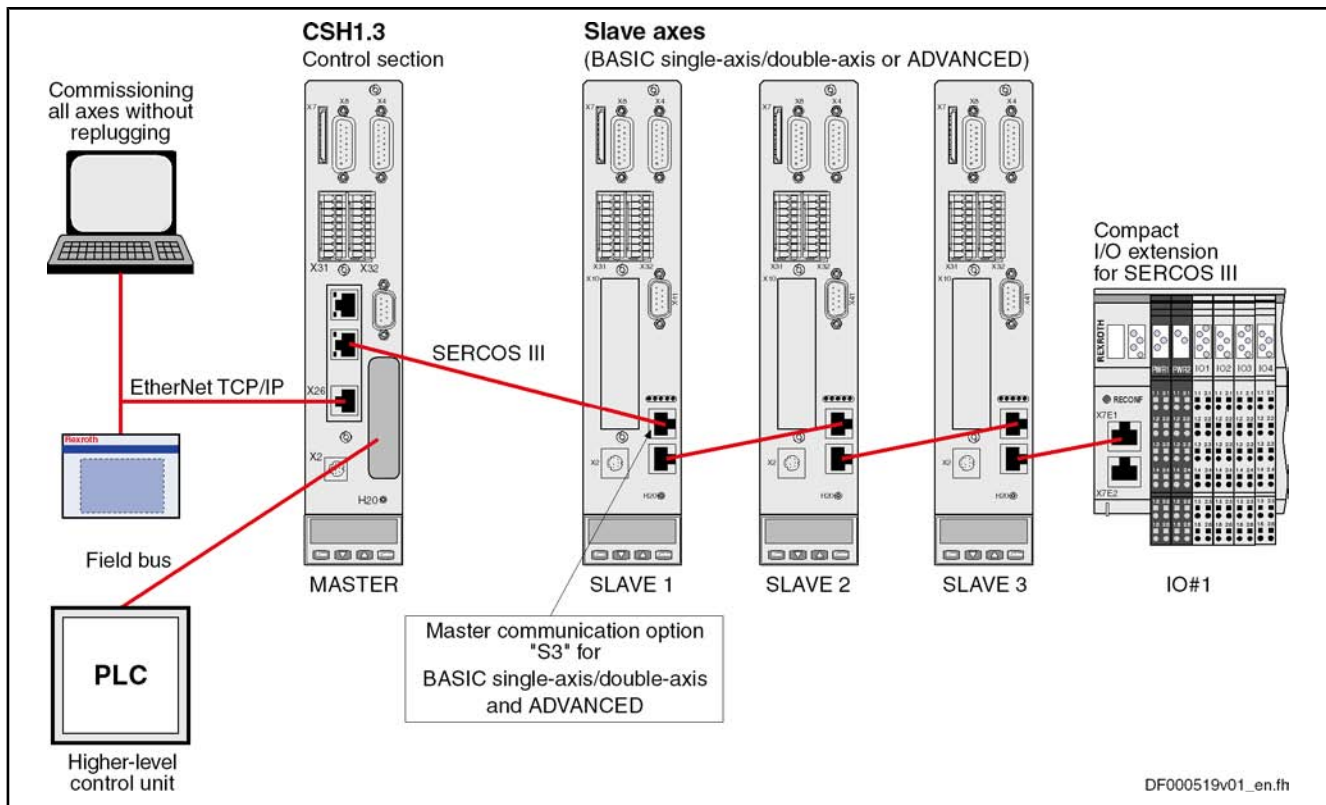


Fig.9-2: Hardware Topology of Drive Cross Communication (CCD)

**Bus Topology**

Configuration of the CCD slaves and communication with the external control unit always takes place via the CCD master drive, as the individual CCD slaves are connected to the master via a SERCOS III interface. Therefore, external access always takes place via the drive acting as the CCD master, which requires a master communication interface (e.g. PROFIBUS®) in addition to the CCD optional module ("SERCOS III master connection").

**CCD Modes (Kinds of Coupling)**

When cross communication (CCD) is used between the drives, we distinguish the following variants (CCD modes):

- **CCD system mode**  
The CCD slaves have a direct logic connection to the field bus master; command triggering and input of process data take place via an external control unit.
- **CCD basic mode**  
The same functions as for the CCD system mode are available. However, the user has to program them. It is not possible to use the MLD-M functionality in the master axis.
- **MLD-M system mode**  
The CCD slaves have no direct logic connection to the external control unit, but only to the MLD-M in the CCD master. Command triggering and input of process data take place by the MLD-M in the CCD master.

**Features**

The device function "cross communication (CCD)" is characterized by the following features:

- Synchronization of CCD slaves to CCD master
- Transmission of freely configurable external **process data** (command values and actual values of the external control unit)

## Optional Device Functions

- Command value linking by transmission of freely configurable process data of the CCD axes (e.g. master/slave, Gantry axis)
- Connection of I/O extensions for SERCOS III via CCD (a maximum of 4 modules per CCD master)
- CCD (SERCOS III) cycle time can be parameterized (0.25 ms to 4 ms; depends on CCD mode, controller performance and number of axes)
- Max. baud rate: 100 MBaud
- CCD communication protocol: SERCOS III (see "SERCOS III")
- Data channels:
  - Cyclic data channel (MDT, AT): Max. 48 bytes and 16 IDN
  - Parameter or service channel: 4 bytes
- Parameterization of all axes in the CCD group via the CCD master interfaces (RS232, Engineering Port, field bus, ...)
- Command triggering of the CCD slaves depending on selected CCD mode via external control unit or internally via MLD in CCD master
- Max. number of CCD slaves: 7 resp. 9 (depending on CCD mode; see below "Performance Features")

**Fields of Application**

Typical fields of application for cross communication:

- Control tasks for multi-axis applications
  - Anti backlash
  - Synchronous operation control
  - Load control of several axes
- Simple command value linking
  - Position command value linking (gantry axes)
  - Torque/force linking
- Simple motion controls with decentralized command value adjustment for single-axis positioning and master axis linking
- I/O extension by connection of I/O modules for SERCOS III via CCD

**Restrictions**

When using cross communication, observe the following restrictions:

- With the cross communication function, "Coordinated Motion" is not possible!
- The higher-level master is usually a PLC with a field bus which does **not** have real-time and synchronization ability (PROFIBUS®, DeviceNet™, EtherNet/IP™).

**Hardware Requirements**

Using the drive function "cross communication" requires the following control section design:

- **CCD master**  
ADVANCED control section with CCD option in optional slot 3  
→ CSH-01.3C-xx-xxx-xxx-CCD-xx-x-..
- **CCD slaves**  
Control section with master communication interface "SERCOS III" (S3); possible with the following designs:
  - BASIC UNIVERSAL single-axis → CSB-01.xC-S3-xxx-xx-x
  - BASIC UNIVERSAL double-axis → CDB-01.xC-S3-xxx-xx-x
  - ADVANCED single-axis → CSH-01.xC-S3-xxx-xx-x

## Optional Device Functions



See documentation "Control Sections for Drive Controllers; Project Planning Manual"

**Firmware Requirements**

When using the drive function "cross communication", observe the following aspects regarding the firmware:

- This drive function is supported as of the firmware version MPx04.
- All drives of a CCD group (CCD master and CCD slaves) have to be operated with the same firmware version.
- As for integrated safety technology, this firmware function does not require separate enabling of functional packages; the function of drive cross communication is available with the corresponding hardware design.

**Pertinent Parameters**

The parameters listed below only exist for the CCD master:

- P-0-1600, CCD: configuration
- P-0-1601, CCD: addresses of projected drives
- P-0-1602, CCD: timing settings
- P-0-1603, CCD: Actual topology addresses
- P-0-1604, CCD: addresses of projected I/Os
- P-0-1605, CCD: command communication phase
- P-0-1606, CCD: actual communication phase
- P-0-1607, CCD: axis error
- P-0-1609, CCD: status word
- P-0-1610, CCD: cycle time
- P-0-1610.0.3, CCD: Actual topology
- P-0-1610.0.21, CCD: Slave addresses at end of line
- P-0-1610.0.30, CCD: Diagnostic message text
- P-0-1611, CCD: configuration list signal status word
- P-0-1612, CCD: configuration list signal control word
- P-0-1613, CCD: assignment list signal status word
- P-0-1614, CCD: assignment list signal control word
- P-0-1615, CCD: extrapolated cmd value IDN list signal selection
- P-0-1616, CCD: extrapolated cmd value signal selection
- P-0-1617, CCD: number of extrapolation steps
- P-0-1618, CCD: extrapolated command value
- P-0-1620.0.3, CCD: Command topology
- P-0-1620.0.21, CCD: Command Close ring
- P-0-1621, CCD: configuration list master communication cmd values
- P-0-1621.x.1, CCD: Slave address in high level network
- P-0-1621.x.2, CCD: S2 AT Transmission starting time (T1)
- P-0-1621.x.3, CCD: S2 Position of data record in MDT
- P-0-1621.x.4, CCD: SERCOS Telegram type parameter
- P-0-1621.x.5, CCD: Master comm. configuration list of AT
- P-0-1621.x.6, CCD: Master comm. configuration list of MDT
- P-0-1621.x.7, CCD: S2 Slave arrangement (SLKN)
- P-0-1621.x.8, CCD: S2 Mask class 3 diagnostics



## Optional Device Functions

- P-0-1621.x.9, CCD: Master comm. C0100 Comm. phase 3 transition check
- P-0-1621.x.10, CCD: Master comm. C5200 Comm. phase 4 transition check
- P-0-1621.x.11, CCD: Mater comm. master control word
- P-0-1621.x.12, CCD: Master comm. drive status
- P-0-1621.x.13, CCD: S2 Allocation of real-time control bit 1
- P-0-1621.x.14, CCD: S2 Allocation of real-time control bit 2
- P-0-1621.x.15, CCD: S2 Allocation of real-time status bit 1
- P-0-1621.x.16, CCD: S2 Allocation of real-time status bit 2
- P-0-1621.x.17, CCD: S2 Bit number allocation of real-time control bit 1
- P-0-1621.x.18, CCD: S2 Bit number allocation of real-time control bit 2
- P-0-1621.x.19, CCD: S2 Bit number allocation of real-time status bit 1
- P-0-1621.x.20, CCD: S2 Bit number allocation of real-time status bit 2
- P-0-1621.x.21, CCD: S2 Bit number allocation of real-time status bit 2
- P-0-1621.x.23, CCD: Master comm. diagnosis
- P-0-1622, CCD: configuration list master communication actual values
- P-0-1623, CCD: configuration list master cmd values
- P-0-1624, CCD: configuration list actual master values
- P-0-1625, CCD: configuration list slave cmd values
- P-0-1626, CCD: configuration list actual slave values
- P-0-1627, CCD: configuration list master cmd values I/Os
- P-0-1628, CCD: configuration list act. master values I/Os
- P-0-1629, CCD: configuration compact I/Os
- P-0-1630, CCD: diagnosis
- P-0-1630.x.1, CCD: Slave IP address
- P-0-1630.x.2, CCD: Device status word (S-Dev)
- P-0-1630.x.3, CCD: Connection-Control #0 (C-Con)
- P-0-1630.x.20, CCD: Resource-Status (S-Res)
- P-0-1631, CCD: AT error counter
- P-0-1632, CCD: system data 2 bytes
- P-0-1633, CCD: system data 4 bytes
- P-0-1635, CCD: command adjust slave addresses
- P-0-1636, CCD: Command topology addresses
- P-0-1637, CCD: error counter Port-1
- P-0-1638, CCD: error counter Port-2
- P-0-1639, CCD: allowed telegram failures
- P-0-1640, CCD: MAC address
- P-0-1641, CCD: IP address
- P-0-1642, CCD: network mask
- P-0-1643, CCD: gateway address
- P-0-1644, CCD: status IP communication
- P-0-1645.x.1, CCD connection: Configuration

## Optional Device Functions

- P-0-1645.x.2, CCD connection: Connection number
- P-0-1645.x.3, CCD connection: Telegram assignment
- P-0-1645.x.4, CCD connection: Max. length of connection
- P-0-1645.x.5, CCD connection: Current connection length
- P-0-1645.x.6, CCD connection: Configuration list
- P-0-1645.x.8, CCD connection: Connection control (C-Con)
- P-0-1645.x.10, CCD connection: Producer cycle time
- P-0-1645.x.11, CCD connection: Allowed losses of producer data
- P-0-1645.x.12, CCD connection: Error counter data losses
- P-0-1645.x.20, CCD connection: IDN allocation of real-time bits
- P-0-1645.x.21, CCD connection: Bit number allocation of real-time bits
- P-0-1651, CCD: master control word, slave 1  
(up to P-0-1659)
- P-0-1660.x.2, CCD: Device control word (C-Res)
- P-0-1660.x.3, CCD: Connection-Control #1 (C-Con)
- P-0-1660.x.20, CCD: Resource-Control (C-Res)
- P-0-1661, CCD: drive status word, slave 1  
(up to P-0-1669)
- P-0-1670, CCD: active actual position value, master
- P-0-1671, CCD: active actual position value, slave 1  
(up to P-0-1679)
- P-0-1680, CCD: actual velocity value, master
- P-0-1681, CCD: actual velocity value, slave 1  
(up to P-0-1689)
- P-0-1690, CCD: actual torque/force value, master
- P-0-1691, CCD: actual torque/force value, slave 1  
(up to P-0-1699)
- P-0-1701, CCD: diagnostic message number slave 1  
(up to P-0-1709)
- P-0-1710, CCD: signal status word, master
- P-0-1711, CCD: signal status word, slave 1  
(up to P-0-1719)
- P-0-1720, CCD: signal control word, master
- P-0-1721, CCD: signal control word, slave 1  
(up to P-0-1729)
- P-0-1730, CCD: Command value data container 1, Master 4Byte
- P-0-1731, CCD: Command value data container 1, Slave 1 4Byte  
(up to P-0-1739)
- P-0-1740, CCD: Command value data container 2, Master 4Byte
- P-0-1741, CCD: Command value data container 2, Slave 1 4Byte  
(up to P-0-1749)
- P-0-1750, CCD: Command value data container 3, Master 4Byte

## Optional Device Functions

- P-0-1751, CCD: Command value data container 3, Slave 1 4Byte (up to P-0-1759)
- P-0-1760, CCD: Command value data container 4, Master 4Byte
- P-0-1761, CCD: Command value data container 4, Slave 1 4Byte (up to P-0-1769)
- P-0-1770, CCD: Actual value data container 1, Master 4Byte
- P-0-1771, CCD: Actual value data container 1, Slave 1 4Byte (up to P-0-1779)
- P-0-1780, CCD: Actual value data container 2, Master 4Byte
- P-0-1781, CCD: Actual value data container 2, Slave 1 4Byte (up to P-0-1789)
- P-0-1790, CCD: Actual value data container 3, Master 4Byte
- P-0-1791, CCD: Actual value data container 3, Slave 1 4Byte (up to P-0-1799)
- P-0-1800, CCD: Actual value data container 4, Master 4Byte
- P-0-1801, CCD: Actual value data container 4, Slave 1 4Byte (up to P-0-1809)
- P-0-1810, CCD: Status word synchronous operation modes, master
- P-0-1811, CCD: Status word synchronous operation modes, slave 1 (up to P-0-1819)
- P-0-1820, CCD: Command value data container 1, Master 2Byte
- P-0-1821, CCD: Command value data container 1, Slave 1 2Byte (up to P-0-1829)
- P-0-1830, CCD: Command value data container 2, Master 2Byte
- P-0-1831, CCD: Command value data container 2, Slave 1 2Byte (up to P-0-1839)
- P-0-1840, CCD: Command value data container 3, Master 2Byte
- P-0-1841, CCD: Command value data container 3, Slave 1 2Byte (up to P-0-1849)
- P-0-1850, CCD: Command value data container 4, Master 2Byte
- P-0-1851, CCD: Command value data container 4, Slave 1 2Byte (up to P-0-1859)
- P-0-1860, CCD: Actual value data container 1, Master 2Byte
- P-0-1861, CCD: Actual value data container 1, Slave 1 2Byte (up to P-0-1869)
- P-0-1870, CCD: Actual value data container 2, Master 2Byte
- P-0-1871, CCD: Actual value data container 2, Slave 1 2Byte (up to P-0-1879)
- P-0-1880, CCD: Actual value data container 3, Master 2Byte
- P-0-1881, CCD: Actual value data container 3, Slave 1 2Byte (up to P-0-1889)
- P-0-1890, CCD: Actual value data container 3, Master 2Byte

## Optional Device Functions

- P-0-1891, CCD: Actual value data container 3, Slave 1 2Byte (up to P-0-1899)



For configuring the SERCOS III communication in the slaves, we use the standard SERCOS III parameters (see S-0-1001 et seq.).

## Pertinent Diagnostic Messages

- C0265 Incorrect CCD address configuration
- C0266 Incorrect CCD phase switch
- C0267 CCD timeout phase switch
- C0403 Switching to CCD phase 2 impossible
- C7000 CCD: Command Close ring
- C7001 CCD: Impossible to close ring
- C7100 CCD: Command Close ring
- C7101 CCD: Impossible to close ring
- E4012 Maximum number of CCD slaves exceeded
- E4013 Incorrect CCD addressing
- E4014 Incorrect phase switch of CCD slaves
- E4016 CCD: Topology error
- F2140 CCD slave error
- F4012 Incorrect I/O length
- F4140 CCD communication error
- F6140 CCD slave error (emergency halt)
- F8140 Fatal CCD error

## 9.2.2 Functional Description of the CCD Modes

### Comparison of the CCD Modes

For IndraDrive, cross communication is available in different variants (CCD modes) which are distinguished by the performance features contained in the following table:

Feature	CCD system mode	CCD basic mode	MLD-M system mode
Acyclic communication between CCD-master-side field bus interface and CCD slaves <sup>1)</sup>	Yes	No	No
Process data gateway and profile interpreter from external master (e.g. field bus interfaced PLC) to CCD slaves <sup>4)</sup>	Yes	No	No
Synchronization of CCD slaves to CCD master	Yes	Yes	Yes
Cross communication for command value linking in CCD group	Yes	Yes	Yes
Command triggering via external control unit, i.e. slaves get elementary information on device control (e.g. drive enable, operating mode input) for slaves from external master (e.g. field bus interfaced PLC)	Yes	Restricted <sup>2)</sup>	Restricted <sup>3)</sup>

Optional Device Functions

Feature	CCD system mode	CCD basic mode	MLD-M system mode
Command triggering by MLD-M in CCD master, i.e. slaves get elementary information on device control (e.g. drive enable, operation mode input) from MLD in CCD master	No	Restricted <sup>2)</sup>	Yes
Use of up to four I/O extensions as CCD slaves	Yes	Yes	Yes

- 1) Acyclic communication does not exist with SERCOS III, EtherCAT®, CANopen interface, EtherNet/IP™ and parallel interface
  - 2) Command triggering is possible, if control words are configured and operated accordingly (e.g. P-0-1651)
  - 3) Command triggering is possible, if MLD registers (e.g. P-0-1370 et seq.) are configured and operated accordingly and accordingly interpreted in MLD-M of CCD master
  - 4) Process data gateway does not exist with SERCOS III, EtherCAT®, CANopen interface and parallel interface
- Fig.9-3: Comparison of the CCD Modes*

Performance Features

The table below contains the main features and important data of the CCD modes:

	Command triggering (Motion Control)		Possible master communications					Max. number of axes
	CCD master	CCD slave	PROFIBUS® PROFINET® EtherNet/IP™ DeviceNet™	CANopen	Parallel, Analog, EtherCAT® et al.	SERCOS		
						II	III	
<b>CCD system mode</b>	Remote	Remote	Profiles 0xFFFE, 0xFFFFD for all CCD nodes	-	-	Yes	No	9+1
<b>CCD basic mode</b>	Local	Local	All profiles (only for CCD master)		Yes	Yes		9+1
<b>MLD-M system mode</b>	Local	Remote MLD-M	All profiles (only for CCD master)		Yes	Yes, without profile		9+1

- Remote Control by external master
  - Remote MLD-M Control by MLD-M in CCD master
  - Local Control by local MLD-S of the respective axis
- Fig.9-4: Performance Features of the CCD Modes*

Maximum Number of Axes and CCD Cycle Time

The maximum number of possible drives in the group (CCD slaves) depends on:

- Selected CCD mode
- CCD cycle time which was set
- Quantity of cyclic data (MDT, AT) per CCD slave

CCD cycle time	CCD system mode	MLD-M system mode <sup>1)</sup>	CCD basic mode
250 μs <sup>2)</sup> / 500 μs	1 slave + 1 master (2 slaves + +1 master)	--	1 slave + 1 master (2 slaves + +1 master)
1000 μs	6 slaves + 1 master	6 slaves <sup>4)</sup> + 1 master	6 slaves + 1 master

## Optional Device Functions

CCD cycle time	CCD system mode	MLD-M system mode <sup>1)</sup>	CCD basic mode
2000 µs / 4000 µs	9 slaves + 1 master 7 slaves + 1 master <sup>3)</sup>	9 slaves + 1 master	9 slaves + 1 master
The values in brackets are only valid for 24 bytes or less of MDT/AT data per slave.			

- 1) MLD-M system mode can only be selected in Basic performance of the CCD master.
  - 2) 250 µs cycle time is only possible if all drives in the CCD group are operated in Advanced control (CSH01.x control sections required).
  - 3) A maximum of 7 CCD slaves is possible for SERCOS II; independent of the MDT-/AT data
  - 4) Economy performance is not possible in the CCD slaves
- Fig. 9-5: Maximum Number of Drives Depending on CCD Cycle Time*



Sercos III I/O slaves are not included in the above overview and are to be added to the maximum possible number of axes specified. Therefore, 4 Sercos III I/O slaves are always possible in addition to the specifications above.

**Cyclic Data** It is possible to transmit up to 16 IDNs, with a total data volume of 48 bytes, in each direction (command values and actual values).

In the **CCD system mode**, (does not apply to SERCOS II) only the freely configurable profile (0xFFFE and 0xFFFD) is supported in the CCD master!

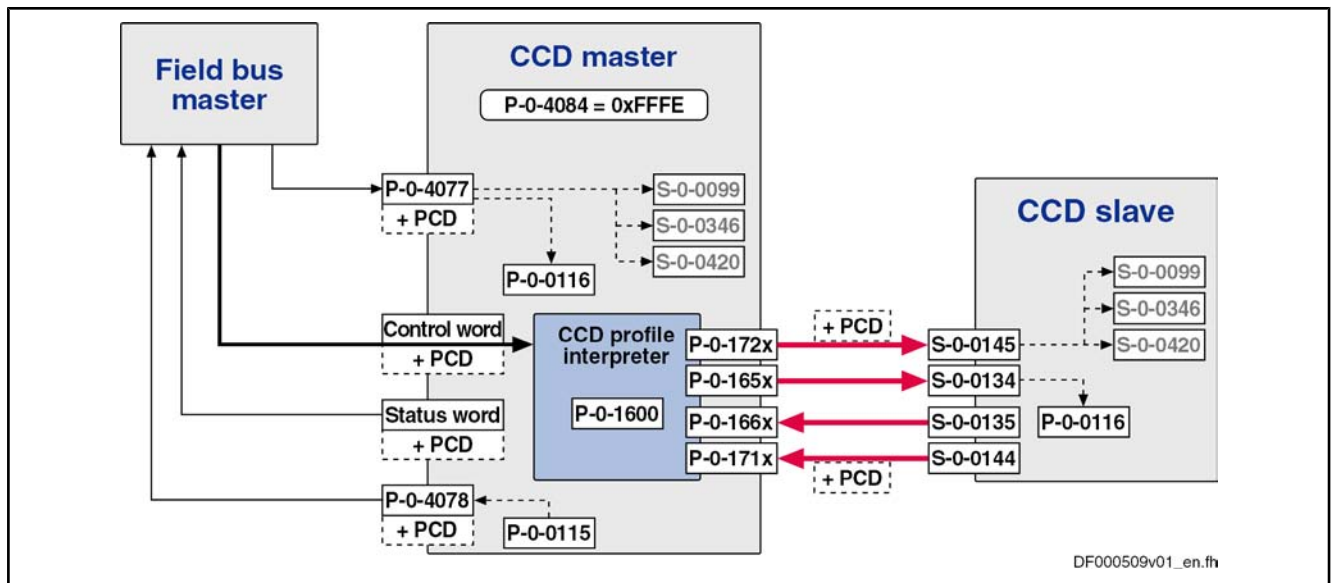
The resulting connection length between CCD master and CCD slaves in the **CCD system mode** results from the cyclic command and actual values which are exchanged between the master communication master (control) and the CCD slaves and the data from parameters P-0-1625 and P-0-1626 which apply in addition to the cyclic communication between CCD master and the CCD slaves.

## CCD System Mode

In the CCD system mode, the higher-level (external) master has control over the CCD slaves. Command triggering and input of process data take place via the external master (e.g. field bus interfaced PLC).

### System Structure (not With SERCOS II)

The figure below illustrates the system structure of the CCD system mode with field bus master communication (as regards command triggering and process data communication for collective bus connection). The figure only contains the command triggering and the process data of the external control unit. It does not show the data between CCD master and CCD slaves.



PCD	Process data (cyclic command values and actual values)
S-0-0099	C0500 Reset class 1 diagnostics
S-0-0144	Signal status word
S-0-0145	Signal control word
S-0-0346	Positioning control word
S-0-0420	C0400 Activate parameterization level 1 procedure command
S-0-0134	SERCOS III: Master control word
S-0-0135	SERCOS III: Drive status word
P-0-0115	Device control: Status word
P-0-0116	Device control: Control word
P-0-1600	CCD: Configuration
P-0-165x	CCD: Master control word, slave x
P-0-166x	CCD: Drive status word, slave x
P-0-171x	CCD: Signal status word, slave x
P-0-172x	CCD: Signal control word, slave x
P-0-4077	Field bus: Control word
P-0-4078	Field bus: Status word
P-0-4084	Field bus: Profile type

Fig.9-6: Overview CCD System Mode With Field Bus Interface

**System Structure With SERCOS II**

The content of the cyclic channel for the SERCOS II slaves is communicated to the SERCOS II slaves in the SERCOS II ring in phase 2. This is either made via

- "S-0-0015, Telegram type parameter", by selecting a standard telegram,
- or via the entries in the lists "S-0-0024 Configuration list of MDT" and "S-0-0026, Configuration list for signal status word".

The position of the data in the MDT for the individual slaves is parameterized via "S-0-0009, Position of data record in MDT". For the remote CCD slaves, these data are stored in parameter "P-0-1621.x.y, Master comm. configuration" of the CCD master and thus not transmitted directly to the CCD slaves by the CCD master (see below: Specific Features With SERCOS II). For the local slave (i.e. the SERCOS II master communication) in the CCD master, the initialization of the cyclic channel in the transition command 2->3 "S-0-0127, C0100 Communication phase 3 transition check" takes place as usual. However, the SERCOS II master communication must perform the initialization of the SERCOS II communication from the contents of parameter "P-0-1621.x.y, Master comm. configuration" for all additional slaves which are mirrored from the CCD group to the SERCOS II ring.

Optional Device Functions

The figure below illustrates the system structure of the CCD system mode with SERCOS II master communication (as regards command triggering and process data communication). The figure contains both, the command triggering and the process data of the external control to the CCD slaves and the (cyclic) data between CCD master and CCD slaves.

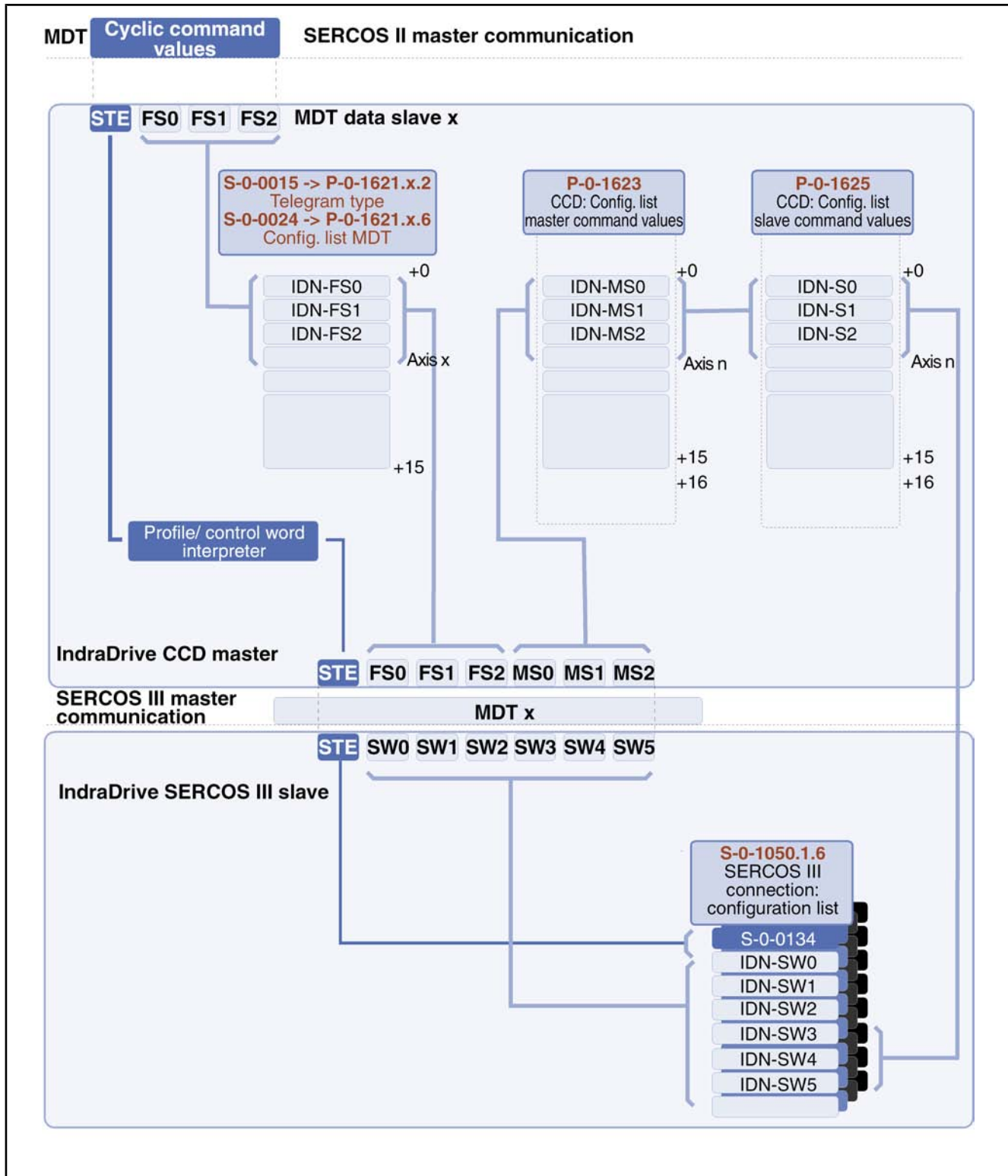


Fig. 9-7: Data Flow and Parameterization of Cyclic Command Values



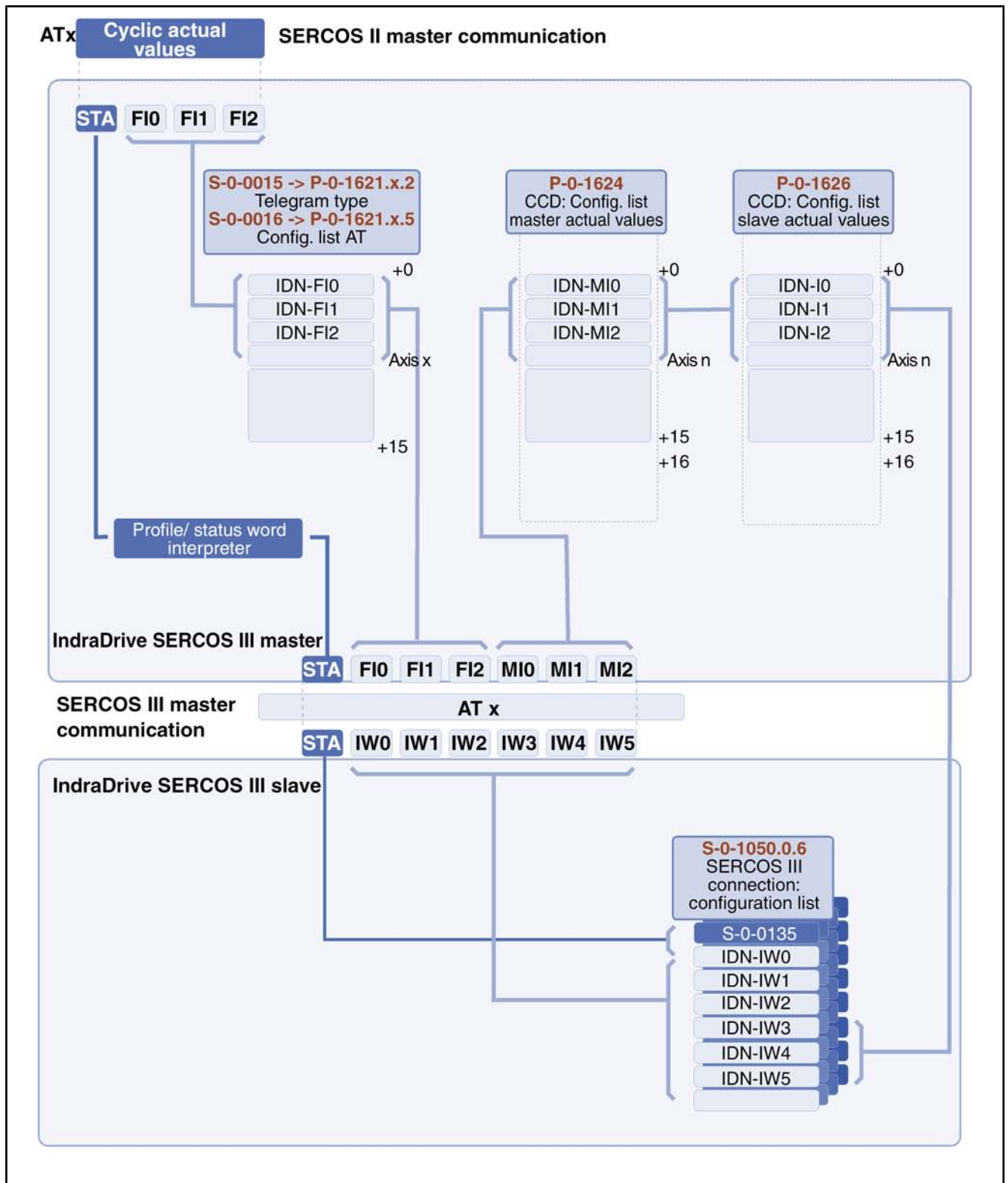


Fig.9-8: Data Flow and Parameterization of Cyclic Actual Values

**Features**

The following applies to the CCD system mode (not with SERCOS II):

- For each logic field bus slave (CCD slave), the field bus/drive control word is segmented and converted by the CCD master to a master control word (S-0-0134) for the corresponding CCD slave, and a signal control word

## Optional Device Functions

(S-0-0145) is segmented and converted for the CCD slave. The higher-level master thereby has full control over the slaves (e.g. enable, operation mode selection).

- For each logic field bus slave (CCD slave), the field bus/drive status word is generated by means of the drive status word (S-0-1135) and the signal status word (S-0-0144) of the respective CCD slave in the CCD master. The higher-level master thereby has the status of each slave (e.g. error).
- In addition, free process data can be used for master/slave cross communication. For this purpose, the parameters "P-0-1623, CCD: configuration list master cmd values" to "P-0-1626, CCD: configuration list actual slave values" have to be configured accordingly.
- Bits 12 to 15 of the signal status word (S-0-0144) and of the signal control word (S-0-0145) of the CCD slaves can be used by the field bus master. For this purpose, the parameters S-0-0144 and S-0-0145 have to be taken into account and written with values in the data exchange between external control unit and CCD master. Parameter setting takes place in the parameters P-0-1621 and P-0-1622 in the CCD master. The master then transmits the signals at bits 12 and 15 of the signal status word (S-0-0144) and of the signal control word (S-0-0145) to the corresponding CCD slaves.



Exception: With SERCOS II, the bits of the signal control and status words are not required, all 15 bits can be used freely. The signal control word and the status word must be taken into account for every slave in the respective MDT (S-0-1050.1.6) and AT(S-0-1050.0.6) data (see following section).

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- The cyclic process data (command values and actual values) of master communication (P-0-1621 and P-0-1622 in the CCD master) are directly mapped to the CCD bus in the AT and MDT (and vice versa). Via these parameters, the external field bus master can access the parameters of the CCD slaves.



Exception: In the case of SERCOS II the parameters P-0-1621 and P-0-1622 are not taken into account. The configuration of the cyclic data from the control to the CCD slaves is made individually for each axis (CCD master and slave) via the configuration lists for drive (S-0-0016) and master data (S-0-0024) telegram.

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**Notes on Utilization**

When using the CCD system mode, observe the following aspects:

- In addition to the process data of master communication, free process data can be used in the CCD system mode for mere master/slave cross communication. For this purpose, the contents of the configuration lists in the parameters P-0-1623 to P-0-1626 have to be manually extended!
- In the case of field bus master communication, the freely configurable profile type (P-0-4084 = 0xFFFFE and 0xFFFFD) is supported.
- When using EtherNet/IP and DeviceNet™ with CCD system mode, data consistency between a CCD master and CCD slaves (container consistency) (synchronization between external control unit's data and drive data) can only be ensured, if the "virtual slave" function (see "Dead Time Compensation") is used for the CCD master data.

Optional Device Functions

- When using the (unassigned) bits of the signal control word and the signal status word (S-0-0145, S-0-0144), take the following aspects into account:
  - The MDT for the slaves must at least contain the signal control word and the AT must at least contain the signal status word (to be configured in P-0-1621 and P-0-1622, with SERCOS II in S-0-1050.0.6 and S-0-1050.1.6, see also above).
  - Only the bits 12 to 15 of the signal status word (S-0-0144) and of the signal control word (S-0-0145) can be used.



Exception: With SERCOS II all bits can be used

- The bits 0 to 11 in the signal status word of the CCD slaves are always zero for the control unit (does not apply to SERCOS II master communication).
- The parameterization of the signal control word of the slaves is performed by the master via the parameters P-0-1612 and P-0-1614, with SERCOS II, as usual, in each axis via the usual standard parameters (S-0-0027 and S-0-0329)
- The parameterization of the signal control word of the slaves is performed by the master via the parameters P-0-1611 and P-0-1613, with SERCOS II in each axis via the standard parameters (S-0-0026 and S-0-0328).

**Control Word in CCD System Mode**

The table below shows the conversion of the bits in the control word of the "emulated field bus slave" of the CCD master to the actual parameters of the CCD slave. The external master thereby has control over the CCD slaves. This control word for the slave emulated in the CCD master corresponds to the structure of the field bus control word (P-0-4077) and has to be taken into account accordingly in the cyclic output data of the external control unit.



This does not apply to SERCOS II. In this case, the master control word (S-0-0134) has to be used. In the CCD master, these data are copied to the respective bits of the SERCOS III parameter (S-0-0134) of the respective CCD slaves.

Bit in P-0-4077	Significance in field bus profile	Target parameter in slave	Access to slave via ...
0	Command value acceptance	S-0-0346, Positioning control word; bit 0	S-0-0145: Bit 0
1	Operating mode setting	S-0-0420, C0400 Activate parameterization level 1 procedure command S-0-0422, C0200 Exit parameterization level procedure command	S-0-0145: Bit 8 S-0-0145: Bit 9
2	Going to zero	S-0-0148, C0600 Drive-controlled homing procedure command	S-0-0145: Bit 2
3	Absolute / relative	S-0-0346: Bit 3	S-0-0145: Bit 3
4	Immediate block change	S-0-0346: Bit 5	S-0-0145: Bit 4
5	Clear error	S-0-0099: Command clear error (S-0-0099, C0500 Reset class 1 diagnostics)	S-0-0145: Bit 5
6,7	Positioning / jogging	S-0-0346: Bit 1,2	S-0-0145: Bit 6,7
8,9	Command operation mode	S-0-0134, Master control word; bit 8,9	Direct access to S-0-0134

Optional Device Functions

Bit in P-0-4077	Significance in field bus profile	Target parameter in slave	Access to slave via ...
10,11	--	--	--
12	IPOSYNC	S-0-0134, Master control word; bit 10	Direct access to S-0-0134
13	Drive Halt	S-0-0134, Master control word; bit 13	Direct access to S-0-0134
14	Drive enable	S-0-0134, Master control word; bit 14	Direct access to S-0-0134
15	Drive ON	S-0-0134, Master control word; bit 15	Direct access to S-0-0134

Fig.9-9: Conversion of Field Bus Control Word (P-0-4077) to CCD Slave Parameters With Field Bus Profile Type 0xFFFE



(Does not apply to SERCOS II master communication)

As "S-0-0145, Signal control word" is used for mapping the control bits not contained in "S-0-1134, Master control word", it has been, in the CCD system mode, by default configured in the cyclic master data telegram (MDT → S-0-1050.1.6) of the corresponding CCD slave! In addition, other bits have been permanently configured so that the user can only define the bits 12 to 15! To transmit these unassigned bits to the slaves, the signal control word (S-0-0145) has to be additionally configured in the cyclic command values of the control unit to the slaves (in parameter P-0-1621).

**Cyclic Command Values of the Master Communication (Does not Apply to SERCOS II Master Communication)**

The cyclic command values for a CCD slave consist of at least 2 bytes control word (same structure as field bus control word; see P-0-4077) and the data from "P-0-1621, CCD: configuration list master communication cmd values". The control word is always transmitted at the beginning of the cyclic data for a slave (is not contained in P-0-1621, but has to be taken into account accordingly in the cyclic output data of the control unit!), followed by the data from P-0-1621.

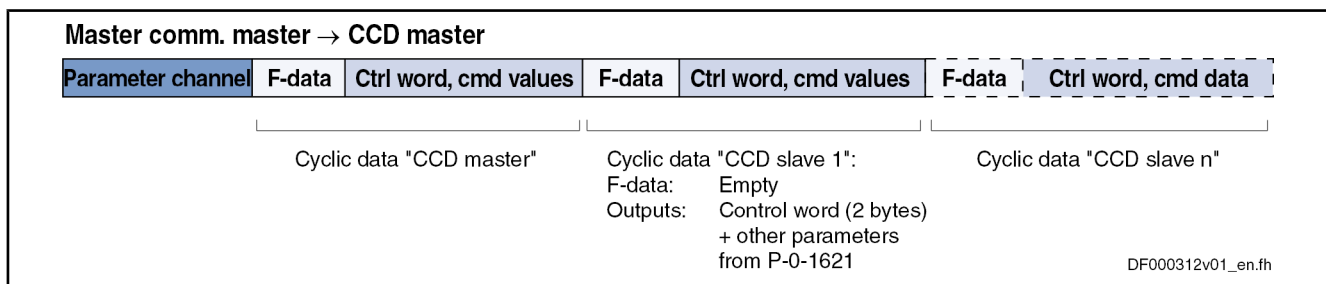


The 2-byte status word P-0-4077 is converted to 4 bytes master status word + 2 bytes signal status word!



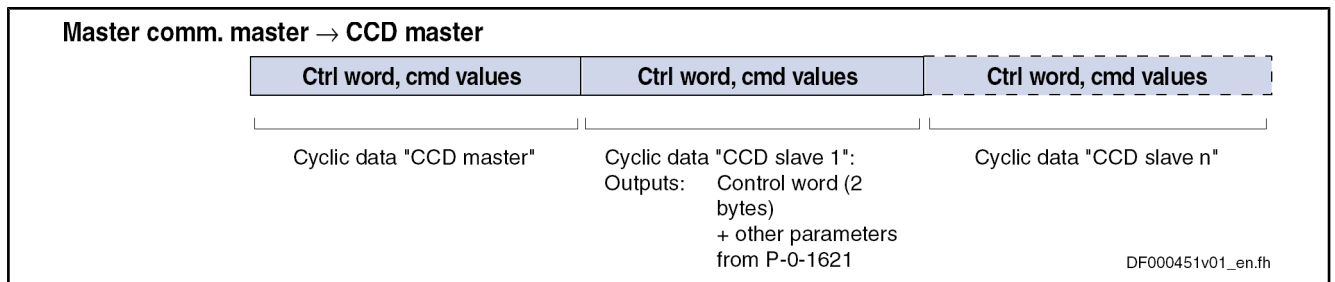
For profile type P-0-4084 = 0xFFFD, the bits 0, 2, 3, 4, 6 and 7 are not evaluated in the control word!

PROFIBUS®



P-0-1621 Configuration list of master communication command values for CCD  
Fig.9-10: Command Value Channel From Master Communication Master to CCD Group With PROFIBUS®

EtherNet/IP



P-0-1621 Configuration list of master communication command values for CCD  
Fig.9-11: Structure of an Assembly/Cyclic Data Container With EtherNet/IP

**Status Word in CCD System Mode**

The table below shows the assignment of the bits in the status word of the "emulated field bus slave" of the CCD master to the actual parameters of the CCD slave. The external master thereby gets the information on the CCD slaves. This status word for the slave emulated in the CCD master corresponds to the structure of the field bus status word (P-0-4078) and has to be taken into account accordingly in the cyclic input data of the external control unit.



This does not apply to SERCOS II. In this case, the bits of the drive status word (S-0-0135 for SERCOS III) of the CCD slaves in the CCD master are copied to the SERCOS II status word (S-0-0135) of the respective SERCOS II slaves.

Bit in P-0-4078	Significance in field bus profile	Source parameter in slave	Access to slave via ...
0	--	--	--
1	Operating mode acknowledgment	S-0-0424, Status parameterization level	S-0-0144: Bit 1
2	In_Reference	S-0-0403, Position feedback value status	S-0-0144: Bit 2
3	In_Standstill	S-0-0331, Status "n_feedback = 0"	S-0-0144: Bit 3
4	Command value reached	P-0-0115, Device control: status word; bit 12	S-0-0144: Bit 4
5	Command change bit	S-0-0135, Drive status word; bit 5	Direct access to S-0-0135
6	--	--	--
7	Status of command value processing	S-0-0135, Drive status word; bit 3	Direct access to S-0-0135
8,9	Actual operation mode	S-0-0135, Drive status word; bit 8,9	Direct access to S-0-0135
10	Command value acknowledgment	S-0-0419: Bit 0	S-0-0144: Bit 10
11	Class 3 diagnostics message	S-0-0135, Drive status word; bit 11	Direct access to S-0-0135
12	Class 2 diagnostics warning	S-0-0135, Drive status word; bit 12	Direct access to S-0-0135
13	Class 1 diagnostics drive error	S-0-0135, Drive status word; bit 13	Direct access to S-0-0135
14/15	Readiness for operation	S-0-0135, Drive status word; bit 14,15	Direct access to S-0-0135

Fig.9-12: Conversion of Field Bus Status Word (P-0-4078) to CCD Slave Parameters With Profile 0xFFFE

Optional Device Functions



(Does not apply to SERCOS II master communication)

As "S-0-0144, Signal status word" is used for mapping the status bits not contained in "S-0-1135, Drive status word", it has been by default configured in the cyclic drive telegram (AT → S-0-1050.0.6)! In addition, other bits have been permanently configured so that the user can only define the bits 12 to 15! To be able to read these unassigned bits of the slaves, the signal status word (S-0-0144) has to be additionally configured in the cyclic actual values of the CCD slaves to the control unit (in parameter P-0-1622).

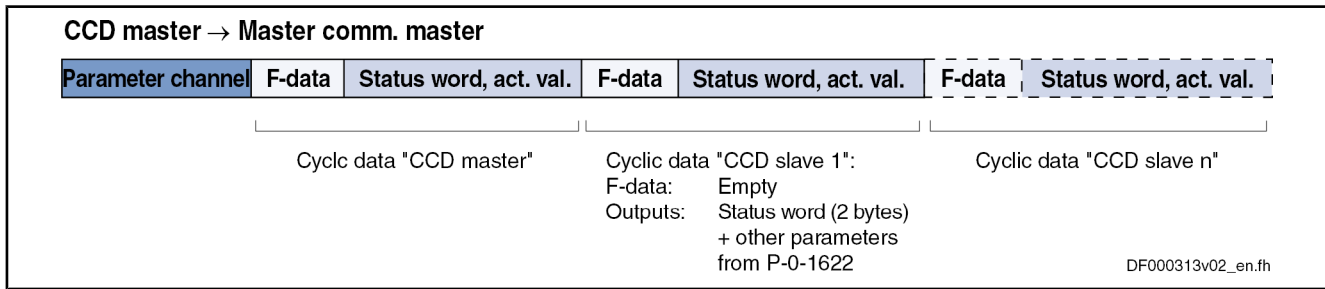
**Cyclic Actual Values of the Master Communication (Does not Apply to SERCOS II Master Communication)**

The cyclic actual values of a CCD slave consist of at least 2 bytes status word (same structure as field bus status word; see P-0-4078) and the data from "P-0-1622, CCD: configuration list master communication actual values". The status word is always transmitted at the beginning of the cyclic data for a slave (is not contained in parameter P-0-1622, but has to be taken into account accordingly in the cyclic input data of the control unit!), followed by the data from P-0-1622.



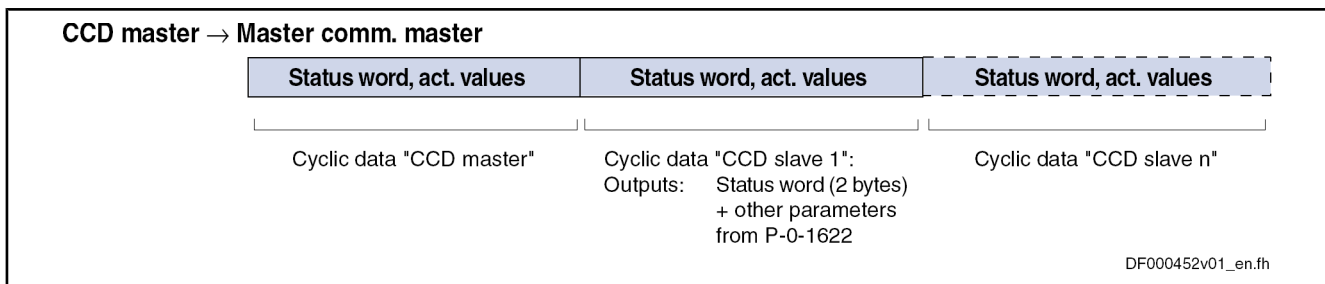
The 2-byte status word P-0-4078 is composed of 4 bytes drive status word + 2 bytes signal status word!

**PROFIBUS®**



P-0-1622 Configuration list of master communication actual values for CCD  
 Fig.9-13: Actual Value Channel From CCD Group to Master Communication Master With PROFIBUS®

**EtherNet/IP**



P-0-1622 Configuration list of master communication actual values for CCD  
 Fig.9-14: Structure of an Assembly/Cyclic Data Container With EtherNet/IP

**Specific Features With SERCOS II**

Parameters that are available in the SERCOS II ring but are not supported by the CCD slaves (SERCOS III) used by the SERCOS III communication in the CCD slave, must be mapped individually for the the SERCOS II service channel. These parameters are collected in a collective parameter "P-0-1621.x.y, Master comm. configuration of CCD master" Write and read requests via the SVC of the CCD master master communication, which are a intended for the CCD slaves, are transmitted to this parameter. The CCD master uses the con-

## Optional Device Functions

tent of this parameter for initialization of the SERCOS II ring and the SERCOS III CCD connection.

IDN	Name	Read/write	Type	Notes
S-0-0002	SERCOS cycle time (TScyc)	R/W	Device	R/W to master IDN
S-0-0003	Minimum AT transmit starting time (T1min)	R	Device	Reading of master IDN
S-0-0004	Transmit/receive transition time (TATMT)	R	Device	Reading of master IDN
S-0-0005	Minimum feedback acquisition time (T4min)	R	Device	Must be generated online
S-0-0006	AT Transmission starting time (T1)	R/W	Slave	Copy to P-0-1621.x.2
S-0-0007	Feedback acquisition starting time (T4)	R/W	Device	R/W to master IDN
S-0-0008	Command value valid time (T3)	R/W	Device	R/W to master IDN
S-0-0009	Position of data record in MDT	R/W	Slave	R/W to P-0-1621.x.3
S-0-0010	Length of master data telegram	R/W	Device	R/W to master IDN
S-0-0016	Configuration list of AT	R/W	Slave	Copy to P-0-1621.x.5 and convert to S-0-1050.0.6 in slave
S-0-0024	Configuration list of MDT	R/W	Slave	Copy to P-0-1621.x.6 and convert to S-0-1050.1.6 in slave
S-0-0028	MST error counter	R	Device	Reading of master IDN
S-0-0029	MDT error counter	R	Device	Reading of master IDN
S-0-0087	Transmit to transmit recovery time (TATAT)	R	Device	Reading of master IDN
S-0-0088	Receive to receive recovery time (TMTSY)	R	Device	Reading of master IDN
S-0-0089	MDT Transmit starting time (T2)	R/W	Device	R/W to master IDN
S-0-0090	Command value proceeding time (TMTSG)	R	Device	Reading of master IDN
S-0-0096	Slave arrangement (SLKN)	R	Slave	Must be generated from S-0-1040 of the CCD slaves P-0-1621.x.7
S-0-0098	Mask class 3 diagnostics	R/W	Slave	Not available with SERCOS III slave P-0-1621.x.8
S-0-0143	Sercos interface version	R	Device	Reading of master IDN
S-0-0185	Length of the configurable data record in the AT	R	Device	Reading of master IDN
S-0-0186	Length of the configurable data record in the MDT	R	Device	Reading of master IDN
S-0-0301	Allocation of real-time control bit 1	R/W	Slave	Copy to P-0-1621.x.13 and convert to S-0-1050.1.20 in slave
S-0-0303	Allocation of real-time control bit 2	R/W	Slave	Copy to P-0-1621.x.14 and convert to S-0-1050.1.20 in slave
S-0-0305	Allocation of real-time status bit 1	R/W	Slave	Copy to P-0-1621.x.15 and convert to S-0-1050.1.20 in slave
S-0-0307	Allocation of real-time status bit 2	R/W	Slave	Copy to P-0-1621.x.16 and convert to S-0-1050.1.20 in slave
S-0-0413	Bit number allocation of real-time control bit 1	R/W	Slave	Copy to P-0-1621.x.17 and convert to S-0-1050.1.20 in slave
S-0-0414	Bit number allocation of real-time control bit 2	R/W	Slave	Copy to P-0-1621.x.18 and convert to S-0-1050.1.20 in slave

## Optional Device Functions

IDN	Name	Read/write	Type	Notes
S-0-0415	Bit number allocation of real-time status bit 1	R/W	Slave	Copy to P-0-1621.x.19 and convert to S-0-1050.1.20 in slave
S-0-0416	Bit number allocation of real-time status bit 2	R/W	Slave	Copy to P-0-1621.x.20 and convert to S-0-1050.1.20 in slave

*Fig.9-15: Conversion of SERCOS II Parameters That are Not Available in SERCOS III CCD Slave*

Parameters with different content for SERCOS II and SERCOS III must be considered individually with regard to the service channel use and preprocessed and maintained for SERCOS II resp. SERCOS III in individual parameters in the CCD master

IDN	Name	Read/write	Type	Notes
S-0-0015	Telegram type parameter	R/W	Slave	R/W to P-0-1621.x.4 → see real-time data
S-0-0021	IDN-list of invalid operation data for CP2	R	Slave	R to P-0-1621.x.21
S-0-0127	C0100 Communication phase 3 transition check	R/W	Slave	R/W to P-0-1621.x.9 No reaction, is confirmed without errors by the master → communication state machine
S-0-0128	C5200 Communication phase 4 transition check	R/W	Slave	R/W to P-0-1621.x.10 No reaction, is confirmed without errors by the master → communication state machine
S-0-0134	Master control word	R	Device	Interpreter required, e.g. for operation mode bits → see profile/profile interpretation to P-0-1621.x.11
S-0-0135	Drive status word	R	Device	Interpreter required, e.g. for class 2 diagnostics bits → see profile/profile interpretation to P-0-1621.x.12
S-0-1040	Drive address of master communication	R/W	Slave	R/W to P-0-1621.x.1 → see addressing

*Fig.9-16: Conversion of SERCOS II Parameters That are not Available in SERCOS III*

#### Cyclic Command Values With SERCOS II

Control-side configuration of the master data telegram is made as usual, via the standard parameters "S-0-0009, Position of data record in MDT" and "S-0-0024, Configuration list of MDT". This information is interpreted in the CCD master and then copied to P-0-1621.x.3 or P-0-1621.x.6. When configuring the connections for the CCD slaves, the CCD master must observe the contents from parameter P-0-1621.x.3 or P-0-1621.x.6 for the command values and copy them accordingly to the parameters, such as to S-0-1050.1.6

#### Cyclic Actual Values With SERCOS II

Control-side configuration of the master data telegram is made as usual, via the standard parameters "S-0-0006, AT Transmission starting time (T1)" and "S-0-0016, Configuration list of AT". This information is interpreted in the CCD master and then copied to P-0-1621.x.3 or P-0-1621.x.6. When configuring the connections for the CCD slaves, the CCD master must observe the contents from parameter P-0-1621.x.2 or P-0-1621.x.56 for the actual values and copy them accordingly to the parameters, such as to S-0-1050.1.5



Class 3 diagnostics bit (S-0-0135, bit 11) does not exit with SERCOS III CCD slaves. This information is therefore not supplied. The bit is always "0".

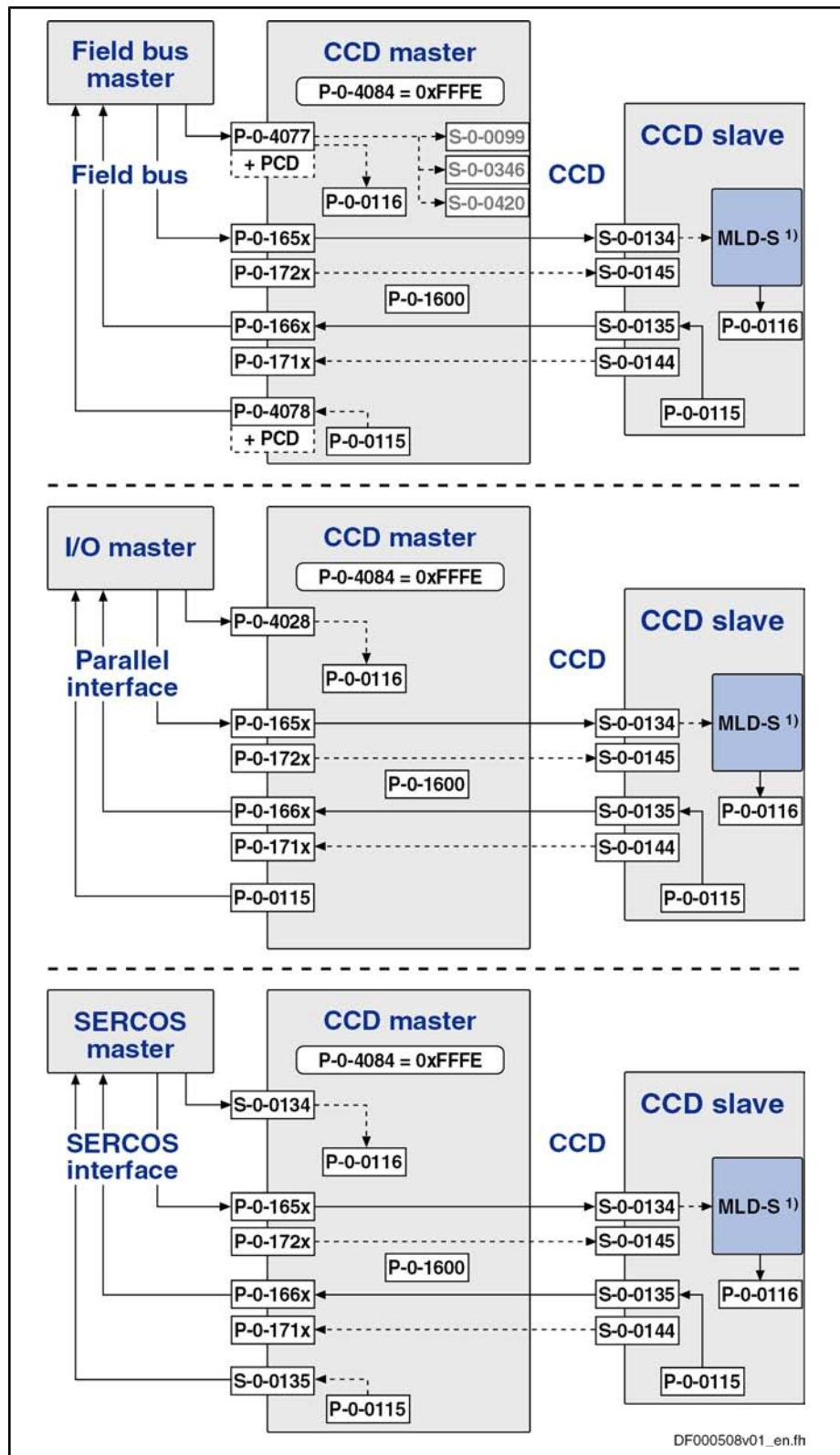


## CCD Basic Mode

In the CCD basic mode, automatic interpretation of control information by the CCD master does not take place. The CCD master cannot automatically route cyclic data of the master communication to the CCD slaves. The master communication "sees" only the CCD master. It is only possible to exchange data via the CCD process data exchange between CCD master and CCD slave.

**System Structure** The figure below illustrates the system structure for the CCD basic mode with field bus master communication, SERCOS interface and parallel/analog interface:

Optional Device Functions



PCD Process data (cyclic command values and actual values)

1) With permanent control

Fig.9-17: Overview CCD Basic Mode for Different Master Communication Interfaces

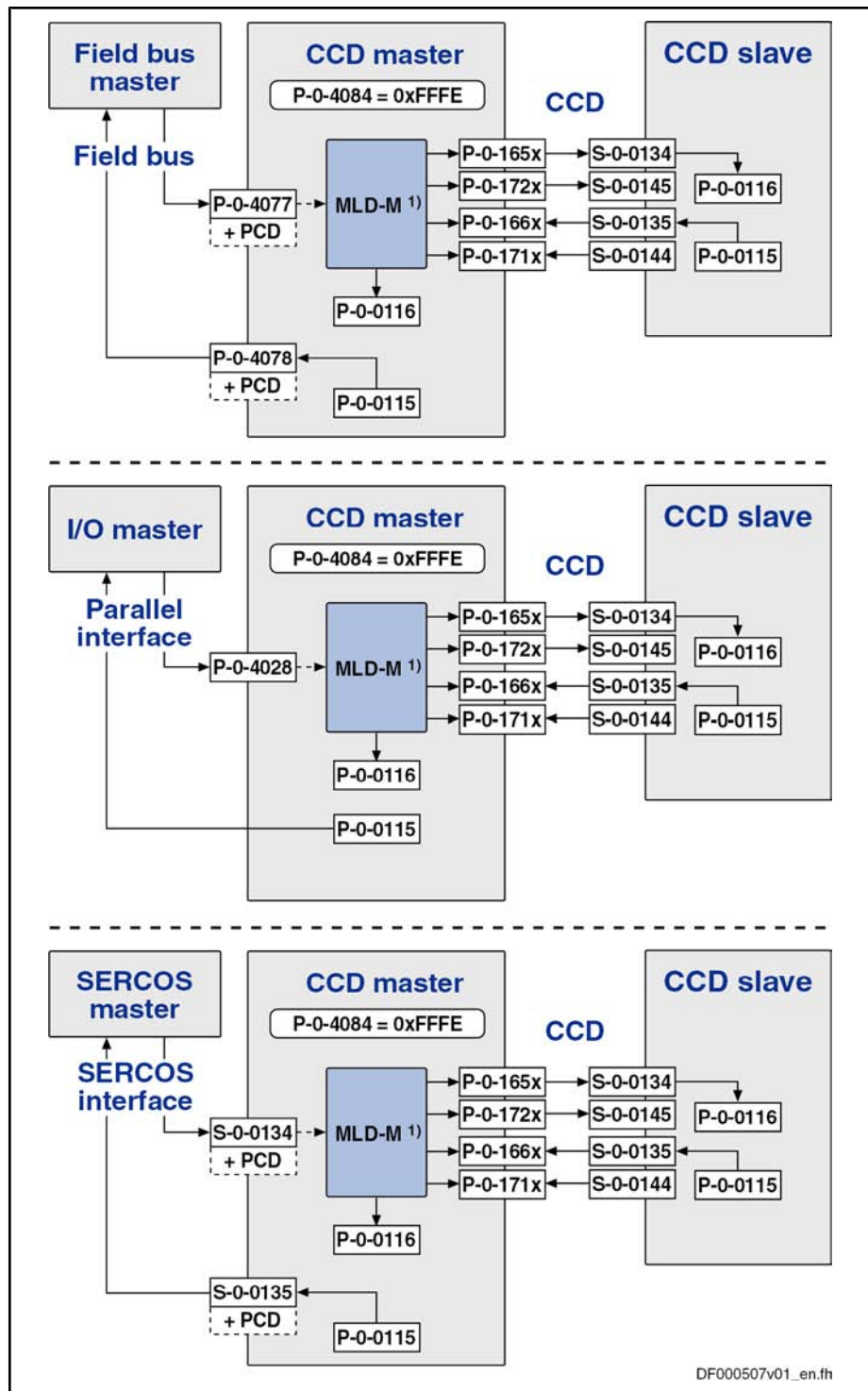
- Features** In the CCD basic mode, the external master (field bus, SERCOS interface, analog/parallel interface) has **restricted access** to the CCD slaves. The following applies:
- The CCD basic mode is used when only process data are to be exchanged between the CCD master and the CCD slaves. The parameters P-0-1623 to P-0-1626 are relevant for parameterizing the data exchange. Only the data listed in these parameters are exchanged between master and slave.
  - Even with active field bus card in the CCD master, the profile interpreter is not active. The parameters P-0-1611 to P-0-1614 do not take effect. The signal control word/signal status word of the slaves is not configured via the master and not automatically transmitted in the MDT/AT. If the master nevertheless writes data to the signal control words and signal status words of the CCD slaves (S-0-0144, S-0-0145), the free process data between CCD master and CCD slave (P-0-1623 to P-0-1626) must be used for this purpose. In the CCD master, the parameters P-0-172x and P-0-171x have to be written or read therefor.
  - As the drive status word of the slaves in the AT is always transmitted in the case of SERCOS, it can be read via the corresponding parameter P-0-1661 to P-0-1667 in the master.
  - As the master control word of the slaves in the MDT is always transmitted in the case of SERCOS, it has to be written via the corresponding parameter P-0-1651 to P-0-1657 (e.g. by MLD-S or via parallel interface). In the CCD basic mode, this allows controlling basic input, such as enable, operation mode selection etc., for the slaves via the CCD master.

## MLD-M System Mode

In the MLD-M system mode, the drive-integrated MLD in the master has control over the axes. Additionally, MLD has access to the CCD slaves. The CCD master cannot automatically route cyclic data of the master communication to the CCD slaves. The master communication "sees" only the CCD master. Data from master communication have to be interpreted and, if necessary, transmitted in the MLD-M of the CCD master.

- System Structure** The figure below illustrates the system structure of the MLD-M system mode with field bus master communication, SERCOS interface and parallel/analog interface:

Optional Device Functions



PCD Process data (cyclic command values and actual values)

1) With permanent control

Fig. 9-18: Overview MLD-M System Mode for Different Master Communication Interfaces

**Features**

In this mode, the external master only has indirect control over the CCD slaves via the CCD master. The following applies:

- The drive PLC in the master generates the master control word for the CCD slaves. The higher-level control unit therefore does not have any

influence on individual slaves. The master control word of a slave can be read via the corresponding parameters P-0-1651 to P-0-1657.

- The drive PLC in the master evaluates the status words of the CCD slaves. The higher-level control unit therefore does not have any information on individual CCD slaves. The drive status word of a slave can be read via the corresponding parameters P-0-1661 to P-0-1667.
- The cyclic process data for the CCD slaves are generated by the CCD master and vice versa (master/slave cross communication). Part of them has been permanently pre-assigned for motion input from the drive PLC. The rest can be freely configured for other purposes (process loop, access to slave peripherals, etc.).
- Parameters of the CCD slaves can be read and written by the MLD in the CCD master.
- Via the corresponding motion function blocks, the MLD in the master can move the CCD slaves.

Signal control word/status word (S-0-0144 / S-0-0145) are permanently parameterized by the internal PLC for the motion channel, but only partly used. For the unassigned bits, the PLC makes available a function which allows the user accessing them from the PLC program (so-called "AxisData structure").

The unassigned bits in the signal control word/status word of the CCD slaves are parameterized in the master via the parameters P-0-1611 to P-0-1614.



See also separate documentation "Rexroth IndraMotion MLD".

## State Machine and Phase Input

### Multi-Axis Field Bus Connection

To generate unequivocal phase input (communication phase) for the CCD slaves in the case of multi-axis field bus connection (in the system mode), this input is realized in the CCD master by a CCD phase state machine.

- The input value of the state machine is the value of parameter "P-0-1605, CCD: command communication phase".
- The present communication phase of the CCD bus is displayed in parameter "P-0-1606, CCD: actual communication phase".
- In the parameter "P-0-1609, CCD: status word", you can find information on the phase state machine, such as "target phase", "actual phase", "phase switch active", "phase switch aborted with error" etc.

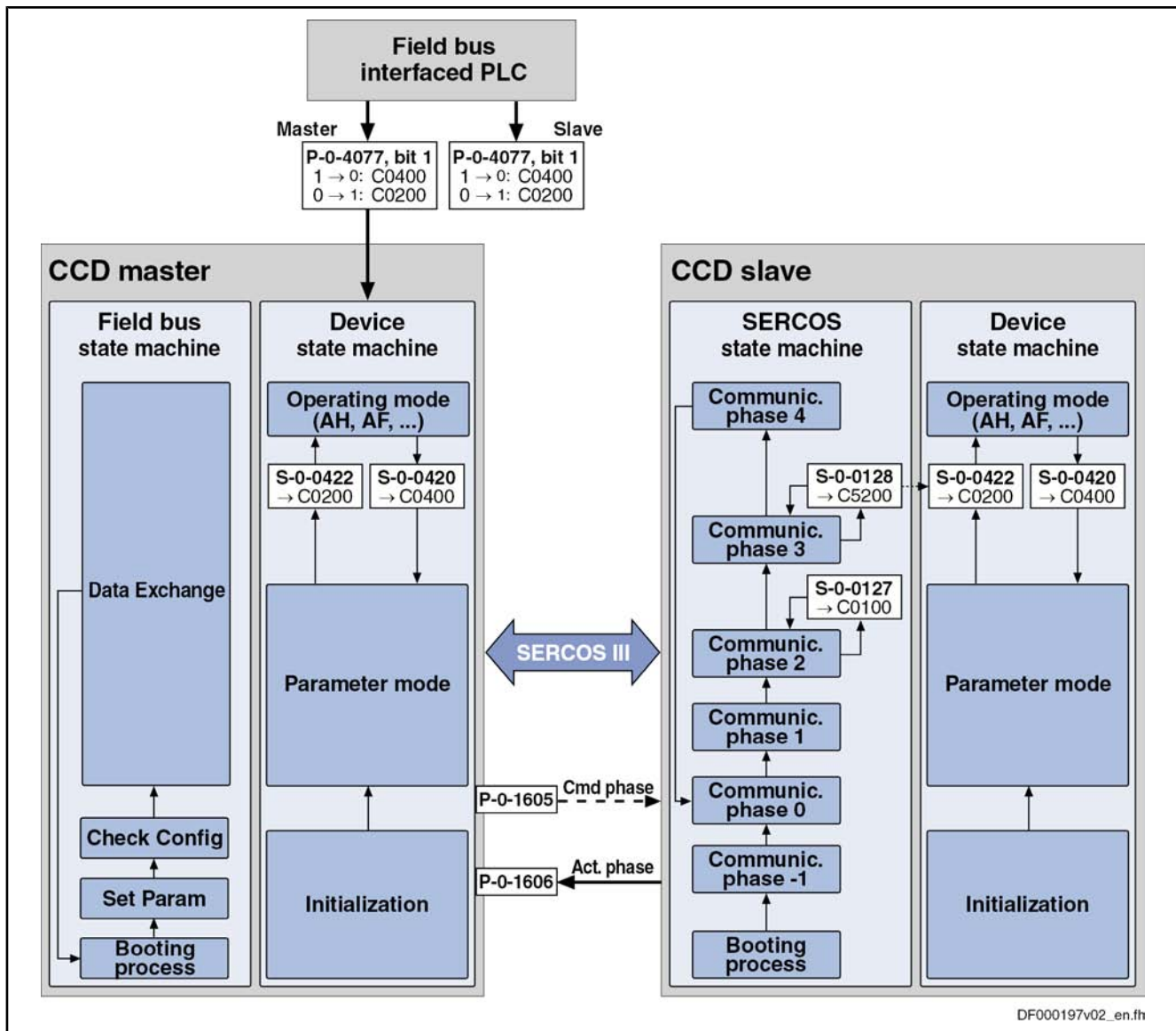


Data are primarily provided to the phase state machine of the CCD bus from the device state machine of the CCD master.

Switching from parameter mode to operating mode (and vice versa) of the device takes place in the CCD master by the following commands:

- S-0-0422, C0200 Exit parameterization level procedure command  
→ By activating the command C0200, all functions are switched to the status "active" again (operating mode → P-0-1605 = 4).
- S-0-0420, C0400 Activate parameterization level 1 procedure command  
→ By activating the command C0400, all functions are switched to the status "inactive" again (parameter mode → P-0-1605 = 2).

Optional Device Functions



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Fig.9-19: State Machine of Cross Communication

Communication State Machine With SERCOS II

After switching on, the CCD master initializes the SERCOS III communication and tries to switch the projected CCD slaves to phase 2.

In phase 1, the SERCOS II master communication of the CCD masters already takes into account all addresses in the CCD group which are available in the SERCOS II ring (addresses of local slave (CCD master) + projected CCD slaves), even if the the CCD group is not in phase 2.

In phase 2, the control can talk to all slaves in the CCD group via the service channel. To do this, the CCD group must also be in phase 2. Otherwise an SVC error will occur (SVC not open). The command "S-0-0127, C0100 Communication phase 3 transition check" from the control to the CCD slaves is detected by the CCD master, not transmitted and acknowledged with or without error, depending on the parameterization of the SERCOS II communication. It is only in the transition command "S-0-0128, C5200 Communication phase 4 transition check" of the master that the phase switch of the CCD slaves takes place.

If the SERCOS II communication between control and CCD master is in phase 3, the SERCOS III communication between CCD master and CCD slaves is

still in phase 2. When the command S-0-0128 is started, this causes the CCD master to perform the phase progression for the CCD slaves from phase 2 to phase 4. At the end of the command S-0-0128 in the CCD master, the S3 communication between the CCD master and the CCD slaves is in phase 4. The command S-0-0128 from the control to the CCD slaves is detected by the CCD master, not transmitted and always acknowledged without error.

In phase 4, cyclic and acyclic communication with the CCD slaves is possible without restrictions and behaves as if the CCD slaves were directly in the SERCOS II ring.

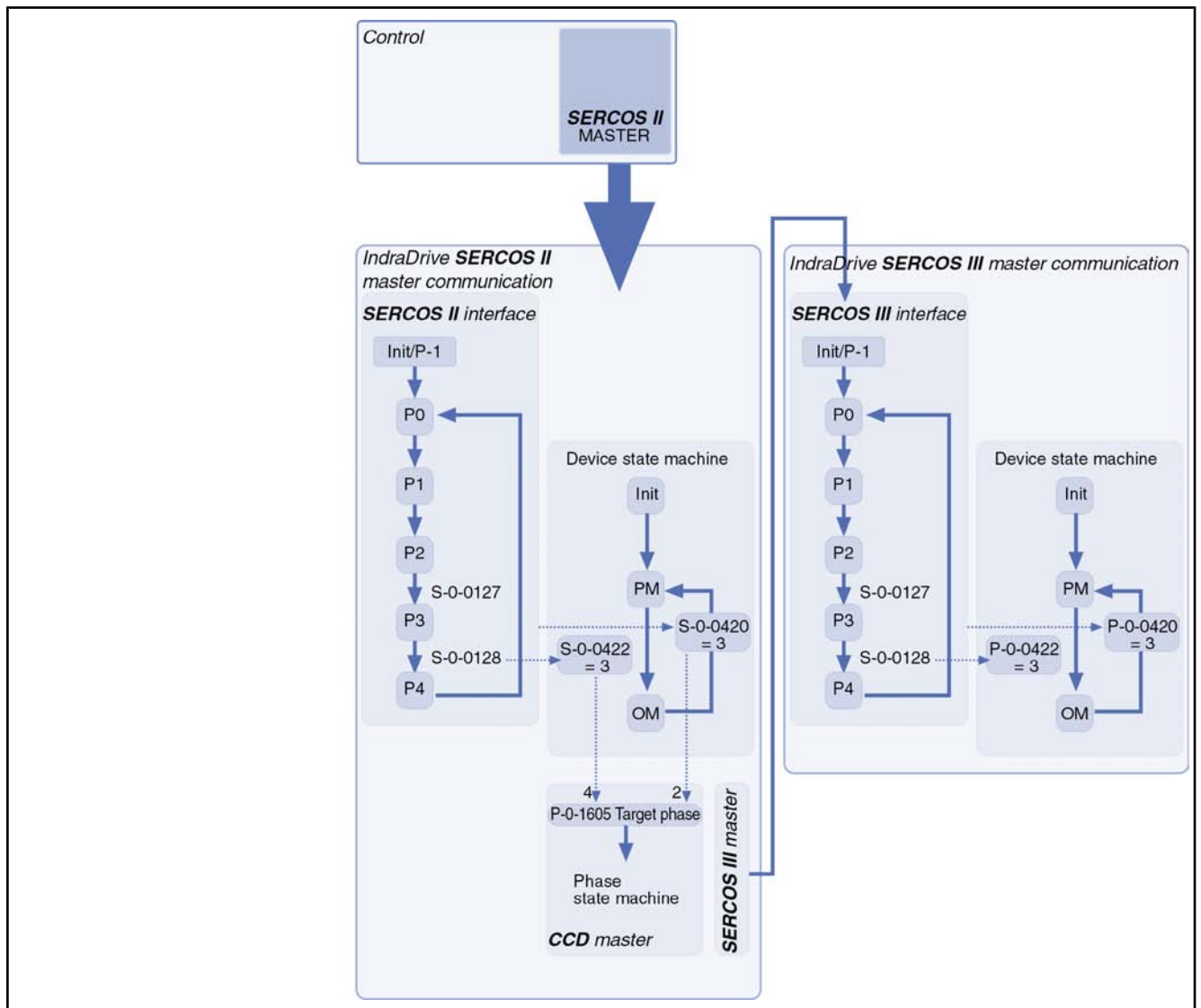


Fig.9-20: SERCOS Phase Progression in CCD System Mode for SERCOS II

## CCD - Diagnostic System

The following parameters are available in the CCD master for displaying the states of all axes in the CCD group and their evaluation via the CCD master:

- P-0-1630, CCD: diagnosis

This parameter displays the status of the CCD group in the CCD master in plain text.

## Optional Device Functions

**Note:** Together with the diagnostic message numbers of the slaves and the master, via this parameter it is possible, in the case of error, to obtain detailed information on causes of error and trouble shooting.

- "P-0-1701, CCD: diagnostic message number slave 1" to "P-0-1709, CCD: diagnostic message number slave 9"

These parameters are used for displaying and evaluating the diagnostic message number for each slave (see Parameter Description "S-0-0390, Diagnostic message number"). By configuring P-0-170x in "P-0-1624, CCD: configuration list actual master values" and S-0-0390 in parameter "P-0-1626, CCD: configuration list actual slave values", the diagnostic message number of the CCD slave is transmitted to the master.

## Diagnostic Parameters of SERCOS Communication

There are different parameters which allow, in the case of problems with SERCOS III communication, getting information on causes of errors or setting conditions for an error reaction:

- The parameter "P-0-1631, CCD: AT error counter" contains the number of AT telegrams which failed. The error counter is incremented once per communication cycle. It is incremented, when the corresponding AT fails both on Port 1 and on Port 2.
- Via the parameters "P-0-1637, CCD: error counter Port-1" and "P-0-1638, CCD: error counter Port-2", it is possible to read the error counters of the SERCOS FPGA according to SERCOS III specification (see Parameter Description).

In the parameter "P-0-1639, CCD: allowed telegram failures", you can set the number of allowed telegram failures (recorded in parameter P-0-1631) which can occur directly one after the other before the error message "F4140 CCD communication error" is triggered.

## Error Reaction of the CCD Group

The CCD error reaction is selected and activated via the bits 7 and 8 of parameter "P-0-1600, CCD: configuration".

Basic setting:

- In parameter "P-0-1600, CCD: configuration" the CCD group error reaction can be activated for all CCD slaves via bit 10. In this case, the master automatically configures the parameter S-0-0390 to the corresponding actual value telegram (AT) of the slaves and copies the content to P-0-1701 (slave 1), to P-0-1702 (slave 2), to P-0-1703 (slave 3), etc.
- If a slave in the CCD axis group is not to participate in the activated error reaction in the master, the automatic parameterization of the slave diagnosis for all slaves must be switched off with bit 10 of P-0-1600. In this case, the inputs for the diagnostic message numbers of the slaves, which are to participate in the error reaction, must be made manually (P-0-1624[i] = P-0-170x and P-0-1626[i] = S-0-0390).



The **CCD error reaction is switched off by default**, i.e. the bits 7, 8 and 10 in parameter P-0-1600 have not been set!

### Specific Features With SERCOS II CCD System Mode

In addition to the possibilities described above regarding the error reaction, the following aspects are to be observed when using the SERCOS II CCD system mode:

- A communication error in the SERCOS II ring results in the CCD slaves being automatically switched via phase 0 to phase 2 by the CCD master.



- A communication error of a CCD slave always results in "F4140 CCD communication error" in the master. Thus all axes are decelerated in the same way, independent of the error reaction parameterized via "P-0-1600, CCD: configuration".

### Cyclic Process Data

For the MDT data (cyclic command values), the process data channel of CCD knows two data sources (master communication and CCD master) and one data sink (CCD slave).

For the AT data (cyclic actual values), there is one data source (CCD slave) and two data sinks (master communication and CCD master).



The parameterization of the process data channel of the CCD group is made exclusively at the CCD master via the parameters P-0-1621 to P-0-1626. During phase progression, the master automatically assumes parameterization of the slaves via S-0-1050.0.6, S-0-1050.1.6, ...

The figure below illustrates the parameterization of the process data channel and the effect of the parameters P-0-1621 to P-0-1626 for the following cases (does not apply to SERCOS II master communication in the CCD master):

1. Configuration of the MDT data (cyclic command values)
2. Configuration of the AT data (cyclic actual values)

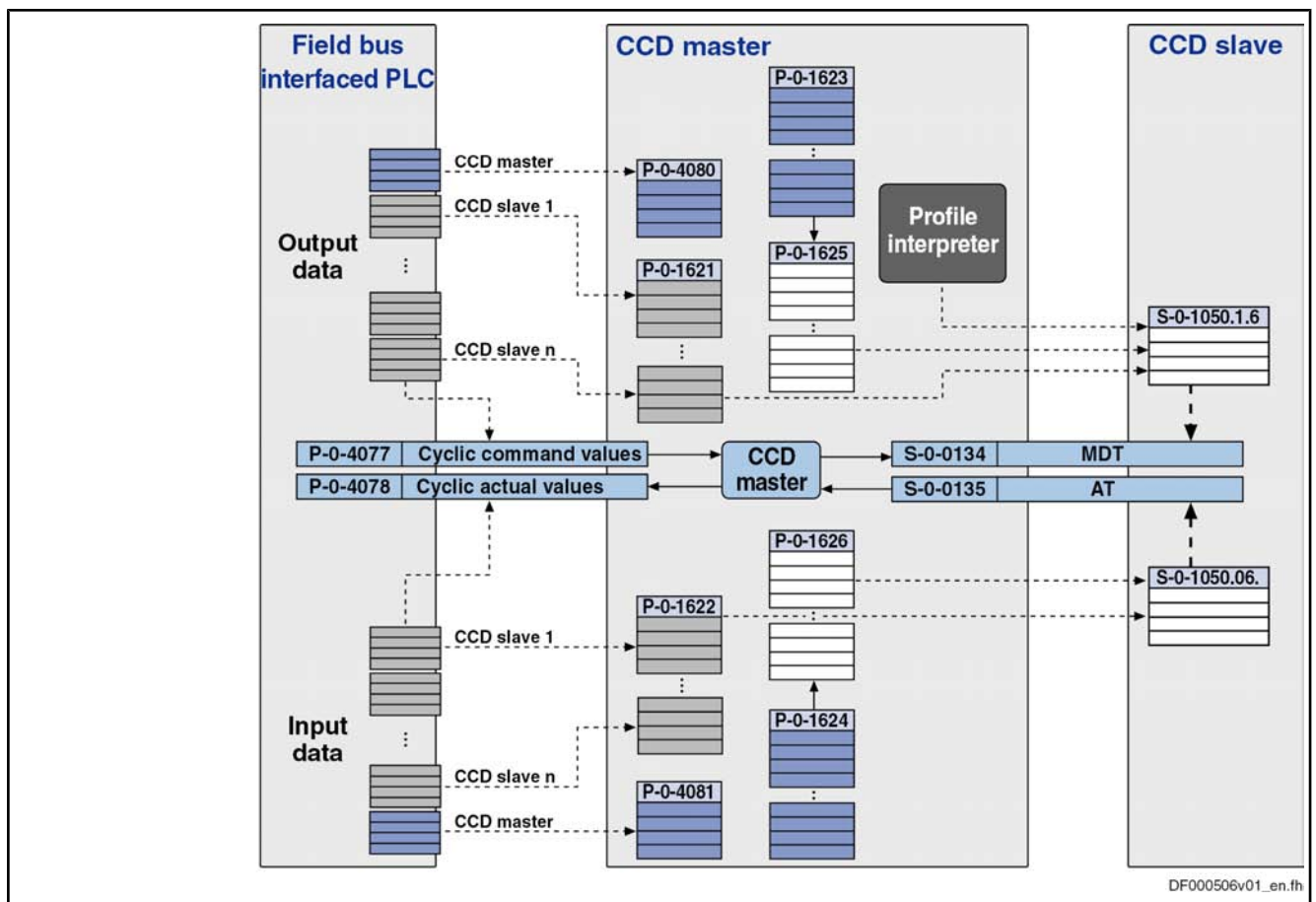


Fig.9-21: Configuring the Cyclic Process Data

Configuration takes place as follows:

## Optional Device Functions

- In the CCD master, the required cyclic process data between the external PLC and the CCD slave are configured in the parameters P-0-1621 (MDT) or P-0-1622 (AT). With SERCOS II, configuration of the cyclic data of the control to the CCD slaves is not made via the parameters P-0-1621 and P-0-1622 mentioned above but in the CCD master with the parameters P-0-1621.x.6 (MDT) and P-0-1621.x.5 (AT). If configuration of the cyclic data is made via the SERCOS II-SVC from the control, the standard parameters S-0-1050.0.6 (AT) and S-0-1050.1.6 (MDT) must be used. This is converted accordingly to the parameters P-0-1621.x.6 (MDT) and P-0-1621.x.5 (AT) by the profile interpreter in the CCD master.
- The command values (MDT) to be transmitted from the CCD master to the CCD slave are configured in the relationship P-0-1623 ↔ P-0-1625. The list parameter P-0-1623 contains the parameters which the master puts into the MDT for the slave. The list parameter P-0-1625 contains the information for which parameters in the slave the data from the master are intended (S-0-1050.1.6).
- The actual values (AT) to be transmitted from the CCD slave to the CCD master are configured in the relationship P-0-1624 ↔ P-0-1626. The list parameter P-0-1624 contains the information for which parameters in the master the data from the slave are intended. The list parameter P-0-1626 contains the information which parameters the slave puts into the AT for the master (S-0-1050.0.6).

**Compact I/O Extensions for  
SERCOS III**

Compact I/O extensions for SERCOS III are only used in the CCD group with MLD-M or MLD-S. There isn't any connection to master communication in the CCD master. Configuration and assignment to the CCD master and the slaves take place via IndraWorks.

Compact I/O extensions are included/projected like a drive as CCD slaves in the CCD group. With MLD-M, it is possible to access these extension modules (see separate documentation "Rexroth IndraMotion MLD").

To configure the compact I/O extensions (of the cyclic data), make the following settings:

- The command values (MDT) to be transmitted from the CCD master to the compact I/O extensions are configured in the parameter "P-0-1627, CCD: configuration list master cmd values I/Os". This list parameter contains the parameters which the master puts into the MDT for the I/O slave; for example, the bits of the PLC register in parameter P-0-1410 (written by MLD-M) are to be output at the outputs of the compact I/O extension in the CCD master.
- The actual values (AT) to be transmitted from the compact I/O extension to the CCD master are configured in the parameter "P-0-1628, CCD: configuration list act. master values I/Os". This list parameter contains the information for which parameters in the master the data of the slave are intended; for example, the inputs of the compact I/O extension are to be read to the parameter P-0-1390 of the CCD master (in MLD-M).

**Addressing**

We distinguish the following schemes of addressing:

- Logic individual axis addressing → for CCD communication setting of master communication address at each axis (e.g. 09, 02, 03, 05)
- Device address with automatic subindex → for PROFIBUS® (e.g. 9.02)
- Subindex address is used via PLC → 1st slave axis has address 1



Any individual setting of the serial addressing via the parameter "P-0-4022, Drive address of serial interface" does not take effect via the CCD group! Via CCD, the remote axes can only be addressed via their master communication address.

The following aspects apply to the addressing of the individual CCD nodes:

- The master communication address is set as usual at the respective drive in parameter "P-0-4025, Drive address of master communication" (e.g. via the control panel).
- In the CCD master, the CCD slave addresses belonging to the respective CCD slave have to be entered in parameter "P-0-1601, CCD: addresses of projected drives". In "P-0-1604, CCD: addresses of projected I/Os", enter the addresses of the compact I/O extension connected to the CCD master. The assignment of slave number and address takes place via the order of the list elements, so that CCD slave 1 is the drive with the address entered in list element 0 (etc.).
- The slave addresses found by the CCD master in phase 0 of the CCD axis group are entered in the list parameter "P-0-1603, CCD: Actual topology addresses" in ascending order according to their actual line topology order (i.e. as they have been connected to the CCD master one after the other). Up to phase 2, this parameter can contain double addresses.
- In parameter "P-0-1636, CCD: Command topology addresses", all addresses of the CCD slave (drives and I/O extensions) connected to the CCD master have to be indicated in ascending order according to their (desired) topology order. Only the slaves contained in this list can be addressed as of CCD phase 2. Also those addresses of the SERCOS III slaves must be listed which are only connected to the CCD master, but have not been projected.
- If the command topology (P1636) contains addresses that were not listed/ found in the actual topology, the warning "E4013 Incorrect CCD addressing" is generated in CCD phase 2. Continued switching to CCD phase 3 or 4 is impossible.
- As of phase 2 all addresses contained in the actual topology (P1603) must also be contained in the command topology (P1636). The order for monitoring is here irrelevant. Either the addresses of the command topology (P1636) must be adjusted to those of the actual topology (P1603) or the addresses of the CCD slaves must be set to those of the command topology via the command "C7000 CCD: Command adjust slave addresses" (P-0-1635). Only in this way is it possible, for example, to assign an unequivocal address for the compact I/O extensions!
- The slaves found in the actual or command topology and projected in parameter P-0-1601 or P-0-1604 are entered in the list parameter "P-0-4031, Overview of device addresses" during the transition to phase 1:
  - List element 0: Address of CCD master
  - List element 1: Address of CCD slave (drive) from P-0-1601 [0]
  - List element 2: Address of CCD slave (drive) from P-0-1601 [1]
  - List element n: Address of CCD slave (drive) from P-0-1601 [n]
  - List element n+1: Address of compact I/O from P-0-1604 [0]
  - List element n+m: Address of compact I/O from P-0-1604 [m]

## Optional Device Functions



The slave addresses contained in the parameters P-0-1601 and P-0-1604 have to be found in the list parameter P-0-1603 or P-0-1636, otherwise the message "E4013 Incorrect CCD addressing" or "C0265 Incorrect CCD address configuration" will be generated during phase progression of the master.

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**Specific Features With SERCOS II**

The CCD system mode for SERCOS II consists of 2 networks: The high-level network for control (SERCOS II master communication) and the low-level network between CCD master and CCD slaves on the basis of the SERCOS III communication. In both networks the individual nodes (slaves) are addressed via the SERCOS address. The CCD master must be able to unequivocally establish the connection between slave address in the high-level network (SERCOS II) and slave address in the low-level network (SERCOS III). Thus, any address within the allowed address frame can be assigned in both networks. Therefore, with the SERCOS II CCD system mode, addressing of the nodes (including the CCD slaves to be addressed) within the SERCOS II ring is independent of the addressing of the CCD slaves in the SERCOS III network of the CCD communication

To enable the CCD master to establish the connection of the addresses in the SERCOS II ring to the addresses of the CCD slaves in the SERCOS III network, the parameters " P-0-1621.x.1 CCD: Slave address in high level network" are available in the CCD master. Which x, i.e. which parameter refers to which CCD slave, depends on the order parameterized in "P-0-1601, CCD: addresses of projected drives". Addresses must be assigned for every CCD slave in the CCD master in the parameters P-0-1621.x.1. The CCD slaves in the SERCOS II ring are detected and addressed via the same addresses.

Example: In this case, the address set in P-0-1621.0.1 corresponds to the address via which the first (->actual drive address P-0-1601, Element 0) CCD slave is reached from the SERCOS II control. With the address set in P-0-1621.1.1 the second slave (P-0-1601, element 1) is reached from the SERCOS II Ring, etc. It is therefore possible to address the CCD slave with the drive address (address in display) 3 from the SERCOS II control with the address 55.

**Deactivating CCD Slaves**

All physically existing/connected CCD slaves (drives and I/Os) must be contained in "P-0-1601, CCD: addresses of projected drives" and "P-0-1604, CCD: addresses of projected I/Os". To deactivate physically existing CCD slaves, it is possible to leave out/remove addresses (drives, I/Os). The concerned slaves in this case are no longer taken into account by the CCD master and signal "E4010 Slave not scanned or address 0".

---

**WARNING**

**When addresses are left out/removed, possible gaps in P-0-1601 and P-0-1604 are automatically filled so that changes in the logic order (Axis2, Axis3, ...) can occur. This has a direct effect on the MLD program and the CCD process data! To avoid the (undesired) effects of gaps being filled up, use the function "parking axis" in the axis to be deactivated (and do not remove the corresponding axis). See also function "parking axis".**

To deactivate physically **inexistent** slaves, use the corresponding firmware functionality as of MPH-05 (deactivate addresses in P-0-1601/P-0-1604, set bit 15 in the respective list element) (supported by IndraWorks). The deactivated slaves in this case are not taken into account by the CCD master, but the logic order is not changed so that the rest of the CCD configuration can be maintained.

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When all CCD slaves have been deactivated, X24 has to be connected to X25 with a SERCOS cable.

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## Acyclic Communication (Parameterization Gateway)

To allow accessing the individual parameters of the slaves from the CCD master, there is a so-called "parameterization gateway" available which processes requests of an interface of the master (via master communication, RS-232, Ethernet, ...) regarding parameters of the slaves.

Acyclic parameter services, requested via RS-232, master communication or drive PLC in the CCD master, must be transmitted to the slaves by the cross communication.

For this purpose, the following interfaces with the following possibilities are supported:

- Serial interface with binary SIS protocol (see also "Serial Communication")




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The parameterization gateway does **not** support the DKC-ASCII format (RSKO)! That is why acyclic access to parameters of the slave drives is only possible via SIS protocol!

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- SERCOS II service channel "Sercos Communication"
- Field bus interface with the available parameterization options (DPV1, ...)




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With EtherNet/IP™, the parameterization gateway is not supported.

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- EtherNet interface with TCP/IP




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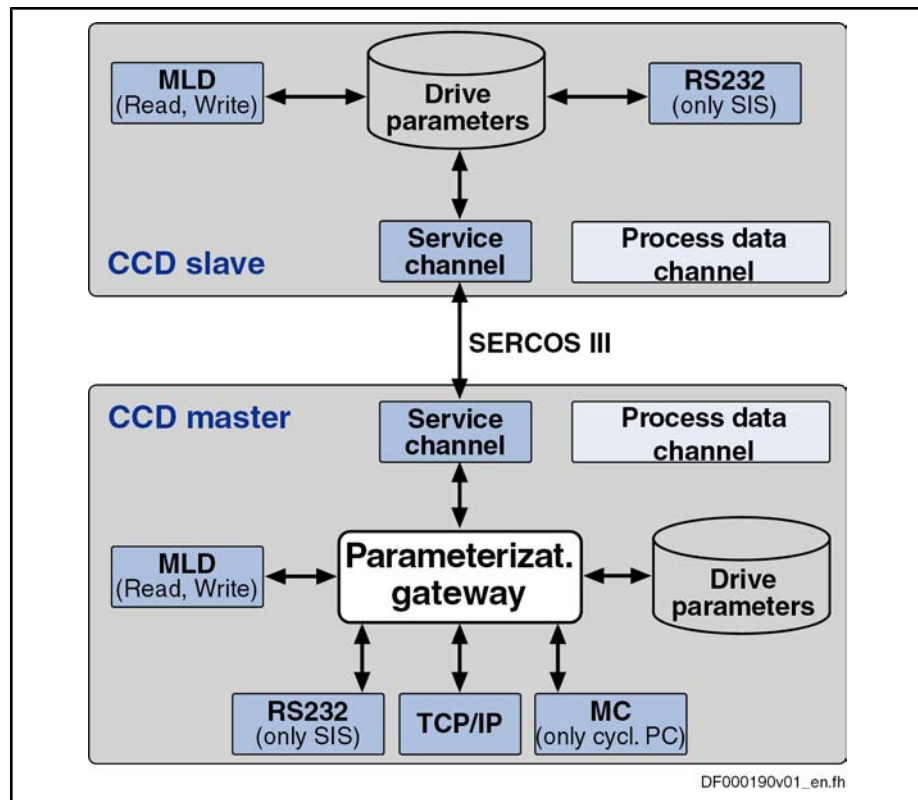
For this application, the unassigned EtherNet connection (so-called "Engineering Port") at the CCD master can be used for parameterization.

---

When accessing the CCD slave via SIS protocol the following must be observed during implementation:

The address of the CCD master must be entered as receiver address in the general SIS telegram header. The receiver address to be entered in the service-dependent section for the parameter services 0x80, 0x10, etc. is the address of the slave. The master will accept the telegram and route the request to the slave via CCD.

Optional Device Functions



MC Master communication

Fig. 9-22: Functional Scheme of the Parameterization Gateway

Cycle Time

Configuration of CCD Cycle Time

The CCD cycle time is set in the master via parameter "S-0-0001, NC cycle time (TNcyc)" or "P-0-1610, CCD: cycle time". The CCD master then presets this time for the slaves in parameter "S-0-1050.x.10, SIII-Connection: Producer cycle time".

The resulting cycle time which is preset for the CCD slaves in parameter S-0-1050.x.10 (→ actual CCD cycle time) corresponds to the smaller value from the parameters S-0-0001 and P-0-1610 of the master (if P-0-1610 unequal zero).

The CCD master automatically determines the SERCOS cycle time of the CCD slaves in parameter "S-0-1002, SERCOS III: Communication Cycle time (tScyc)" and sets it to the smallest connection cycle time.

The timing settings made by the master can be seen in parameter "P-0-1602, CCD: timing settings"

The number of CCD slaves limits the possible CCD cycle time (see "Performance Features").

Ring Recovery and Redundancy

Redundancy in the master means that, in the event of a ring interruption, the CC data that were previously exchanged directly between the slaves are copied from one line to the other by the CCD master. This causes a SERCOS cycle offset with the CC data. This does not affect the MS data.

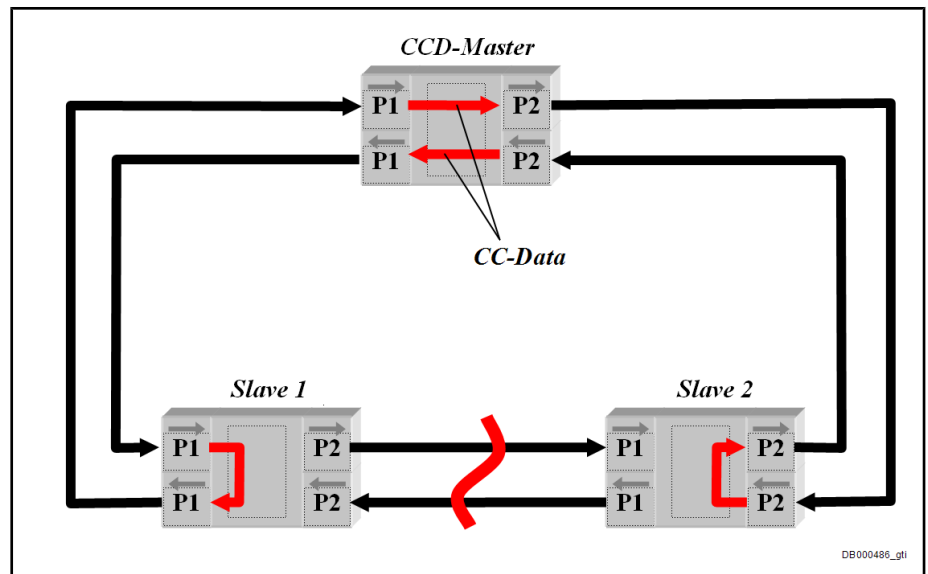


Fig.9-23: Redundancy in the Master

In the case of a ring interruption the double ring is split into 2 lines. In the case of a ring recovery the topology is changed vice versa. To ensure that this functions without errors, bus master and bus slave must be able to handle both, the respective topology states and the transitions. The values in parameter "S-0-1003, SERCOS III: Allowed MST losses in CP3/CP4" must not be exceeded, even during the transitions.

For display of the ring interruption and for ring recovery the CCD master has the following functions:

- Parameterization of command topology (P-0-1620.0.3) and display of a warning (E4016) in the case of differing command and actual topologies (P-0-1610.0.3)
- Command function for ring recovery (C7100) via parameter P-0-1620.0.21

### Redundancy

The redundancy in the master is a function becoming active if a ring interruption is detected and the slaves activate LoopBack at the interruption point. The CC data that were previously exchanged directly between the slaves are then copied from one line to the other by the CCD master. This causes a SERCOS cycle offset with the CC data. This does not affect the MS data. In the case of a difference between the parameterized command topology and the actual topology, the CCD master displays the warning "E4016 CCD: Topology error" to indicate this condition.

The CCD master displays the address of the CCD slaves at the end of the lines in parameter "P-0-1610.0.21, CCD: Slave addresses at end of line" which is created as a list with two elements. This allows to locate the ring brake.

- List element 1: Address of slave at the end of the line at port 1
- List element 2: Address of slave at the end of the line at port 2

### Ring Recovery

For ring recovery the CCD master provides the command "P-0-1620.0.21, CCD: Command Close ring" (C7100). With the command topology P-0-1620.0.3 = 4 (double ring) this allows to close the line or 2 lines to the double ring. Due to the change of topology, the ring delay is measured again, if necessary, transmitted to the slaves and the command S-0-1024 (Synchronization measuring procedure) activated. If an error occurs with the command C7100,

Optional Device Functions

the message "C7101 CCD: Impossible to close ring" is displayed. Possible causes for the message C7101:

- CCD group not in phase 4
- Topology is not line or double line
- No line between the last nodes of the lines.
- New ring delay could not be transmitted to the slave.

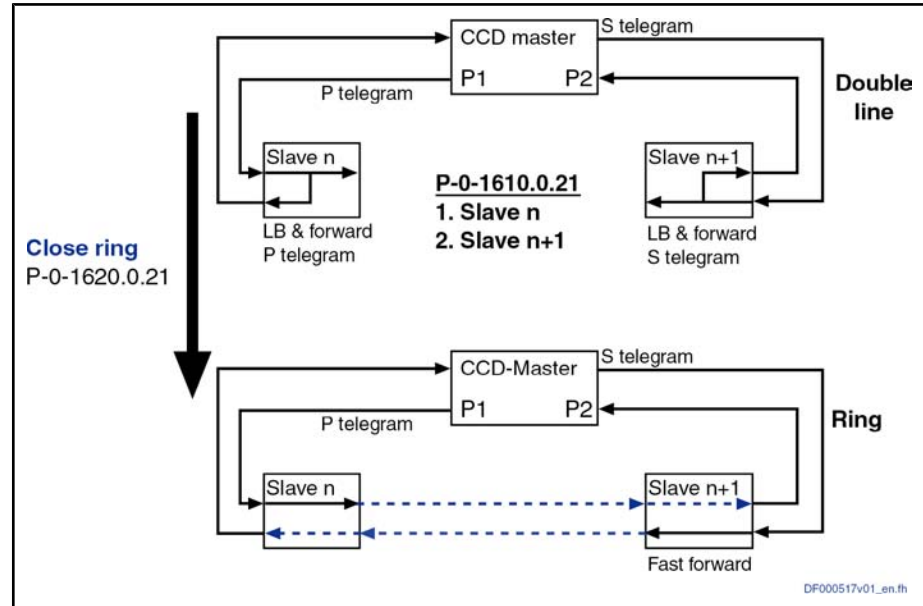


Fig.9-24: Ring Recovery

Dead Time Compensation

For command value linking (e.g. with Gantry axes) via CCD, it is necessary that the command values take effect at the same point of time in the individual axes. To prevent the master axis from preceding the slaves, dead time compensation was realized for the command value input to the slaves.



In the MLD-M system mode (with permanent control in the CCD master), dead time compensation takes place by calculating a virtual slave in the CCD master to artificially delay the command values for the master axis (see also separate documentation "Rexroth IndraMotion MLD").

Basic Function

In the CCD system mode or MLD-M system mode (without permanent control in the CCD master), extrapolation of a selected command value is carried out for each CCD slave to compensate the internal processing dead times. The parameter of the CCD master to be transmitted to the CCD slave first is extrapolated. The extrapolated value is then contained in parameter "P-0-1618, CCD: extrapolated command value". This parameter with the extrapolated value has to be copied to the corresponding parameter of the slave (free process data). The parameter "P-0-1617, CCD: number of extrapolation steps" indicates for how many CCD cycles in advance the parameter value of the master is calculated.



In the CCD master, the extrapolator is only available once so that only one parameter of the CCD master can be extrapolated.



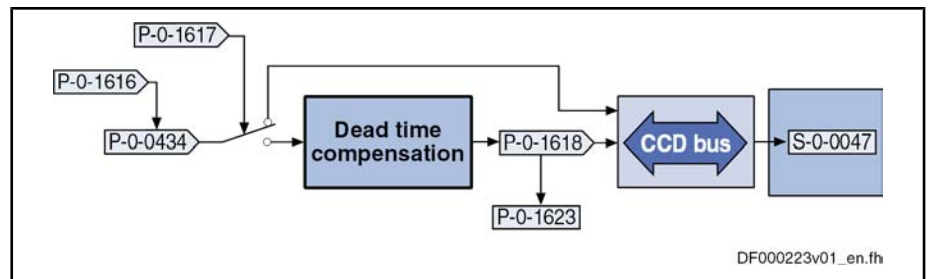


Fig.9-25: Command Value Extrapolation for Dead Time Compensation of the Command Values for the CCD Slaves

#### Example of Application With Configuration

The operating principle of the function is described for a Gantry axis (position command value linking).

The CCD master is to preset the position loop command value (P-0-0434) for the slaves as the value for parameter S-0-0047. The position loop command value is active in the master the next time the position loop is called. For the CCD slaves there is a delay of up to two SERCOS cycles until this command value takes effect in the position loop.

To avoid this, activate the dead time compensation by the following setting:

- Dead time compensation is activated when a value unequal "0" (default setting) is entered in parameter "P-0-1617, CCD: number of extrapolation steps".
- Enter the desired command value (with position command value linking → P-0-0434) in the parameter "P-0-1616, CCD: extrapolated cmd value signal selection".
- Instead of P-0-0434, the value of parameter "P-0-1618, CCD: extrapolated command value" is then entered for the slaves in parameter "P-0-1623, CCD: configuration list master cmd values".



Due to extrapolation, position deviations (worse profile) result for the extrapolated command value as compared to the original command value, the extrapolated command value becomes greater as the number of extrapolation steps (P-0-1617) increases.

## 9.2.3 Notes on Commissioning and Utilization

### Navigation in IndraWorks

The dialogs for parameterizing the CCD communication can be found in IndraWorks under the SERCOS III branch (→ right mouse key):

Optional Device Functions

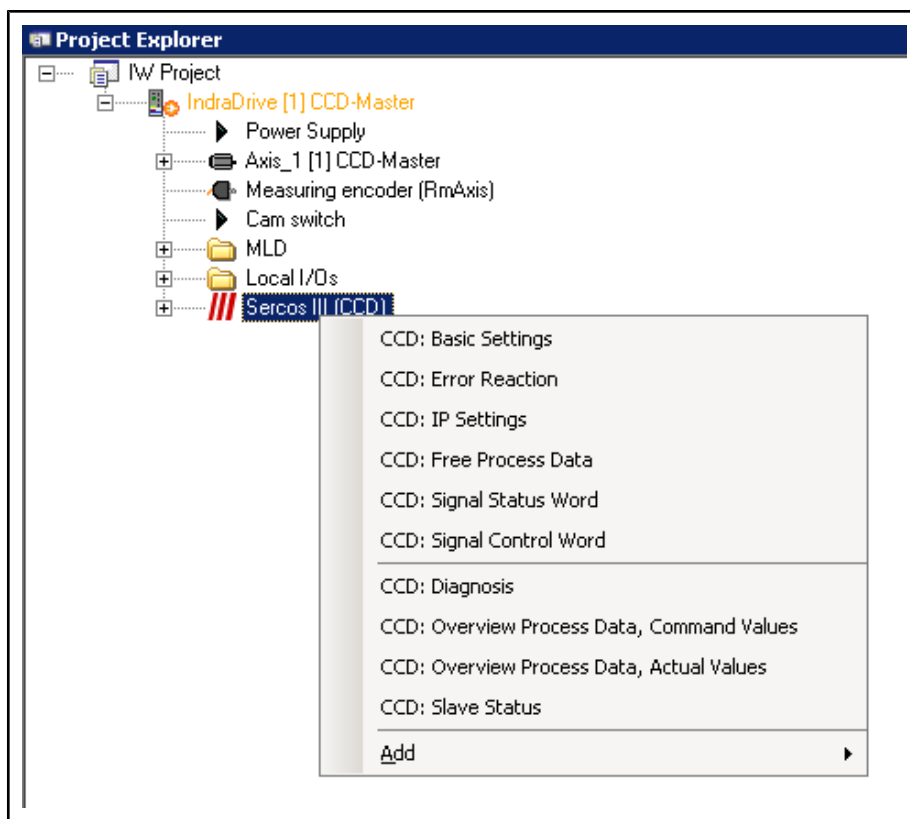


Fig.9-26: Overview of IndraWorks Dialog Windows for CCD Communication

By analogy to drives under a control unit, the slaves of the CCD group are displayed below a SERCOS III branch in the project tree.

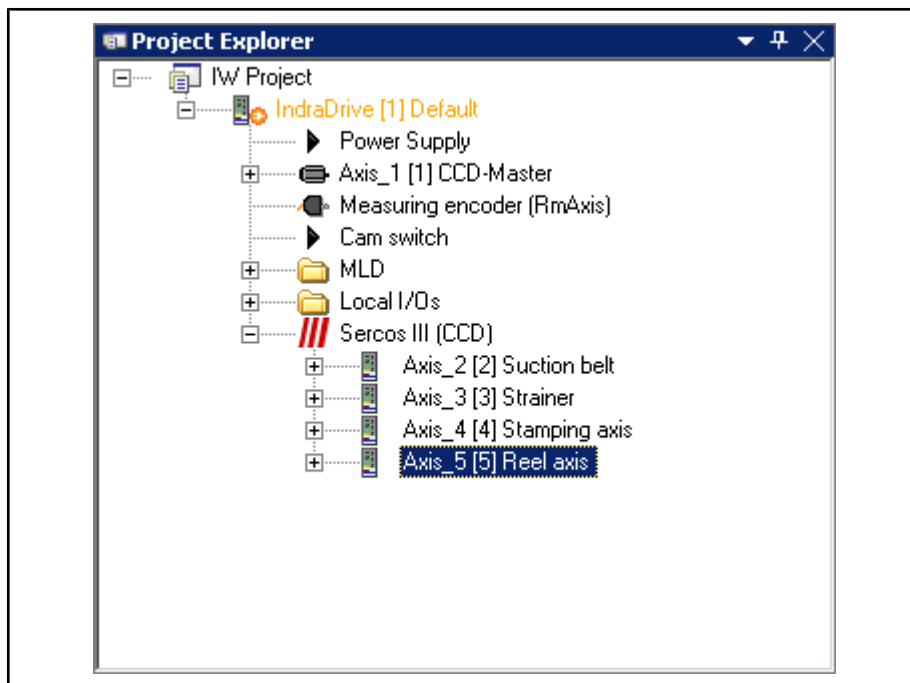


Fig.9-27: CCD Display in the Project Explorer

The slaves can be addressed in the same way as drives under a control unit. In the offline mode, it is possible to drag drives from the library under the SERCOS III branch. The configuration found is used in the online mode.

**Basic Settings** The figure below shows the basic settings for parameterizing the CCD communication.

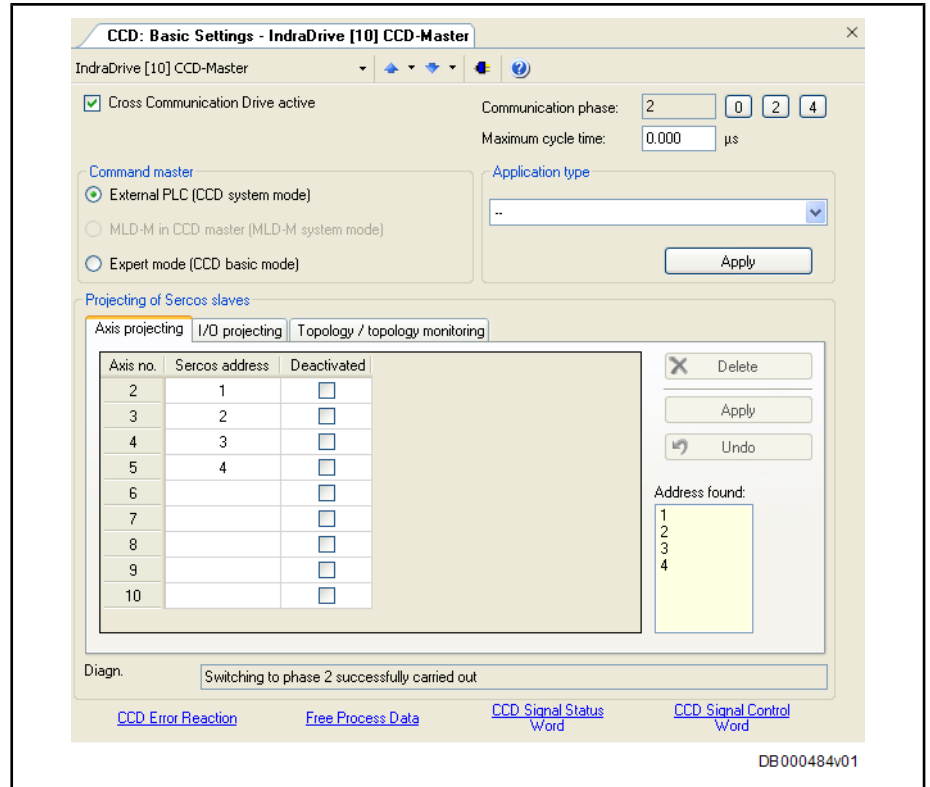


Fig. 9-28: IndraWorks Dialog for Basic Settings of CCD Communication

## Selection of Cross Communication Modes

### Possible Applications of the CCD Modes

Due to their different properties, there are preferred applications for the respective CCD modes:

- Preferably use the **CCD system mode (command triggering master: external PLC)**, when mere command value linking must be realized with field bus master communication and control over all drives still is in the external control unit.

Other features:

- Command triggering of the CCD slaves by higher-level control unit ("remote" external with profile interpreter or possibly via local MLD with permanent control)
- Process data exchange possible between CCD master and slaves, as well as between external control unit and CCD slaves
- CCD slaves are known to external control unit (logic nodes)

- Preferably use the **CCD basic mode (expert mode)**, when an MLD with permanent control is used in at least one CCD slave

- or -

mere command value linking is to be realized with master communication "SERCOS", "parallel" or "analog" and control still is in the external control unit.

Other features:

## Optional Device Functions

- Command triggering of CCD slaves can take place by higher-level control unit ("remote" external, but without profile interpreter) via parameter P-0-165x in the master, via MLD in the master drive or, where possible, via local MLD-S with permanent control
- Only process data exchange between CCD master and slaves; CCD slaves are **not** known to external control unit (no logic nodes)
- Preferably use the **MLD-M system mode (command triggering master: MLD-M in CCD master)**, when multi-axis motion is to be realized in the master and the MLD in the master is to access the remote axes (CCD slaves).

Other features:

- Command triggering of the CCD slaves takes place via MLD-M in the master drive or, where possible, via local MLD-S with permanent control
- Only process data exchange between CCD master and slaves
- CCD slaves are **not** known to external control unit (no logic nodes)

The figure below illustrates how to select the appropriate CCD mode:

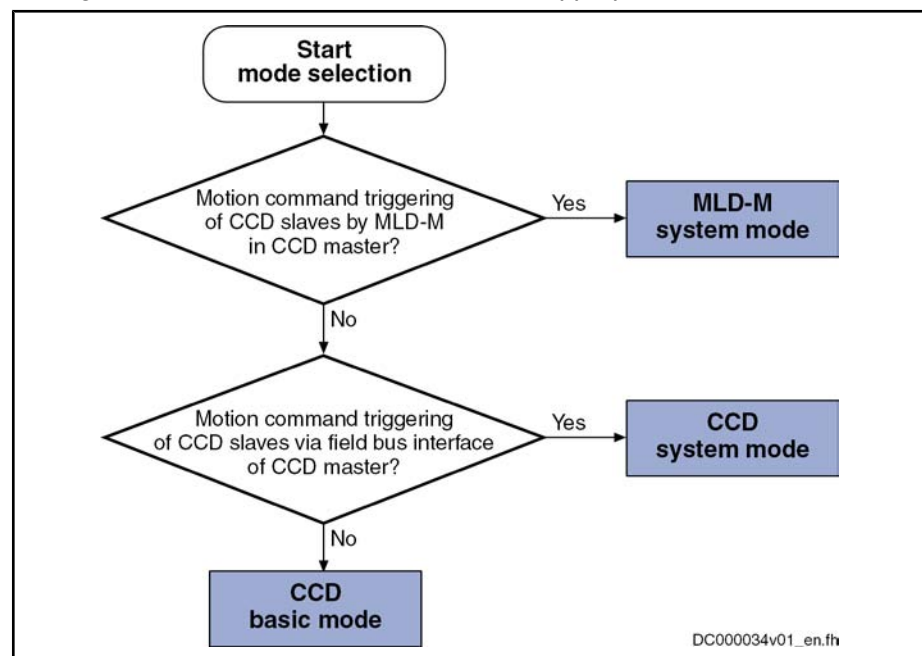


Fig.9-29: Selection Criteria for CCD Mode (See P-0-1600)

**Selection Criteria** Using the **CCD system mode** makes sense when:

- The external master is to have control over the CCD slaves,
- process data (command values and actual values) must be exchanged between the external master (e.g. field bus interfaced PLC) and the CCD slaves,
- other process data apart from the external process data are input by the CCD master to the CCD slaves (e.g. command value linking).

Using the **CCD basic mode** makes sense when:

- The external master is to have control over the CCD slaves,
- only process data are preset to the CCD slaves by the CCD master (e.g. command value linking),
- an MLD with permanent control is used in the slave axes.

Using the **MLD-M system mode** makes sense when:

- The CCD master is to have control over the CCD slaves,
- only data between CCD master and CCD slaves are exchanged.

## Setting the Cycle Time

Depending on the slowest controller performance (position loop clock), the minimum CCD cycle time to be set can be selected in the CCD group. The CCD cycle time mustn't be smaller than the slowest position loop clock in the CCD group:

- Advanced performance: 0.25 ms, 0.5 ms, 1 ms, 2 ms, 4 ms
- Basic performance: 0.5 ms, 1 ms, 2 ms, 4 ms
- Economy performance: 1 ms, 2 ms, 4 ms



The MLD-M mode is only possible in Basic performance of the CCD master; in addition, the CCD cycle time which was set has to be greater than the slowest position loop clock in the CCD group!

The possible CCD cycle time results from the number of CCD slaves and the selected CCD mode (see "Performance Features").



The CCD cycle time should always be greater than the slowest position loop clock of the CCD group. If both cycle times are equal, only half of the cyclic data can be transmitted to the corresponding CCD slave.

## Assigning the Addresses

By means of the fields for projecting the CCD slaves, for the drives and compact I/Os of the CCD group the SERCOS address is assigned to the slave number (Axis\_x).

<b>Axis No.</b>	The axis no. (slave no.) refers to the CCD slave number in the CCD master relevant for the CCD configuration. This is also equivalent to the logic axis number axis_x of MLDM (axis2 to axis_10).
<b>SERCOS Address</b>	The SERCOS address establishes an unequivocal relationship between the logic axis number and the physical device. Any access to the logic axis number by the CCD master or the MLD-M is executed on the device with this SERCOS address (S-0-1040 in the SERCOS slave) via the address entered here.
<b>Deactivated</b>	If a projected CCD slave does not exist physically, it can be deactivated by marking this field for the CCD master. This does not result in an offset of the logic order and the remaining CCD configuration can be maintained. This provides the advantage that projects with similar applications, only deferring in the existence of individual slaves, can be changed.

## Error Reaction

<b>CCD Error Reaction</b>	With regard to the error reaction of the CCD group, you have to observe that apart from the module bus connection there is an additional digital connection of the master communication. That is why there are different possibilities for the group to react in the cause of error which must be specifically selected and coordinated. The possible error reactions are summarized in the table below.
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## Optional Device Functions

Kind of error reaction	Description
<b>Independent error reaction</b>	All axes in the group carry out an independent error reaction, when package reaction has not been activated and the CCD error reaction has not been activated either.
<b>Package reaction</b>	The axes operated in the axis group at a DC bus are interconnected via the module bus and carry out a collective coordinated error reaction (package reaction) in the case of error (see "Error Reactions: Package Reaction on Error")
<b>CCD error reaction</b>	For certain applications (e.g. Gantry axes) it can be useful to shut down the complete CCD group in a controlled way or at least equally in all axes when an error occurs in a CCD slave or in the CCD master. If required, it is therefore possible to activate a CCD error reaction in the CCD master!

Fig. 9-30: Overview of Error Reactions of the CCD Group

## Configuring the Error Reaction

The CCD error reaction is set in the IndraWorks dialog window shown below:

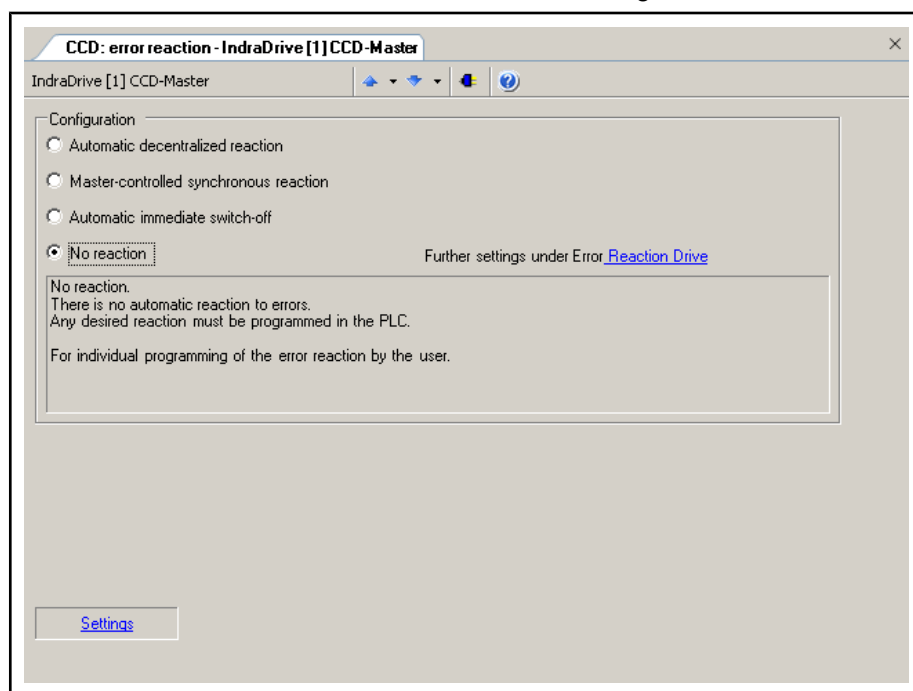


Fig. 9-31: IndraWorks Dialog for Configuring the CCD Error Reaction

Explanation of possible settings:

- **No reaction**

In the case of an error in a CCD axis, other CCD axes do not react automatically. A group error reaction has to be explicitly programmed by the control unit (example of application: master-axis-synchronous deceleration).

**Note:** In the MLD-M mode, motion function blocks of the MLD do not trigger any error in the case of faulty parameter setting.

- **Automatic decentralized reaction**

In the case of errors in a CCD slave, the warning "E2140CCD error at node" is displayed in the master (example of application: master-axis-synchronous deceleration).

**Note:** In the MLD-M mode, this warning is also displayed when a motion function block with faulty parameters is called in MLD-M, if this has been set in "P-0-1367, PLC configuration".

- **Master-controlled synchronous error reaction**

The error reactions of master and slaves take place depending on the error class (F2xxx, F4xxx, ...) and the configuration in "P-0-1600, CCD: configuration"; see fig. below (example of application: mechanically coupled axes).

**Note:** In the MLD-M mode, the error "E2140 CCD error at node" is displayed in the master, when a motion function block with faulty parameters is called in MLD-M, if this has been set in parameter "P-0-1367, PLC configuration". For the remote CCD slaves, automatic deceleration does not take place in the case of a motion function block error, but the error reaction has to be programmed by means of MLD!

- **Automatic immediate switch-off**

When the CCD master detects that an axis in the CCD group (master or slave) signals a class 1 diagnostics error, all axes are decelerated with "best possible deceleration" (see P-0-0119). The CCD master outputs the error message **F2140 CCD slave error**. If the CCD master is not in control, only the warning "E2140CCD error at node" is displayed (the axes are nevertheless decelerated!).

**Special Case: Master-Controlled Synchronous Error Reaction**

When the **master-controlled synchronous error reaction** is active, the content of the parameters P-0-170x ("x" is the number of the slave) is cyclically evaluated and interpreted in the CCD master. Depending on the error class of the slave diagnosis number, the corresponding error message is generated in the CCD master when the slave signals an error and the master is in control. The other CCD slaves react directly to the error message of the master (see fig. below).

We distinguish between:

- Non-fatal (safety technology) errors (F2xxx, F3xxx)
- Interface errors (F4xxx)
- Travel range errors, safety technology errors (F6xxx, F7xxx)
- Fatal errors (F8xxx)

In addition, the F8xxx and F4xxx errors of the slaves are specifically treated in the master with the error reaction active:

- In the case of a fatal error (F8xxx), the CCD error reaction of master and slaves (torque disable, best possible deceleration) is defined depending on the setting in parameter P-0-1600 (bit 9).
- If an F4xxx error is present, it is always the error reaction "best possible deceleration" which is triggered.

As regards the master-controlled synchronous error reaction of the CCD group, we must basically distinguish two cases of possible errors:

- Error in a CCD slave
- Error in the CCD Master

**Error in the CCD Slave**

The figure below illustrates the cases of possible errors in the CCD slave and the corresponding error reaction in the CCD master for the master-controlled synchronous error reaction.

Optional Device Functions

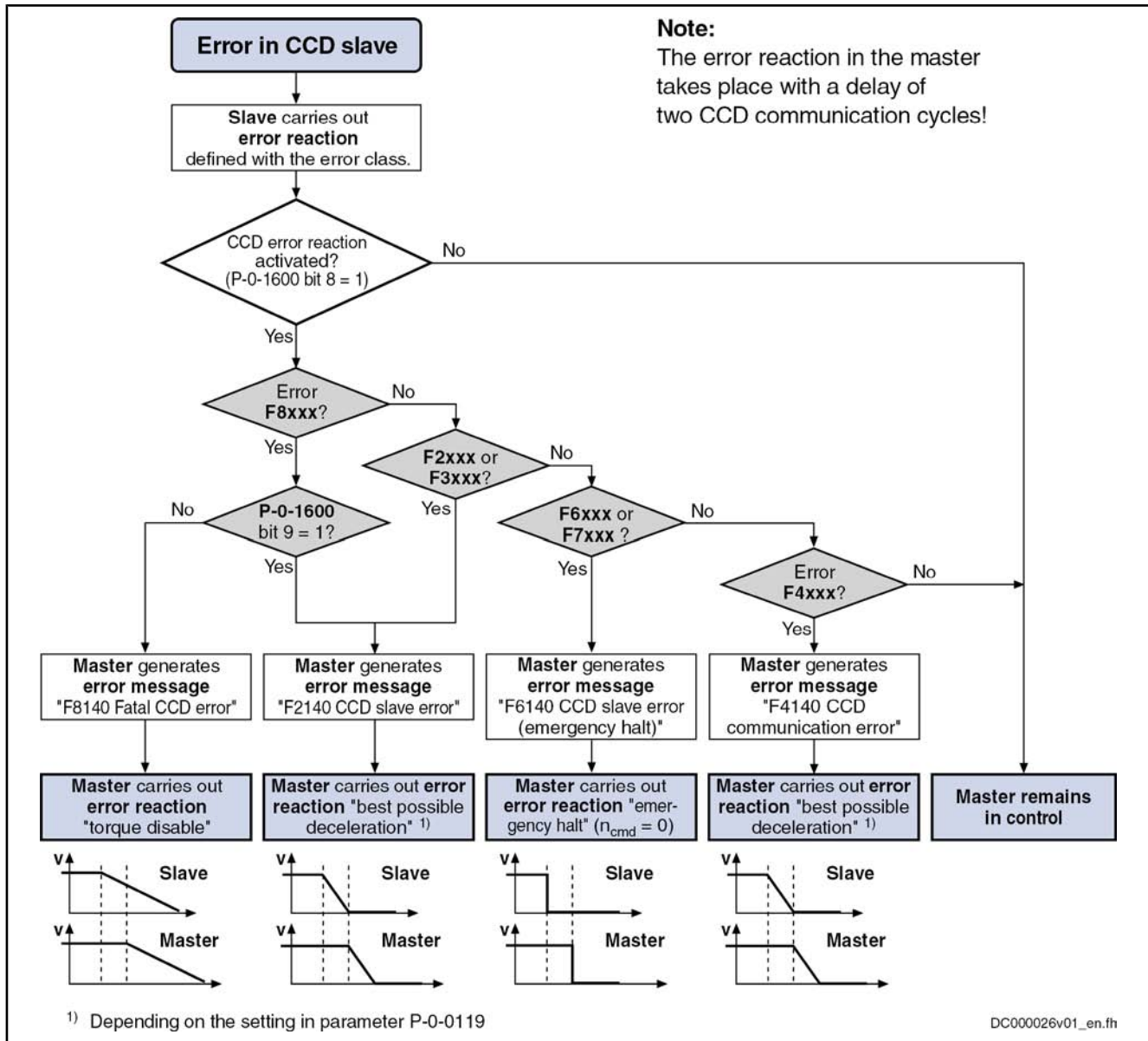


Fig.9-32: CCD Error Reaction for Master-Controlled Synchronous Error Reaction With Errors in the Slave

**Error in the CCD Master**

The figure below illustrates the cases of possible errors in the CCD master and the resulting reaction of the slaves for the master-controlled synchronous error reaction.



The reactions of the slaves are (implicitly) preset, run automatically and do not need to be activated!



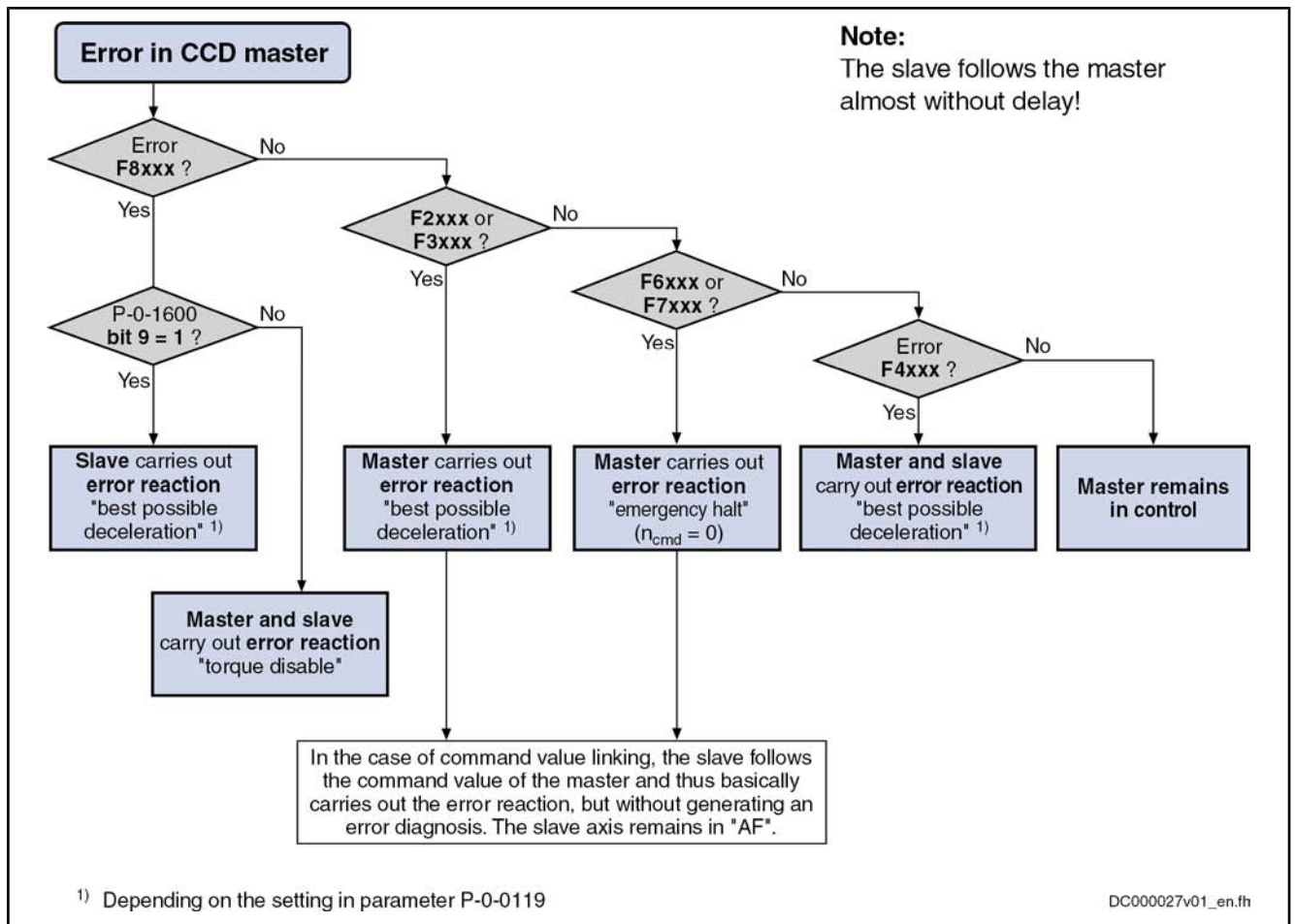


Fig.9-33: CCD Error Reaction for Master-Controlled Synchronous Error Reaction With Errors in the Master

### IP Settings

To establish an EtherNet connection with the CCD master, the IP address of the Engineering Port can be read or set in the IndraWorks dialog window shown below.

## Optional Device Functions

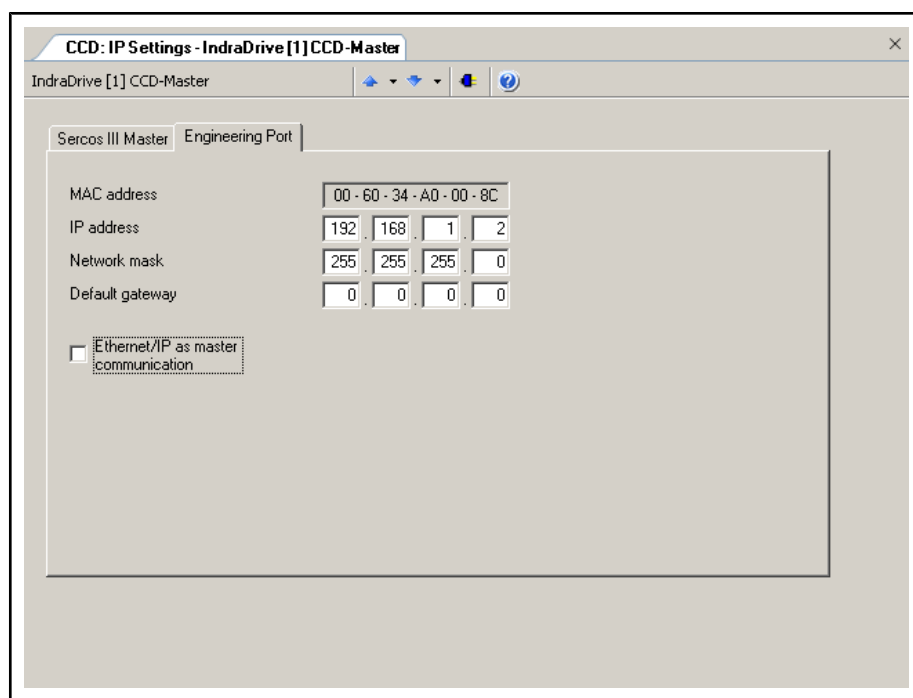


Fig.9-34: IndraWorks Dialog for IP Settings

## Free Process Data

By means of the free process data, parameter values of the CCD master (command values) can be copied to parameters of the CCD slaves. The other way round it is possible to copy parameter values of the CCD slaves (actual values) to parameters of the CCD master.

Only in the CCD system mode is it additionally possible to exchange data between higher-level control unit and the CCD slaves.

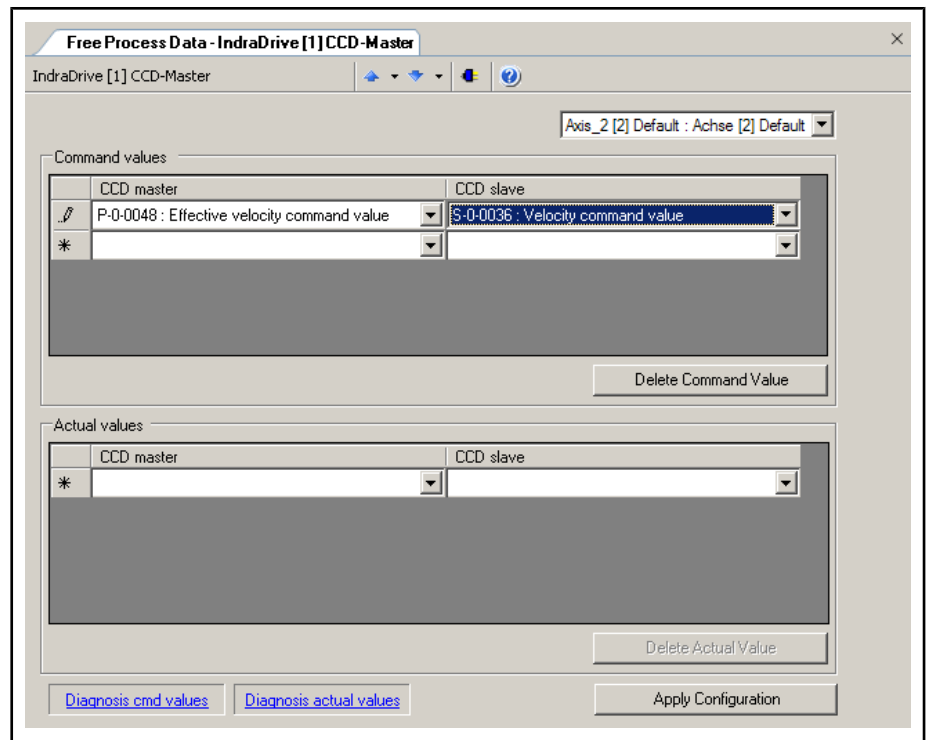


Fig.9-35: IndraWorks Dialog for Configuring the Process Data Between CCD Master and CCD Slave

Under the command values in the column of the CCD master, enter the parameter the value of which is to be copied to the selected CCD slave. In the column of the CCD slave in the same row, set the parameter of the CCD slave to which this value is to be copied.

Under the actual values in the column of the CCD master, enter the parameter to which the parameter value of the CCD slave is to be copied. In the column of the CCD slave in the same row, set the parameter value of the CCD slave which is to be copied to the parameter of the CCD master.

Please observe:

- You first have to select for which CCD slave (Axis\_x) the free process data are to be configured.
- With Axis\_1 you address the so-called "virtual slave". This slave is used for artificially delaying command values in the CCD master for dead time compensation and is automatically configured in the MLD-M system mode.
- The parameter of the CCD master and the belonging target or source parameter in the CCD slave must have the same data length.

## Optional Device Functions

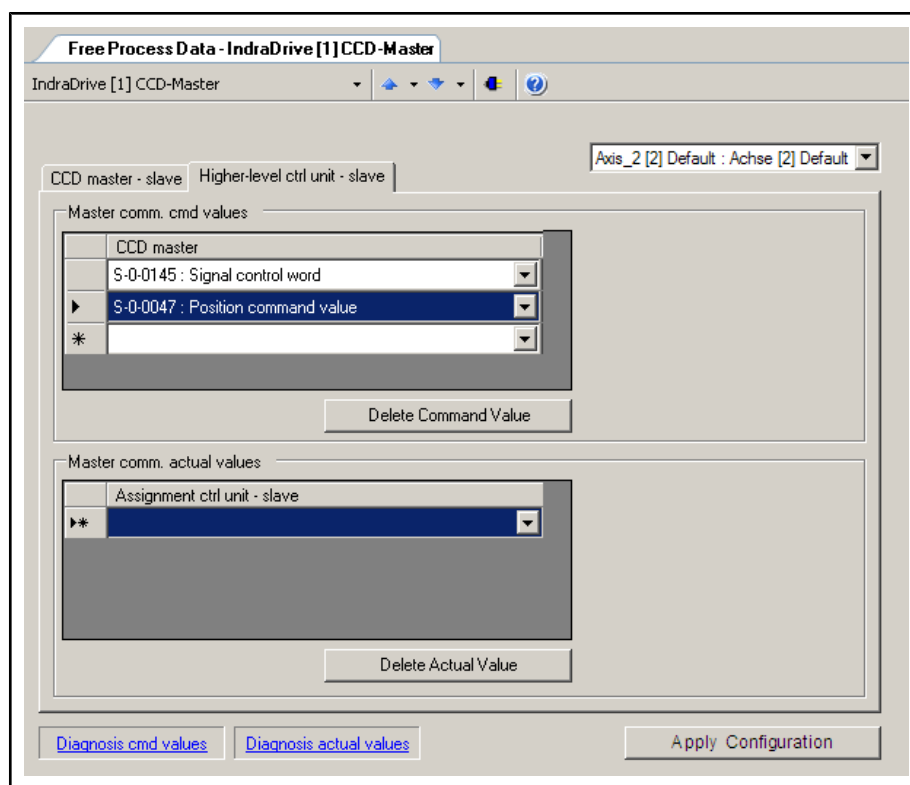


Fig. 9-36: *IndraWorks Dialog for Configuring the Process Data Between Higher-Level Control Unit and CCD Slave (Only With CCD System Mode)*

Under the command values of master communication, enter the parameters of the CCD slave which are directly written by the external control unit. Under the actual values of master communication, enter the parameters of the CCD slave which are to be cyclically read by the external control unit. The entered parameters have to be taken into account in the output and input data of the external control unit.

Please observe:

- If the four unassigned bits of the signal control word (see below) are to be used, the parameter "S-0-0145, Signal control word" always has to be contained in the master communication command values.
- If the four unassigned bits of the signal status word (see below) are to be used, the parameter "S-0-0144, Signal status word" always has to be contained in the actual master communication values.
- A control word for the CCD slave, with a structure identical to the parameter "P-0-4077, Field bus: control word", is always contained in the master communication command values. For this word you do not have to make any entry. Therefore, the 2 bytes always have to be taken into account at the first place in the output data of the control unit for the corresponding CCD slave (see "Overview Process Data, Command Values"). Via these bytes, the control unit can command each CCD slave individually like a normal field bus drive.
- A status word of the CCD slave, with a structure identical to the parameter "P-0-4078, Field bus: status word", is always contained in the actual master communication values. For this word you do not have to make any entry. Therefore, the 2 bytes always have to be taken into account at the first place in the input data of the control unit of the corresponding CCD slave (see "Overview Process Data, Actual Values"). Via these bytes, the external control unit cyclically gets the status of each CCD slave.

## Signal Status Word

### Use in CCD System Mode (Does not Apply to SERCOS II)

By means of the CCD signal status word, individual bits of the CCD slave can be directly read by the external control unit in the CCD system mode (see "S-0-0144, Signal status word" for normal field bus slave). It is necessary to indicate which bit of which parameter of the CCD slave is output via the corresponding bit in the CCD status word.



To read the CCD signal status word in the external control unit in the CCD system mode, the corresponding CCD slave must have entered the parameter S-0-0144 in the (cyclic) free process data of the control unit!

Only the bits 12 to 15 can be configured. The other bits are reserved (bits 0 to 11 are always zero in the control unit)!

### Use in the MLD-M System Mode

By means of the CCD signal status word, individual bits in the CCD slave, in the MLD-M system mode, can be directly read by MLD-M in the CCD master via the so-called AxisData structure (AxisData elements: wUserActualDataBitA\_q to wUserActualDataBitD\_q). It is necessary to indicate which bit of which parameter of the CCD slave is addressed via the corresponding element of the AxisData structure.

### Use in the CCD Basic Mode

If the signal status word of the CCD slaves (S-0-0144) is to be read by the CCD master, the free process data between CCD master and CCD slave (P-0-1624 and P-0-1626) have to be used for this purpose. The parameter S-0-0144 of the CCD slave has to be copied to parameter P-0-171x of the CCD master. The parameter P-0-171x then has to be read in the CCD master.

### IndraWorks Dialog

Via the dialog window below, IndraWorks supports the configuration of the signal status word. This IndraWorks dialog is **not available in the CCD basic mode**.

## Optional Device Functions

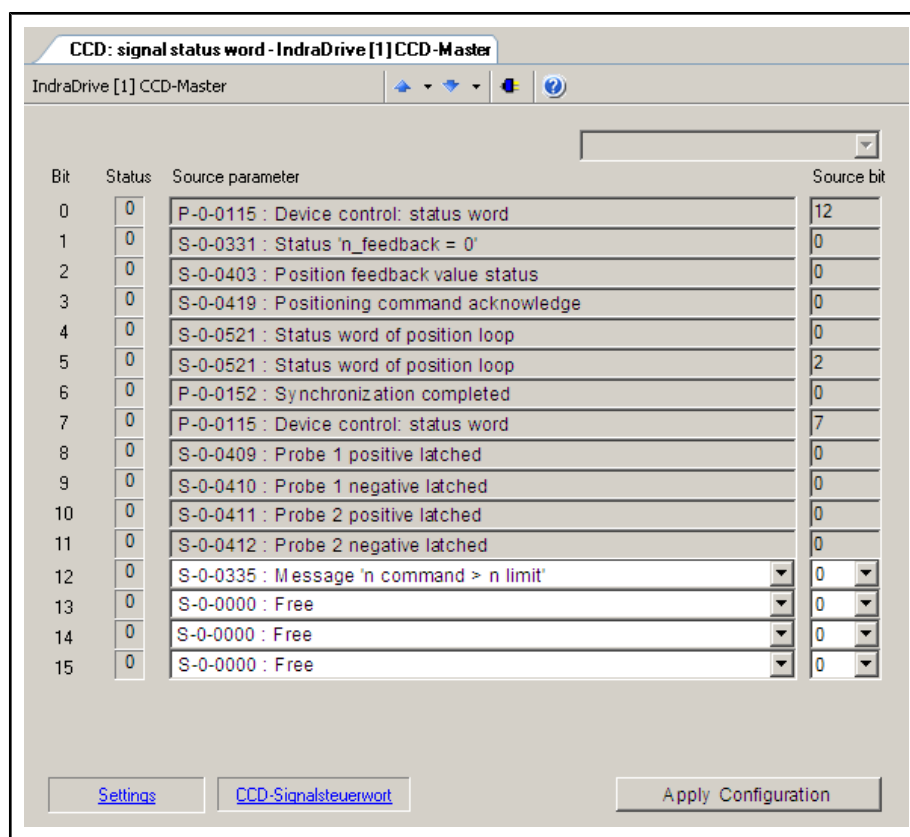


Fig. 9-37: IndraWorks Dialog for Configuring the Signal Status Word

## Signal Control Word

## Use in CCD System Mode (Does not Apply to SERCOS II)

By means of the CCD signal control word, individual bits in the CCD slave can be directly addressed by the external control unit in the CCD system mode (see "S-0-0145, Signal control word" for normal field bus slave). It is necessary to indicate which bit of which parameter of the CCD slave is addressed via the corresponding bit in the CCD control word.



To use the CCD signal control word of the external control unit in the CCD system mode, the parameter S-0-0145 must have been entered in the (cyclic) free process data of the control unit to the corresponding CCD slave!



Only the bits 12 to 15 can be configured. The other bits are reserved.

## Use in the MLD-M System Mode

By means of the CCD signal control word, individual bits in the CCD slave, in the MLD-M system mode, can be directly addressed by MLD-M in the CCD master via the so-called AxisData structure (AxisData elements: wUserCmdDataBitA\_q to wUserCmdDataBitD\_q). It is necessary to indicate which bit of which parameter of the CCD slave is addressed via the corresponding element of the AxisData structure.

## Use in the CCD Basic Mode

If the signal control word of the CCD slaves (S-0-0145) is to be written by the CCD master, the free process data between CCD master and CCD slave (P-0-1623 and P-0-1625) have to be used for this purpose. The parameter P-0-172x of the CCD master has to be copied to parameter S-0-0145 of the CCD slave. The parameter P-0-172x then has to be written in the CCD master.

**IndraWorks Dialog**

Via the dialog window below, IndraWorks supports the configuration of the signal control word. This IndraWorks dialog is **not available in the CCD basic mode**.

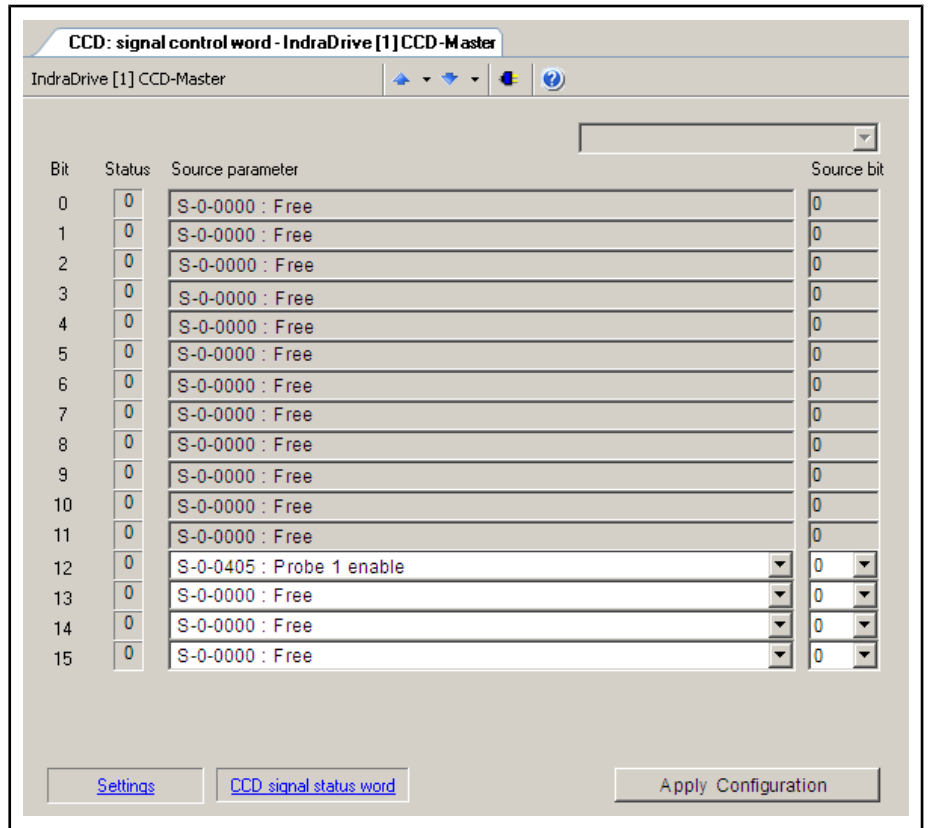


Fig.9-38: IndraWorks Dialog for Configuring the Signal Control Word

## Optional Device Functions

## 9.2.4 Diagnostic and Status Information

## Diagnostic Information

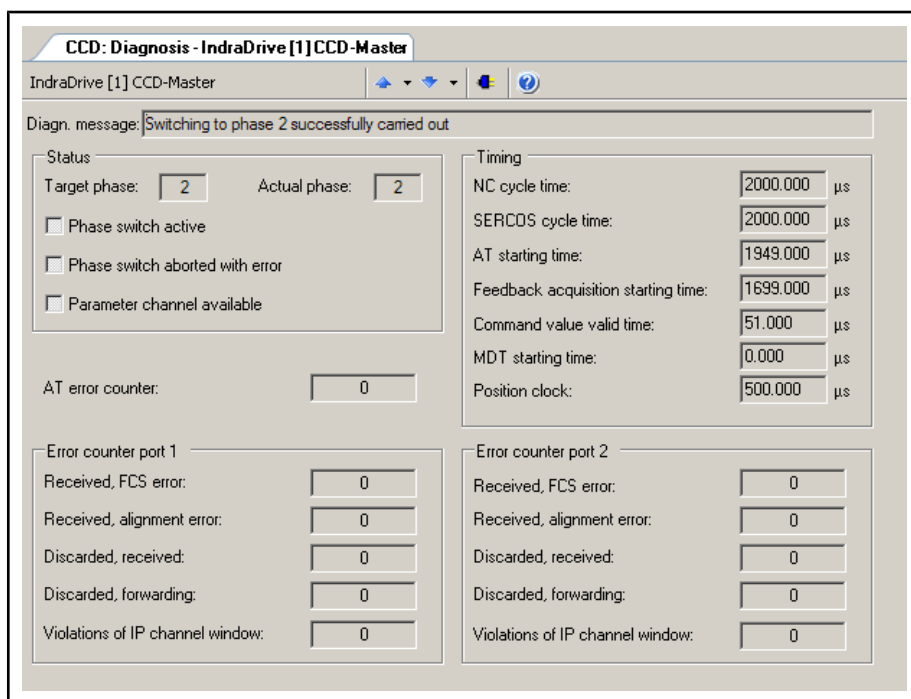


Fig.9-39: Diagnostic Information in IndraWorks for CCD Communication

In the case of problems with the SERCOS cross communication between CCD master and connected CCD slaves, you can get different kinds of information in this IndraWorks window:

- Diagnostic message text for CCD cross communication
- Status of phase switch of the entire CCD group
- Timing of the SERCOS III connection
- Number of AT telegrams which have failed in "AT error counter"
- Count of error counters of SERCOS FPGA according to SERCOS III specification in "Error counter port 1" and "Error counter port 2"



## Overview Process Data, Command Values

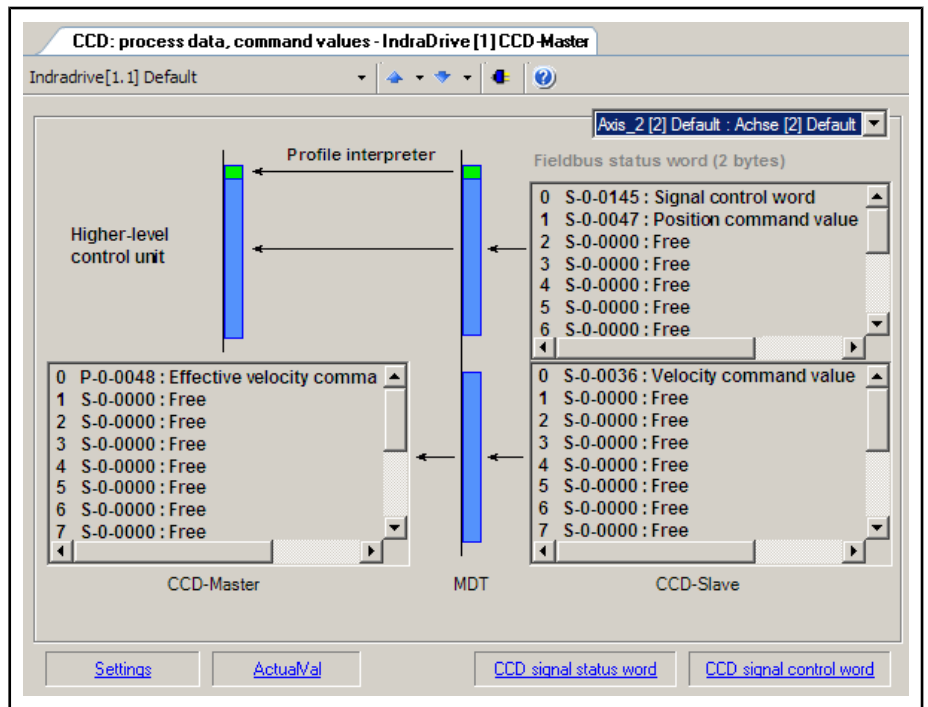


Fig.9-40: IndraWorks Overview Window of Process Data Command Values

This overview shows all process data command values for the selected CCD slave. The lower part displays the process data command values which are copied from the CCD master (left side) to the corresponding parameters of the CCD slave (right side). In the MLD-M system mode, the data configured in the AxisData structure are displayed here, too.

In the CCD system mode and apart from the process data between CCD master and CCD slave, the upper part displays the cyclic command values which directly go from the external control unit to the slave. The output data which the control unit has to take into account can be seen here. The field bus control word for the CCD slave which is always existing is displayed (and to be taken into account in the output data of the control unit), too.

## Optional Device Functions

## Overview Process Data, Actual Values

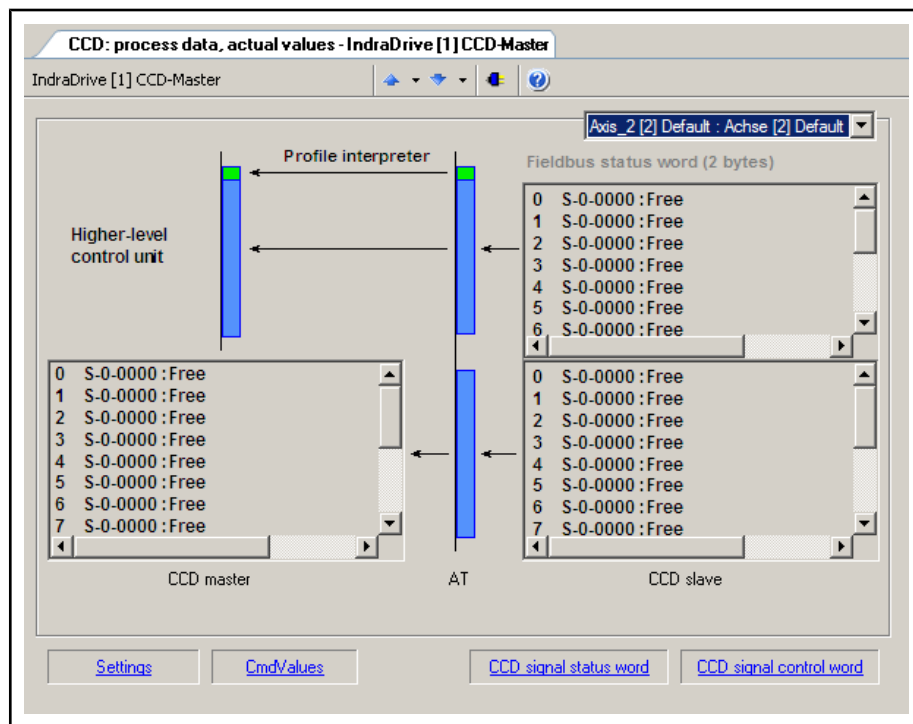


Fig.9-41: IndraWorks Overview Window of Actual Process Data Values

This overview shows all actual process data values for the selected CCD slave. The lower part displays the actual process data values which are copied from the CCD slave (right side) to the corresponding parameters of the CCD master (left side). In the MLD-M system mode, the data configured in the AxisData structure are displayed here, too.

In the CCD system mode and apart from the process data between CCD master and CCD slave, the upper part displays the cyclic actual values which directly go from the CCD slave to the external control unit. The input data which the control unit has to take into account can be seen here. The field bus status word of the CCD slave which is always existing is displayed (and to be taken into account in the input data of the control unit), too.

## Slave Status

IDN	Name	Value	Unit
P-0-1651	CCD: master control word, slave 1	0b0000.0000.0000.0000.0000	--
P-0-1661	CCD: drive status word, slave 1	0b0000.0000.0000.0000.0000	--
P-0-1701	CCD: diagnostic message number slave 1	0x00000000	--
P-0-1711	CCD: signal status word, slave 1	0b0000.0000.0000.0000	--
P-0-1721	CCD: signal control word, slave 1	0b0000.0000.0000.0000	--
P-0-1731	CCD: MDT real-time container 1, slave 1	0x00000000	
P-0-1741	CCD: MDT real-time container 2, slave 1	0x00000000	
P-0-1751	CCD: MDT real-time container 3, slave 1	0x00000000	
P-0-1761	CCD: MDT-Echtzeitcontainer 4, Slave 1	0x00000000	
P-0-1771	CCD: AT real-time container 1, slave 1	0x00000000	
P-0-1781	CCD: AT real-time container 2, slave 1	0x00000000	
P-0-1791	CCD: AT real-time container 3, slave 1	0x00000000	
P-0-1801	CCD: AT real-time container 4, slave 1	0x00000000	

Fig.9-42: Overview Window of Slave Status Information

This overview displays all pieces of status information on the selected CCD slave available in the CCD master (incl. the containers for copying).

## 9.3 Rexroth IndraMotion MLD (Drive-Integrated PLC)

### 9.3.1 Brief Description



Assignment to functional firmware package: Extension package **IndraMotion MLD** (order code **ML, MA** or **TF**)

The optional expansion packages "IndraMotion MLD" provide the function of a PLC integrated in the drive according to IEC 61131-3 with the following scope of functions:

- **Integrated logic control** (standard PLC tasks)
  - IEC-61131-3-conform
  - Online change
  - Debugging
  - Offline simulation
- **Integrated multi-axis/single-axis motion control**
  - Motion function block according to PLCopen positioning and synchronization operation
  - Programming via ST, SFC, FBD and LD
  - Library management with system and user libraries
- **Basis for technology functions**
  - Examples: Following-on cutting devices, process controller (register controller, winding computation, productivity agent, IndraMotion for handling, IndraMotion for metal forming,...

## Optional Device Functions



This optional extension of the drive functionality is described in detail in the separate documentation "Rexroth IndraMotion MLD" (DOK-INDRV\*-MLD-\*\*VRS\*\*-AW\*\*-EN-P; part no. R911306084).

**Hardware Requirements**

According to design, the expansion packages "IndraMotion MLD" require one of the following control section designs:

- **IndraMotion MLD-M** (multi-axis motion control)
  - Single axis ADVANCED (CSH01.3C)
- **IndraMotion MLD-S** (single-axis motion control)
  - Single-axis ADVANCED (CSH01.1C, CSH01.3C)
  - Single-axis BASIC (CSB01.1)



The expansion packages "IndraMotion MLD" are **not** available for double-axis control sections (CDB01.1C)!

**Firmware Requirements**

In the firmware **MPx-07VRS**, the function "IndraMotion MLD" is available in the following variants:

- Advanced design (**MPH**)
- Basic single-axis design (**MPB**)
- Multi-axis design MLD-M (**MPC**)



Using the function "IndraMotion MLD" generally requires the enabling of one of the additive expansion packages **ML**, **MA** or **TF**.

See also sections:

- "Overview of functions/functional packages"
- "Enabling of Functional Packages"

**Features/Characteristic Values**

The functional packages "IndraMotion MLD" include the following general features/characteristic values:

- Up to 4 preemptive user tasks are possible
- Task types:
  - Periodic (min. cycle time: 1 ms for advanced; 2 ms for basic)
  - Free-running (permanently cyclic)
  - Event-controlled (min. reaction time: 1 ms for advanced; 2 ms for basic)
- Memory resources:
  - MPH, MPB: 350 kbytes program memory (with MMC expandable to 2 MB)
  - MPC: 350 kbytes program memory (with MMC expandable to 4 MB)
  - MPH, MPB: 512 kbytes data memory
  - MPC: 2 MB data memory
  - 250 bytes retain or 32 kbytes with optional module MD1 or MD2 or control section design CSH01.3C
- Digital inputs/outputs:

## Optional Device Functions

- 7...11 digital inputs, 0...4 digital outputs on x31/x32 (with advanced control section CSH)  
→ PLC and drive are sharing the inputs!
  - 12 digital inputs, 8 digital outputs on the optional module MD1 (optional)
  - 16 digital inputs, 16 digital outputs on the optional module MD2 (optional)
  - 16 digital inputs, 16 digital outputs on the optional module PL (for parallel master communication)
  - 1 relay output on x31/x32 (CSH control section)  
→ PLC and drive are sharing the inputs!
- Note:** For BASIC control sections there are restrictions regarding the available inputs/outputs (see documentation "Drive Controllers, Control Sections; Project Planning Manual").
- Analog inputs/outputs:
    - 1 analog input (+/-10 V) on x31/x32 (CSH control section)
    - 2 analog outputs (0-5 V) on 31/x32 (CSH control section)
    - Analog inputs/outputs (+/-10 V) on MA1 (optional)

**Note:** For BASIC control sections there are restrictions regarding the available inputs/outputs (see documentation "Drive Controllers, Control Sections; Project Planning Manual").
  - Inputs/outputs on remote axes:
    - Digital and analog inputs/outputs of the slaves connected to SERCOS III can be read and written.
    - Number of inputs/outputs depends on the used control sections of the slaves
  - SERCOS-III I/O
    - Evaluation of digital block inputs/outputs (every block with 32 inputs or with 16 inputs and 16 outputs)
  - Parameters for general purpose:
    - Parameters for process image: Inputs PIs
      - 20 input words per 2 bytes
      - 8 input words per 4 bytes
    - Parameters for process image: Outputs POIs
      - 20 output words per 2 bytes
    - Global registers (4 bytes)
      - 32 buffered parameters
      - 32 unbuffered parameters
    - List parameters (4 bytes)
      - 1 list register with 8192 values (not buffered)
      - 3 list registers with 1024 values (buffered)
    - 2 global text registers with 255 characters each
    - Display format of the global register that can be parameterized
    - Name, unit and limit values of the global registers can be configured via PLC functions

## Optional Device Functions

- Other features:
  - Extensive debug possibilities (single-step, watch, force/write, break-points, powerflow)
  - File access from the PLC (save source code on MMC, ...)
  - Keep symbol file on MMC ready for access to PLC variables
  - Source download (only with MMC)
  - Access to serial interface
  - Access to ethernet interface

### Pertinent Parameters

PLC parameters for general purpose

- P-0-1350, PLC control word
- P-0-1351, PLC status word
- P-0-1352, PLC user program administration data
- P-0-1362, PLC boot project info
- P-0-1363, PLC project info
- P-0-1367, PLC configuration
- P-0-1369, PLC internally reserved

User program (filing):

- P-0-1353, PLC user program area 0
- P-0-1354, PLC user program area 1
- P-0-1355, PLC user program area 2
- P-0-1356, PLC user program area 3
- P-0-1357, PLC user program area 4
- P-0-1358, PLC user program area 5

Process input images PIs

- P-0-1390, PLC input WORD0 AT %IB0  
to  
P-0-1409, PLC input WORD19 AT %IB38
- P-0-1440, PLC input DWORD25 AT %IB100  
to  
P-0-1447, PLC input DWORD32 AT %IB128

Process output images POIs

- P-0-1410, PLC output WORD0 AT %QB0  
to  
P-0-1429, PLC output WORD19 AT %QB38

Global PLC registers, unbuffered:

- P-0-1270, PLC Global Register A0  
to  
P-0-1301, PLC Global Register A31

Global text registers, unbuffered:

- P-0-1387, PLC Global Register AT0  
to  
P-0-1388, PLC Global Register AT1

Global list register, unbuffered:

- P-0-1368, PLC Global Register AL0

Global PLC registers, buffered:

- P-0-1370, PLC Global Register G0  
to  
P-0-1385, PLC Global Register G15
- P-0-1316, PLC Global Register G16  
to  
P-0-1331 PLC Global Register G31

Global list registers, buffered:

- P-0-1389, PLC Global Register GL0
- P-0-1311, PLC Global Register GL1
- P-0-1312, PLC Global Register GL2

To configure the display format of the registers:

- P-0-1386, PLC display format Global Register

## 9.3.2 Notes on Installation/System Configuration

### Installation

For installing "IndraMotion MLD" on the PC, it is necessary to install the current version of the **"IndraWorks MLD" commissioning tool** on the PC.

After successful installation the **"IndraLogic" PLC programming system** and **"IndraWorks"** can simultaneously communicate with the drive.

### Project Planning Manual

The system configuration of "IndraMotion MLD" is carried out via a PC with the "IndraLogic" program installed that communicates with the drive via a serial interface or TCP/IP communication (with CSH01.3).

The projects are filed on the PC. The generated binary code is loaded into the drive and stored in parameters or in the MMC. With the MMC plugged, the source code, symbols and user files can also be stored there.

## 9.3.3 Overview of the Available Libraries



This chapter only gives a short explanation of the basic libraries or functions. The details are described in the separate documentation "Rexroth IndraMotion MLD".

**IndraLogic Libraries** (compatible with "CoDeSys"):

- AnalyzationNew.lib  
→ This library contains blocks for the analysis of expressions. If a composed expression has the total value FALSE, those components can be determined that contribute to this result. In the AS editor, the flag "SFCErrorAnalyzationTable" uses these functions implicitly for the analysis of the transition expressions.
- Lecsfclib  
→ Apart from the simplified steps, the IEC steps conforming to standard are available in AS. In order to use the IEC steps, the special SFC library "lecsfc.lib" must be included in the project.
- NetVarUdp\_LIB\_V23.lib (system-internal library)

## Optional Device Functions

→ This library is automatically loaded by the system and serves internally for the processing of network variables. It does not contain any user-relevant contents. When using network variables, this library is automatically included in the library manager.

- Standard.LIB

→ This library is available as a standard. It contains all functions and function blocks that are required by the IEC 61131-3 as standard blocks for an IEC programming system. The difference between a standard function and an operator is that the operator is implicitly known to the programming system while the standard blocks must be included in the project as library (standard.lib). When creating a new project, this library is automatically included in the library manager.

- SysLibCallback.lib (system-internal library)

→ This library is used by internal libraries. It does not contain any user-relevant contents. When using network variables, this library is automatically included in the library manager.

- SysLibSockets.lib

→ This library supports the access to sockets for communication via TCP/IP and UDP. When using network variables, this library is automatically included in the library manager.

- SysLibStr.lib

→ This library offers functions for the handling of strings. If the target system contains the functionality, the following library functions can be used to compare or to copy strings or to determine the length of the strings (synchronous processing).

- Util.lib

→ This library contains an additional collection of various blocks that can be used for BCD conversion, bit/byte functions, mathematical auxiliary functions, controllers, signal generators, function manipulators and for analog value processing.

**IndraMotion MLD libraries:**

- MX\_Base.lib

→ When creating a new project, this library is automatically included in the library manager. It contains the functions below:

- General functions
- Functional blocks/functions for drive control
- Functions for diagnostic messages
- Functional blocks/functions for access to parameters
- Functions for scaling
- Data types or structures
- Cyclic parameters as direct variables (system-wide variables)
- Variables for addressing of axes
- Global axis structures with cyclic data (AxisData)

- MX\_CheckRtv.lib (system-internal library)

→ This library contains testing functions, which ensure that errors such as "Dividing by zero" or invalid field addressing are detected during the program runtime and are signaled with an F6010 error reaction. When creating a new project, this library is automatically included in the library manager.



- **MX\_DSP.lib**  
→ This library contains variables and a functional block for operation or control of the (local) real-time channel. This serves for time-controlled synchronous exchange of data with the drive for special fields of applications such as customer-specific command value generators or controllers.
- **MX\_Internal.lib (system-internal library)**  
→ This library is used by internal libraries. It does not contain any user-relevant contents. When creating a new project, this library is automatically included in the library manager.
- **MX\_PLCOpen.lib**  
→ This library contains functional blocks for motion control according to PLCOpen. When creating a new project, this library is automatically included in the library manager.
- **MX\_SysLibCom.lib**  
→ This library supports the synchronous, serial communication via the serial interface. The library functions can be used in order to open and close a serial port and write or read data via the serial port.
- **MX\_SysLibDir.lib**  
This library contains functions for the reading of directories at the (optional) MMC. The calls are synchronous so that the function only returns as soon as the task is completed.
- **MX\_SysLibFileAsync.lib**  
→ This library contains functional blocks for the access to files in the user directory of the (optional) MMC. The calls are asynchronous so that the blocks are called cyclically until they signal the status "completed".
- **MX\_SysLibIecTasks.lib**  
→ This library contains functions for calling information about the configuration and the status (e.g. runtime) or IEC tasks.
- **MX\_SysLibMem.lib**  
→ This library contains functions for copying, shifting or comparing memory ranges. Functions for the dynamic memory management are not included.
- **RIL\_CommonTypes.lib**  
→ This library contains general global data types and declarations of constants. When creating a new project, this library is automatically included in the library manager.
- **RIL\_VExUtil.lib**  
This library ensures a safe key-type operation in conjunction with a VEx control station.

### 9.3.4 Overview of the Function of the Parameters for General Purpose

The following parameters are available for communication between "IndraMotion MLD" and external devices:

- Global registers G0 to G31 (buffered)  
→ P-0-1370 to P-0-1385 and P-0-1316 to P-0-1331  
→ Global registers with a data length of 4 bytes; This parameter is a register with individual values for data exchange of the PLC with the drive or a higher-level PLC or control unit.
- Global registers A0 to A31 (unbuffered)

## Optional Device Functions

- P-0-1270 to P-0-1301
- Parameters for data exchange (input and output data) of the PLC with a higher-level control unit or HMI
- Global text registers AT (unbuffered)
  - P-0-1387, P-0-1388
  - Freely usable text parameter with a maximum of 255 characters plus terminating zero-character.
- Global list registers GL (buffered)
  - P-0-1389, P-0-1311, P-0-1312
  - List parameters with 1024 elements (4 bytes each) for data exchange of the PLC with an external control or HMI
- Global list register AL (unbuffered)
  - P-0-1368
  - List parameters with 8192 elements (4 bytes each) for data exchange of the PLC with an external control or HMI
- Process input images PIIs
  - P-0-1390 to P-0-1409 (with 2 bytes each → word-wise)
  - P-0-1440 to P-0-1447 (with 4 bytes each → double-word-wise)
  - Parameters contain the process image of the PLC inputs (PIIs); before the beginning of the task, the PLC reads the values in the PIIs and updates the process image of the inputs.
- Process output images POIs
  - P-0-1410 to P-0-1429 (with 2 bytes each → word-wise)
  - Parameters contain the process image of the PLC outputs (PIIs); At the end of the task, the PLC writes the value from the POIs in the outputs.

## 9.4 Digital Inputs/Outputs

### 9.4.1 Brief Description

#### General Information



Assignment to functional firmware package, see chapter "Availability of the Optional Device Functions".

#### Hardware Requirements

In their basic configuration (without optional modules), all IndraDrive controllers already have configurable digital inputs/outputs.

The number, assignment and function of the digital inputs/outputs depend on the type and configuration of the respective control section and are contained in the respective hardware description (Project Planning Manual).



See separate documentation "Control Sections for Drive Controllers; Project Planning Manual"

#### Digital Inputs/Outputs on Control Section

- Features**
- Sampling of digital inputs and outputs or transmitting data to them in the position loop clock  $T_{A\_position}$  (see "Performance Data")

- Configurable digital inputs/outputs with effective direction that can partly be freely set (input or output):
  - **ADVANCED** control sections with firmware **MPH**:
    - 4 digital inputs/outputs
    - 3 digital inputs
    - 2 inputs can alternatively be used as analog input (differential input)
    - 2 rapid inputs as probe inputs (in steps of  $\mu\text{s}$ )
    - 1 isolated relay switch contact (can be configured)
  - **BASIC single-axis** control sections with firmware **MPB**:
    - 3 digital inputs/outputs
    - 4 digital inputs
    - No analog input
    - 1 rapid input as probe input (in steps of  $\mu\text{s}$ )
    - 1 isolated relay switch contact (can be configured)
  - **BASIC double-axis** control sections with firmware **MPD**:
    - 4 digital inputs/outputs
    - 6 digital inputs
    - 2 inputs can alternatively be used as analog input (differential input)
    - 2 rapid inputs as probe inputs (in steps of  $\mu\text{s}$ )
    - 2 isolated relay switch contacts (can be configured)
- All inputs/outputs (except for the relay contact) designed for level of 0 V (LOW) or 24 V (HIGH)
- Assignment of inputs/outputs to internal parameters or bits
- Signal states of digital inputs and digital outputs mapped to individual parameter
- Signal states of digital inputs can be directly read by the control master
- Digital outputs can be directly controlled by the control master, if not used on drive-side
- External 24 V supply of the digital outputs required
- Inputs/outputs galvanically isolated from control section



Each individual input/output can be assigned to parameters of the drive; IDN of the permitted parameters from IDN lists in S-0-0398 and S-0-0399.

#### Pertinent Parameters

- S-0-0398, IDN-list of configurable data in signal status word
- S-0-0399, IDN-list of configurable data in signal control word
- P-0-0300, Digital I/Os, assignment list
- P-0-0301, Digital I/Os, bit numbers
- P-0-0302, Digital I/Os, direction
- P-0-0303, Digital I/Os, inputs
- P-0-0304, Digital I/Os, outputs

#### Pertinent Diagnostic Messages

- C0246 Trav. range lim. switch not ass. to dig. input

## Optional Device Functions

- C0247 Dig. output already assigned to other axis
- C0248 Dig. input assigned differently to axes
- C0249 Dig. I/Os: Bit number too large
- F2010 Error when initializing digital I/O (-> S-0-0423)
- F2033 External power supply X10 error

## Digital Inputs/Outputs on Optional Module MD1

For the configurable ADVANCED control sections, it is possible to individually configure, apart from the standard digital inputs/outputs, an extension of these inputs/outputs.

This requires the optional module MD1 which can be used for the following purposes:

- Making available digital inputs/outputs to external control unit
- Enabling input/output of drive parameters
- Making available digital inputs/outputs to drive-integrated PLC (IndraMotion MLD-S)
- Extension of memory (32 kB non-volatile memory) for drive-integrated PLC (IndraMotion MLD)



Utilization of digital I/O extension by using the optional module MD1 is **only possible for ADVANCED** control sections!

## Features

- Connection via 25-pin D-Sub connector
- All inputs/outputs designed for level of 0 V (LOW) or 24 V (HIGH)
- External 24 V supply of the digital outputs required
- Inputs/outputs galvanically isolated from control section
- Assignment of inputs/outputs to internal parameters or bits
  - Parameters P-0-0081 and P-0-0082 can be completely assigned to parameters of the drive or of the integrated PLC
  - Free configuration of the digital inputs/outputs via "S-0-0144, Signal status word" and "S-0-0145, Signal control word"
- 12 digital inputs (freely configurable and protected from reverse polarity)
- 8 digital outputs (max. output current 0.5 A and sustained short-circuit-proof)

## Pertinent Parameters

- S-0-0144, Signal status word
- S-0-0145, Signal control word
- S-0-0398, IDN-list of configurable data in signal status word
- S-0-0399, IDN-list of configurable data in signal control word
- P-0-0081, Parallel output 1
- P-0-0082, Parallel input 1
- P-0-0681, Assignment IDN -> parallel output 1
- P-0-0682, Assignment parallel input 1 -> IDN

## 9.4.2 Function and Commissioning of the Digital Inputs/Outputs of the Control Section

### Overview

**Configuring the Inputs/Outputs** The IDNs of the target or source parameters for digital inputs/outputs are contained in parameter "P-0-0300, Digital I/Os, assignment list". Further definitions for the indicated IDN are made via parameters P-0-0301 and P-0-0302, the assignment being carried out via the list element.

**Direct Bit Transfer** As a standard, the parameter of an IDN entered in P-0-0300 is considered to be the direct data source (when configured as output) or the target (when configured as input).

**Cases to Distinguish for Determining Source or Target** The IDNs entered in the list parameter P-0-0300 can have two different functions:

- **1. Input**

In the case of an input, the bit, configured in "P-0-0301, Digital I/Os, bit numbers", of a parameter defined via P-0-0300 is written with the logic value (0 or 1) provided at the input.

- **2. Output**

In the case of an output, the content of the bit configured in P-0-0301 is taken from the IDN determined in P-0-0300 and transmitted to the hardware output.

The following table shows some exemplary standard configurations frequently used:

Function	P-0-0300[i]	P-0-0301[i]	P-0-0302[i]	Notes
Relay contact "ready for operation"	P-0-0115	0	1	Only makes sense for HCS!
Positive limit switch	P-0-0222	0	0	
Negative limit switch	P-0-0222	1	0	
E-Stop	P-0-0223	0	0	

i = index List element / terminal slot

Fig. 9-43: Standard Configurations for Digital Inputs/Outputs (Examples)

**Source or Target Parameter** The respective bit in the source or target parameter is selected via "P-0-0301, Digital I/Os, bit numbers".



When P-0-0300[i] = "S-0-0000", the respective entry in P-0-0301 is ignored!

### Operating Principle

A number of digital inputs/outputs can be used both as an input and as an output. The operating principle (direction) of these combined inputs/outputs is determined via the list parameter "P-0-0302, Digital I/Os, direction". The following applies:

- Entry "0" → digital input (default setting)
- Entry "1" → digital output

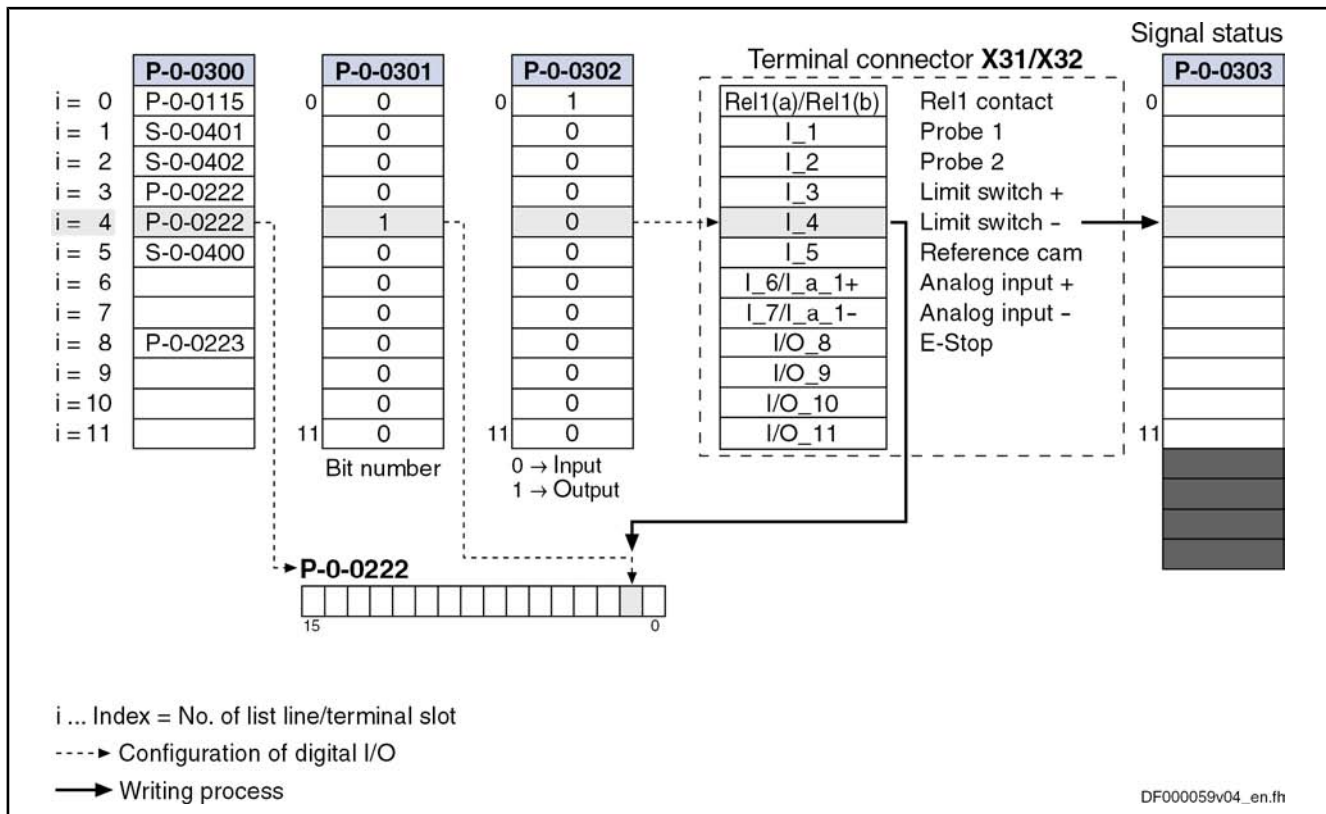
Optional Device Functions



When determining the operating principle (direction) of the inputs/outputs, the hardware requirements have to be taken into consideration. The relay contacts, for example, can only be operated as outputs.

See also section "X31/X32, Digital and Analog Inputs/Outputs" in the documentation "Control Sections for Drive Controllers; Project Planning Manual"

As an example, the following figure illustrates the configuration of input I\_4 (terminal connector X31.6) as an input signal on bit 1 of the parameter S-0-0222 (negative travel range limit switch); the configuration assignment takes place via list element 4 of "P-0-0300, Digital I/Os, assignment list" and "P-0-0301, Digital I/Os, bit numbers".



- P-0-0300 Digital I/Os, assignment list
- P-0-0301 Digital I/Os, bit numbers
- P-0-0302 Digital I/Os, direction
- P-0-0303 Digital I/Os, inputs

Fig.9-44: Configuring the Digital Inputs/Outputs (Configuration for ADVANCED Control Section With Default Settings)



This example applies to control sections of ADVANCED design; for BASIC and BASIC double-axis design, the distribution of the digital inputs/outputs is different.



The signal status of the digital inputs/outputs is displayed in the following parameters:

- P-0-0303, Digital I/Os, inputs
- P-0-0304, Digital I/Os, outputs

**Deactivation** To deactivate an input/output, the IDN "S-0-0000" has to be entered in the respective list element of parameter "P-0-0300, Digital I/Os, assignment list".

**Validity Check of Configuration Lists** When a new assignment list is input or an element of the list is changed, all entries are checked for validity. If an entry is invalid (i.e. no allowed IDN entered) only this invalid entry is rejected.



Incorrect entries are rejected when the list is checked and set to the respective default value (Rel1 contact → output; all other pins → inputs).

### Specific Features of Double-Axis Devices (Firmware MPD)

Basically, the existing inputs and outputs can be freely assigned to all axes. To do this, the parameters P-0-0300, P-0-0301, P-0-0302 are available for both axes.

There are the following restrictions:

- A digital output can only be used by one axis. All other axes have to deactivate this output by the entry "S-0-0000" in parameter P-0-0300.
- The output contact of the relay "Rel1" is an exception. It can be used by both axes. The default assignment is the "ready for operation" message (see Parameter Description P-0-0300). For controlling the relay, the information of both axes is ANDed.
- An input can only be used simultaneously by both axes, if it is used by both axes with the same IDN, bit number and directional assignment (for inputs/outputs).
- A digital input **cannot be used simultaneously** by both axes, if the assignment parameters of both axes differ in the respective line with regard to the IDN (P-0-0300), bit number (P-0-0301) or directional assignment (P-0-0302). The respective line of P-0-0300 of one of the two axes must contain "S-0-0000" (→ no assignment)!



The above-mentioned restrictions are checked in the transition command from phase 3 to phase 4 (cf. C2000). In the case of conflict, the corresponding diagnostic message is generated.

### Special Cases and Exceptions

**Probe and Reference Cam Input** In some special cases, there is no direct bit transfer, because the function assigned to the input/output is more complex. The probe function is an example. In this case, the entry in P-0-0301 is irrelevant, it is only a valid value that must be contained (e.g. "0").

All special functions are listed in the following table:

Function	P-0-0300[i]	P-0-0301[i]	P-0-0302[i]	Notes
Probe 1	S-0-0401	Not relevant	Not relevant	Only possible when "i = 1"!
Probe 2	S-0-0402	Not relevant	Not relevant	Only possible when "i = 2"!
Reference cam	S-0-0400	Not relevant	Not relevant	

i = index      List element / terminal slot  
 Fig. 9-45:      Special Functions via Digital Inputs/Outputs

Optional Device Functions

**Fixed Assignment of Function-Rellevant Inputs and Default Configuration**

As a matter of principle, the inputs/outputs can be freely configured. Only for the special function "probe" is the fixed assignment of the corresponding parameters to the appropriate inputs on the hardware side obligatory!

By the default configuration (condition as supplied or status after "basic parameter load"), the inputs/outputs are appropriately predefined (see below).



All changes in the parameters P-0-0300, P-0-0301 and P-0-0302 have to be carefully made because important functions might be deactivated (e.g. E-Stop).

**Direct Access to Digital Inputs/Outputs of the Control Section via Master Communication**

**Access to Digital Outputs**

In order to directly control ("set") the digital outputs of the control section via the master communication or directly poll ("read") the digital inputs, the parameters "P-0-0303, Digital I/Os, inputs" and "P-0-0304, Digital I/Os, outputs" can be included in the cyclic data of the master communication.

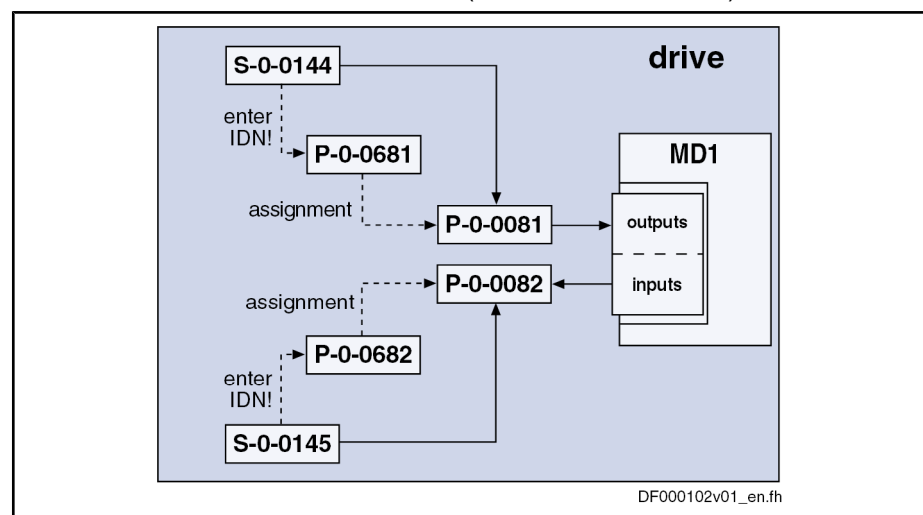
Requirements:

- Including parameter P-0-0303 in the group of cyclic actual values (SERCOS: S-0-0016, field bus: P-0-4080)
- Including parameter P-0-0304 in the group of cyclic command values (SERCOS: S-0-0024, field bus: P-0-4081)



The digital outputs can only be directly controlled by the master communication, if they are not used on the drive side (enter "S-0-0000" in the respective list line of parameter P-0-0300; setting as output in parameter P-0-0302)!

The figure below illustrates the access to the digital inputs/outputs of the control section via the master communication (SERCOS in this case).



- S-0-0016 Configuration list of AT
- S-0-0024 Config. list of the master data telegram
- P-0-0303 Digital I/Os, inputs
- P-0-0304 Digital I/Os, outputs

Fig.9-46: Access to Digital Inputs/Outputs of the Control Section via SERCOS Master Communication

**Behavior When Master Communication Fails**

When the cyclic communication fails, the value "0" is written to the parameters; this means that those digital outputs are cleared to which the master transmits data via the cyclic communication.



## Default Configurations of Digital Inputs/Outputs of Control Section

Depending on the design of the control section, there are the following factory-provided default settings for the digital inputs/outputs:

Signal name	ADVANCED	BASIC UNIVERSAL single-axis	BASIC UNIVERSAL double-axis	BASIC-OPEN-LOOP	BASIC-SERCOS	BASIC-PROFIBUS	BASIC-ANALOG
I_1	Probe 1	Probe 1	Axis 1: Probe 1	Clear error	Probe 1	Probe 1	Clear error
I_2	Probe 2	X	Axis 2: Probe 1	Drive ON	X	X	Drive ON
I_3	Travel range limit switches	Travel range limit switches	Axis 1: Travel range limit switches	Vel. cmd value from memory of fixed values	Travel range limit switches	Travel range limit switches	Travel range limit switches
I_4	Travel range limit switches	Travel range limit switches	Axis 1: Travel range limit switches	Vel. cmd value from memory of fixed values	Travel range limit switches	Travel range limit switches	Travel range limit switches
I_5	Home switch	Home switch	Axis 1: Home switch	Vel. cmd value from memory of fixed values	Home switch	Home switch	Home switch
I_6	Analog input (I_a_1+)	--	X	--	--	--	--
I_7	Analog input (I_a_1-)	--	X	--	--	--	--
I/O_8	As input: E-Stop	As input: E-Stop	As input for axis 1: E-Stop	As input: E-Stop	As input: E-Stop	As input: E-Stop	As input: E-Stop
I/O_9	X	X	As input for axis 2: Travel range limit switches	As input: Vel. cmd value from memory of fixed values	X	X	As input: Drive Halt
I/O_10	X	X	As input for axis 2: Travel range limit switches	As input: Vel. cmd value from memory of fixed values	X	X	As output: Ready signal
I/O_11	X	--	As input for axis 2: Home switch	--	--	--	As output: Warning
I_12 to I_22	--	--	X	--	--	--	--

x

Signal name available, but no default setting

--

Signal name not assigned in this control section type

I/O

Can be used as input or output (not for BASIC OPENLOOP)

Fig.9-47:

Default Setting of Digital Inputs/Outputs of Different Control Section Designs

## Optional Device Functions



See documentation "Control Sections for Drive Controllers; Project Planning Manual"

### 9.4.3 Function and Commissioning of the Digital Inputs/Outputs of the Optional Module MD1

#### Overview

**Mapping the Inputs/Outputs** To map the digital inputs and outputs of the optional module MD1, the following parameters are available:

- P-0-0081, Parallel output 1  
→ Contains the bits that are output via the digital outputs of the MD1 module
- P-0-0082, Parallel input 1  
→ Contains the bits that are read in via the digital inputs of the MD1 module



The parameters P-0-0081 and P-0-0082 are only available when the optional module MD1 has been plugged.

**Configuration** The two above parameters can be cyclically configured (MDT or AT data). This allows assigning the complete digital inputs or outputs to existing, cyclically configurable drive parameters (see S-0-0398, S-0-0399). The following parameters are used for assignment:

- P-0-0681, Assignment IDN -> parallel output 1
- P-0-0682, Assignment parallel input 1 -> IDN

**Possibilities of Access** There are the following possibilities for using the digital inputs/outputs on the optional module MD1:

- Direct access via master communication by the master (e.g. PLC)
- Configuration of inputs/outputs to any drive parameter and bit (see S-0-0398 and S-0-0399)
- Direct access to inputs/outputs via drive-integrated PLC
- Configuration of digital inputs for safety technology on MD1

#### Direct Access to Digital Inputs/Outputs of the Module MD1 via Master Communication

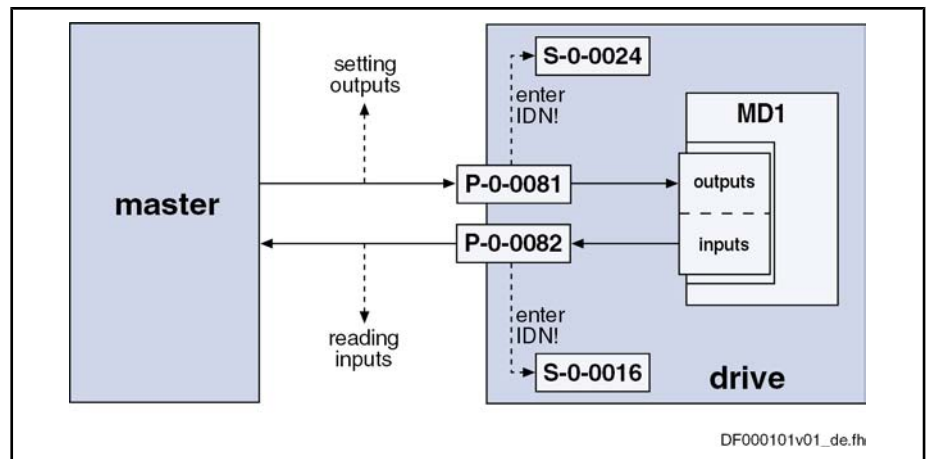
In order to transmit data to the digital inputs/outputs directly via the master communication, the following steps are required:

- Configuration of:
  - [P-0-0681] = "S-0-0000"
  - [P-0-0682] = "S-0-0000"

The parameters P-0-0081 and P-0-0082 can then be used as mere "data containers" for exchanging data between drive and master.

- Configuration of P-0-0081 and P-0-0082 in the cyclic data
- Including parameter P-0-0081 in the group of cyclic command values (SERCOS: S-0-0024, field bus: P-0-4081)
- Including parameter P-0-0082 in the group of cyclic actual values (SERCOS: S-0-0016, field bus: P-0-4080)

The figure below illustrates the access to the digital inputs/outputs of the optional module MD1 via the master communication (SERCOS in this case).



S-0-0016	Configuration list of AT
S-0-0024	Config. list of the master data telegram
P-0-0081	Parallel output 1
P-0-0082	Parallel input 1

Fig. 9-48: Access to Digital Inputs/Outputs of the Optional Module MD1 via SERCOS Master Communication

## Configuring the Digital Inputs/Outputs of Module MD1 to any Parameter and Bit

It is possible to assign the digital inputs/outputs of the optional module MD1 to any drive parameter.

To do this, the following steps are required:

- Configuration of
  - P-0-0681 = [S-0-0144] → [S-0-0144] → P-0-0081
  - P-0-0682 = [S-0-0145] → [P-0-0082] → S-0-0145

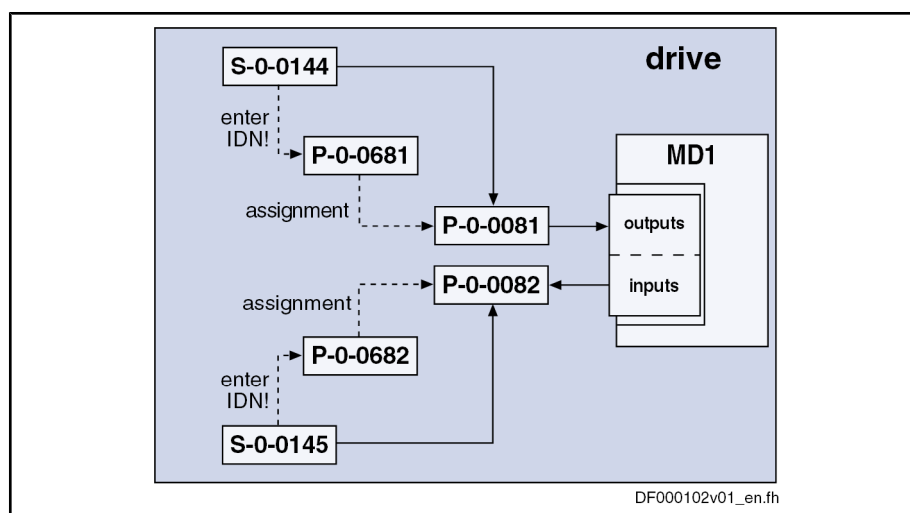
The contents of the parameters P-0-0081 and P-0-0082 are thereby mapped to the parameters S-0-0144 and S-0-0145.
- Configuration of the desired parameters and bits for the digital inputs/outputs by means of the mechanism of the freely configurable signal control word and signal status word (see also Parameter Description for "S-0-0145, Signal control word" and "S-0-0144, Signal status word")
- Configuration of parameter S-0-0144 via S-0-0026 and S-0-0328 (see also "S-0-0398, IDN-list of configurable data in signal status word")
- Configuration of parameter S-0-0145 via S-0-0027 and S-0-0329 (see also "S-0-0399, IDN-list of configurable data in signal control word")



If the parameters "S-0-0144, Signal status word" or "S-0-0145, Signal control word" are used for configuring the digital inputs/outputs of the optional module MD1, they can no longer be used for master communication (as cyclic data).

The figure below illustrates the access to any drive parameter via the digital inputs/outputs of the optional module MD1:

## Optional Device Functions



S-0-0144	Signal status word
S-0-0145	Signal control word
P-0-0081	Parallel output 1
P-0-0082	Parallel input 1
P-0-0681	Assignment IDN -> parallel output 1
P-0-0682	Assignment parallel input 1 -> IDN

Fig. 9-49: Access to Any Drive Parameter via Digital Inputs/Outputs of the Optional Module MD1



For the digital inputs/outputs of the optional module MD1 there is no default configuration.

See documentation "Control Sections for Drive Controllers; Project Planning Manual"

## Direct Access to Inputs/Outputs of Module MD1 via Drive-Integrated PLC

In order to transmit data directly from the drive-integrated PLC (IndraMotion MLD) to the digital inputs/outputs, the respective assignments to the drive-integrated PLC have to be made via "P-0-0681, Assignment IDN -> parallel output 1" and "P-0-0682, Assignment parallel input 1 -> IDN":

- **Inputs** (cf. P-0-1390 to P-0-1397)
- **Outputs** (cf. P-0-1410 to P-0-1417)
- **Registers** (cf. P-0-1370 to P-0-1385)



P-0-0081 and P-0-0082 are used as mere display parameters that are mapping the status of the digital inputs/outputs on the optional module MD1.

### Example of Application (PLC Uses Inputs of MD1)

The digital inputs of the optional module MD1 are to be used as PLC inputs. This requires the following configuration:

- Assign "P-0-0082, Parallel input 1" to parameter "P-0-1390, PLC input WORD0 AT %IB0" by making the following entry in parameter P-0-0682  
→ [P-0-0682] = "P-0-1390"



An internal parameter may only be assigned via "P-0-0681, Assignment IDN -> parallel output 1", if "P-0-0081, Parallel output 1" is not written via a 1st class master communication (e.g. SERCOS).

## Configuration of Digital Inputs/Outputs for Integrated Safety Technology

In order to use the digital inputs/outputs for the safety technology integrated in the drive, the corresponding assignments have to be made via the parameters P-0-0681 and P-0-0682:

- **Inputs** (e.g. "P-0-3212, Safety technology control word, channel 1")
- **Outputs** (e.g. "P-0-3214, Safety technology status word, channel 1")

## 9.4.4 Diagnostic and Status Messages

### Digital Inputs/Outputs on Control Section

- Status of Digital Inputs/Outputs** The status (= signal status) of the digital inputs/outputs is displayed in the parameters "P-0-0303, Digital I/Os, inputs" and "P-0-0304, Digital I/Os, outputs":
- Bit set ("1")
    - At the assigned input/output, a HIGH level (+24 V) is provided or the Rel1 contact is closed.
  - Bit not set ("0")
    - At the assigned input/output, a LOW level (0 V) is provided or the Rel1 contact is opened.

- Check for Invalid Bit Numbers** When entering data in parameter "P-0-0301, Digital I/Os, bit numbers", a check is run to find out whether the indicated bit number is a valid bit of the parameter (IDN) configured in parameter P-0-0300.

The following applies:

- **2-byte** parameter → bit numbers between **0 and 15** allowed
- **4-byte** parameter → bit numbers between **0 and 31** allowed



In the case of invalid inputs or inputs/outputs that haven't been configured yet, "-1" is displayed as bit number.

- Checks in Transition Command** The following monitoring functions are used for guaranteeing an efficient configuration of the digital inputs/outputs and preventing invalid configurations:
- If the limit switch function (Limit+/-) was activated in P-0-0090 (bit 1) but not assigned to any digital input via P-0-0300, the error message "C0246 Trav. range lim. switch not ass. to dig. input" will appear when progressing to the operating mode. This message is output to avoid moving the drive without configured limit switch function.
  - For double axis devices the digital inputs/outputs basically can be assigned to both axes. This is the reason why an input or output is sometimes configured for both axes. In this case, the error message "C0247 Dig. output already assigned to other axis" will be displayed.
  - Monitoring and possibly error message "C0248 Dig. input assigned differently to axes"
  - If the bit number entered in P-0-0301 is too large, the error message "C0249 Dig. I/Os: Bit number too large" will appear.

### Digital Inputs/Outputs on Optional Module MD1

- Status of Digital Inputs/Outputs** The status of the digital inputs/outputs on the optional module MD1 is displayed in the following parameters:
- P-0-0081, Parallel output 1
    - Contains the information regarding the digital output bits
  - P-0-0082, Parallel input 1

Optional Device Functions

→ Contains the information regarding the digital input bits

The following applies to these parameters:

- Bit set ("1")
  - At the assigned input/output, a HIGH level (+24 V) is provided.
- Bit not set ("0")
  - At the assigned input/output, a LOW level (0 V) is provided.



There is no additional configuration check, as the restriction of the IDN selection lists already prevents invalid configurations.

## 9.5 Analog Inputs

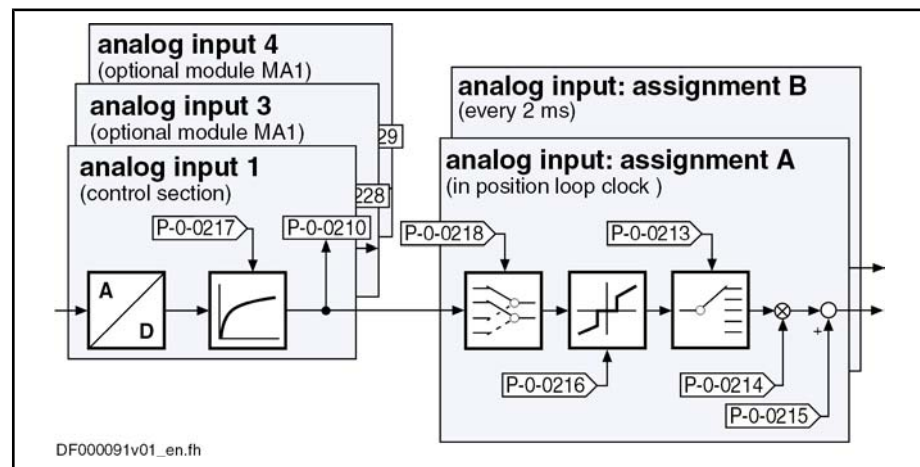
### 9.5.1 Brief Description



Assignment to functional firmware package, see chapter "Availability of the Optional Device Functions".

**Overview**

According to the control section type, IndraDrive controllers already have analog inputs in their basic configuration (without optional modules). Configurable control sections can be upgraded with this function by using the optional module MA1. Double-axis control section can alternatively also be equipped with an extension for analog master communication, if the control section is operated as analog device (control section configuration CDB01.xC-AN...). The number and function of the analog outputs differ according to the type and configuration of control section (see "Hardware Requirements" below).



- P-0-0210 Analog input 1
- P-0-0213 Analog input, assignment A, target parameter
- P-0-0214 Analog input, assignment A, scaling per 10V full scale
- P-0-0215 Analog input, assignment A, signal value at 0V
- P-0-0216 Analog input, assignment A, dead zone
- P-0-0217 Analog input 1, time constant input filter
- P-0-0218 Analog input, control parameter

Fig.9-50: Overview: Analog Inputs and Their Assignments (Example of Control Section CSH01.1C)

**Features**

**General features:**

- 2 assignment mechanisms for analog inputs (assignment A or B)
- Different sampling rates of assignments A and B

## Optional Device Functions

- Assignment channel A works in position loop clock (see "Performance Data")
- Assignment channel B works in 2-ms clock
- Assignment to command value/limit value/control parameters of the drive by means of adjustable scaling
- Possible assignment of max. 2 analog inputs to internal drive parameters
- Variable scaling for 2 analog channels
- Dead zone to be entered for suppressing the zero drift for both analog channels
- Offset and amplification adjust for both analog channels via command

**Features of analog inputs at control section:**

- Number and resolution of analog inputs depend on control section design:
  - ADVANCED → 1 analog input with resolution of 14 bits (by means of 8-fold oversampling for both analog channels)
  - BASIC OPENLOOP and BASIC ANALOG → each have 2 analog inputs with 12 bits (other Basic variants do not have any analog inputs)
  - BASIC UNIVERSAL double-axis → 1 analog input with resolution of 14 bits (by means of 8-fold oversampling for both analog channels) for both axes in common. The input can, however, be used by both axes at the same time!
- Low-pass filtering to be activated for both analog channels
- Analog inputs designed as differential input
- Input voltage range of  $\pm 10$  V

**Features of analog inputs on optional module MA1:**

The optional module MA1 was developed according to VDE 0411-part 500 (programmable logic controllers) and should be used according to the specifications contained in this standard.

Properties of the analog inputs on the optional module MA1:

- Connection via 15-pin D-Sub connector
- 2 analog inputs with resolution of 14 bits (by means of 8-fold oversampling for both analog channels)
- Low-pass filtering to be activated for both analog channels
- Analog inputs designed as differential input
- Input voltage range of  $\pm 10$  V

**Features of analog inputs at optional module AN:**

- 4 analog inputs with resolution of 14 bits (by means of 8-fold oversampling for all analog channels)
- Low-pass filtering to be activated for both analog channels
- Analog inputs designed as differential input
- Input voltage range of  $\pm 10$  V
- Connection via 12-pole terminal board by Phoenix

**Hardware Requirements**

The table below shows the hardware requirements of the analog inputs and their assignment to the connection points (terminal connectors) of the control section (on basic circuit board, at optional module MA1 or at optional module AN).

## Optional Device Functions

Control section type	Analog input no.					
	1	2	3	4	5	6
	... to be found ...					
	On basic circuit board		Optional module MA1			
CSH01.xC,	X32 (4/5)	--	Optional slot 2 X8 (2/9)	Optional slot 2 X8 (4/11)	--	--
	X32 (4/5)	--	Optional slot 3 X10 (2/9)	Optional slot 3 X10 (4/11)	--	--
CSB01.xC	--	--	Optional slot 2 X8 (2/9)	Optional slot 2 X8 (4/11)	--	--
CDB01.xC	X32 (4/5)	--	Optional slot 3 X8.1 (2/9)	Optional slot 3 X8.1 (4/11)	--	--
	X32 (4/5)	--	Optional slot 4 X8.2 (2/9)	Optional slot 4 X8.2 (4/11)	--	--
	X32 (4/5)	--	Optional slot 3 X8.1 (2/9)	Optional slot 3 X8.1 (4/11)	Optional slot 4 X8.2 (2/9)	Optional slot 4 X8.2 (4/11)
CSB01.xN-AN	X32 (4/5)	X32 (1/2)	Control section type cannot be configured			
CSB01.xN-SE	--	--				
CSB01.xN-PB	--	--				
CSB01.xN-FC	X32 (4/5) <sup>1)</sup>	X32 (1/2) <sup>1)</sup>				
	X36 (1/2) <sup>2)</sup>	X36 (2/3) <sup>2)</sup>				
	On basic circuit board		Optional module AN			
CDB01.xC-AN	X32 (4/5)	--	X39 (1/2)	X39 (4/5)	X39 (7/8)	X39 (10/11)

1) For voltage signals (selected via bit 12 in P-0-0218)

2) For current signals (selected via bit 12 in P-0-0218)

Fig. 9-51: Overview of Hardware Requirements of Analog Inputs (Incl. Assignment of Connection Points)



See also section "Optional Module MA1" In the documentation "Control Sections for Drive Controllers; Project Planning Manual"

## Pertinent Parameters

## Configuring the analog inputs:

- P-0-0212, Analog input, list of assignable parameters
- P-0-0218, Analog input, control parameter
- P-0-0219, Analog input, maximum value for adjustment
- P-0-0220, C2800 Analog input adjustment command
- P-0-3901, Adjustment values of control section
- P-0-3904, Adjustment values analog I/O interface 3-4
- P-0-3905, Adjustment values analog I/O interface 5-6
- P-0-3906, Adjustment values analog inputs interface 3-6

## Analog input values:



- P-0-0210, Analog input 1
- P-0-0211, Analog input 2
- P-0-0228, Analog input 3
- P-0-0229, Analog input 4
- P-0-0208, Analog input 5
- P-0-0209, Analog input 6
- P-0-0217, Analog input 1, time constant input filter
- P-0-0231, Analog input 2, time constant input filter
- P-0-0232, Analog input 3, time constant input filter
- P-0-0233, Analog input 4, time constant input filter
- P-0-0234, Analog input 5, time constant input filter
- P-0-0235, Analog input 6, time constant input filter

**Assignment A:**

- P-0-0213, Analog input, assignment A, target parameter
- P-0-0214, Analog input, assignment A, scaling per 10V full scale
- P-0-0215, Analog input, assignment A, signal value at 0V
- P-0-0216, Analog input, assignment A, dead zone

**Assignment B:**

- P-0-0236, Analog input, assignment B, target parameter
- P-0-0237, Analog input, assignment B, scaling per 10V full scale
- P-0-0238, Analog input, assignment B, signal value at 0V
- P-0-0239, Analog input, assignment B, dead zone

**Pertinent Diagnostic Messages**

- C2800Analog input adjustment command
- C2801Analog input not configured
- C2802Oscillations of input signal outside tolerance range
- C2803Measured values at zero point and max. value identical
- C2804Automatic adjustment failed

Optional Device Functions

## 9.5.2 Functional Description

### Reading and Assigning an Analog Input

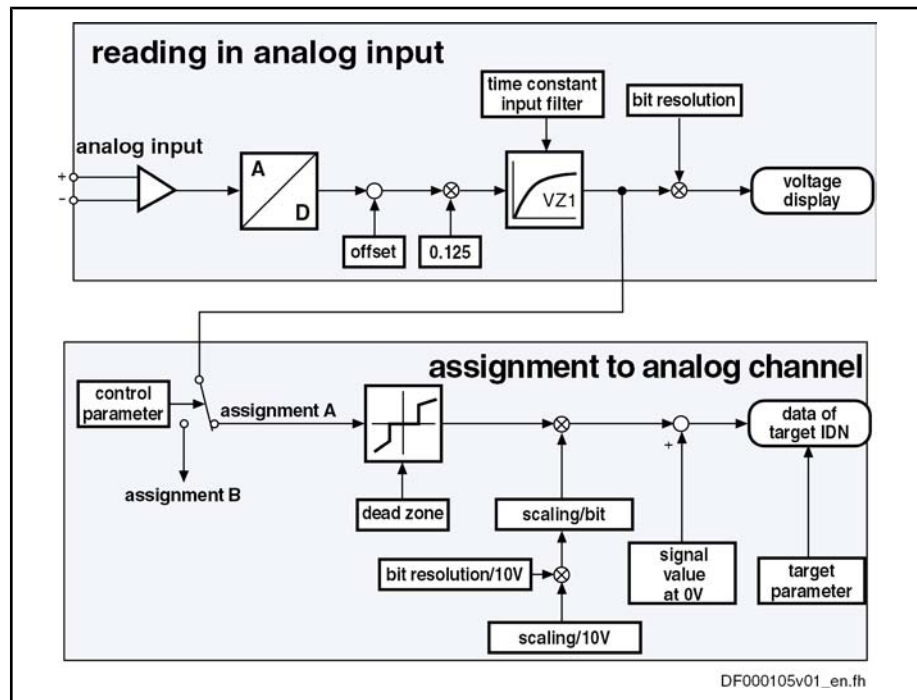


Fig.9-52: Overview of Functions: Reading and Assigning an Analog Input

### Sampling and Signal Adjustment of Analog Inputs

**Sampling** The analog input signals (a maximum of 5 analog inputs can be used) are sampled with 8-fold oversampling in the position loop clock (see "Performance Data").

**Filtering** All sampled analog input signals can be smoothed by a PT1 filter. The following parameters are available to set the respective filter:

- P-0-0217, Analog input 1, time constant input filter
- P-0-0231, Analog input 2, time constant input filter
- P-0-0232, Analog input 3, time constant input filter
- P-0-0233, Analog input 4, time constant input filter
- P-0-0234, Analog input 5, time constant input filter
- P-0-0235, Analog input 6, time constant input filter

When the filter has been activated, its limit frequency results from the following relationship:

$$f_g = \frac{1000}{2\pi \times T}$$

$f_g$  Limit frequency (in Hz)

$T$  Time constant (in ms)

Fig.9-53: Limit Frequency of the Activated Filter

#### Voltage Display of Analog Inputs

The sampled and possibly smoothed voltage (14-bit resolution) of the analog inputs channels is displayed in the following parameters:

- P-0-0210, Analog input 1
- P-0-0211, Analog input 2
- P-0-0228, Analog input 3
- P-0-0229, Analog input 4
- P-0-0208, Analog input 5
- P-0-0209, Analog input 6



These parameters can be, for example, transmitted to the higher-level master or directly processed in the drive-integrated PLC (IndraMotion MLD).

---

#### Factory-Provided Adjustment

During the adjustment of the control module or the optional modules MA1 or AN at the factory, the adjustment values for offset and amplification of the analog inputs are stored in the following parameters:

- P-0-3901, Adjustment values of control section
- P-0-3904, Adjustment values analog I/O interface 3-4
- P-0-3905, Adjustment values analog I/O interface 5-6
- P-0-3906, Adjustment values analog inputs interface 3-6

### Internal Processing of Analog Input Values

Via two assignment mechanisms, the analog input values can be assigned to internal drive parameters.

#### Assignment of Analog Inputs

The assignment of an analog input to an internal channel (assignment A or B) takes place via parameter "P-0-0218, Analog input, control parameter".

- Bits 4 to 7 → assignment of an analog input for assignment A
- Bits 8 to 11 → assignment of an analog input for assignment B

See also "Notes on Commissioning" in the same section



See also Parameter Description "P-0-0218, Analog input, control parameter"

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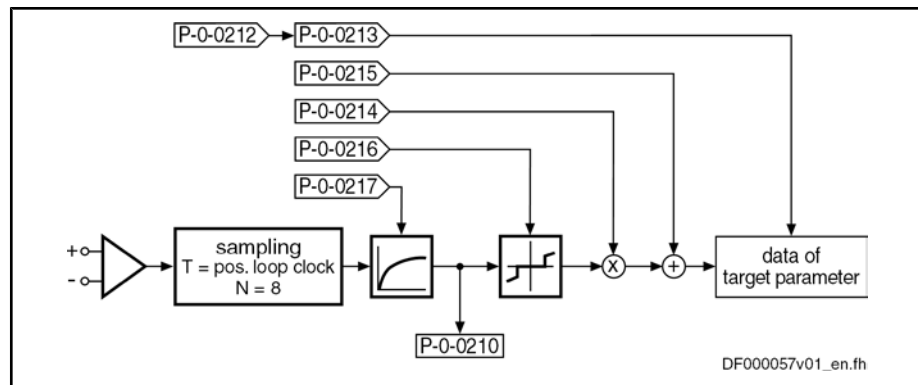


It is therefore only possible to assign a maximum of 2 analog inputs to internal drive parameters (assignment A or B). All other analog inputs can then only be used for direct access via the master communication or the drive-integrated PLC (IndraMotion MLD) (e.g. reading the voltage levels).

---

The assignment channels to internal parameters available in the drive basically have the same functionality. That is why we will only describe assignment channel A. The description of assignment channel B corresponds to that of assignment channel A.

Optional Device Functions



- P-0-0210 Analog input 1
- P-0-0212 Analog input, list of assignable parameters
- P-0-0213 Analog input, assignment A, target parameter
- P-0-0214 Analog input, assignment A, scaling per 10V full scale
- P-0-0215 Analog input, assignment A, signal value at 0V
- P-0-0216 Analog input, assignment A, dead zone
- P-0-0217 Analog input 1, time constant input filter

Fig.9-54: Functional Principle of Analog Input (Example for Assignment A)

**Processing Clock for Analog Input Values**

The processing of the analog input values in the two channels (assignment A or B) only differs in the cycle time:

- **Assignment A**  
→ The **position loop clock** is used (see "Performance Data")
- **Assignment B**  
→ A clock of **T = 2 ms** is used

**Controlling the Internal Processing**

Settings in parameter "P-0-0218, Analog input, control parameter" control the internal processing functions (adjustment and assignment):

- Bit 0 → Defining the adjustment mode (for "C2800 Analog input adjustment command")
- Bit 1 → Defining the assignment channel for the adjustment (for "C2800 Analog input adjustment command")
- Bits 4...7 → assignment of the analog inputs for assignment channel A
- Bits 8...11 → assignment of the analog inputs for assignment channel B

**Automatic Scaling (or Zero Point Shifting)**

Apart from manual adjust or scaling of the analog inputs (assignment A or B), it is also possible to adjust them automatically by activating the command "C2800 Analog input adjustment command".

In the case of automatic scaling, the parameters P-0-0214 and P-0-0215 or P-0-0237 and P-0-0238 are written by the drive.



The analog channels are already adjusted at the factory and the correction values are stored in the parameters P-0-3901, P-0-3904 and P-0-3905.

**Zero Point Shifting**

The zero point for processing the analog input value can be automatically shifted by activating command C2800 which allows compensating a possibly existing offset.

The following settings can be made in "P-0-0218, Analog input, control parameter":

- Bit 0 → defines the step of adjust ("0" → zero point shifting)

- Bit 1 → defines the assignment channel for the adjustment (A or B)

The result of automatic zero point shifting is directly entered in

- P-0-0215, Analog input, assignment A, signal value at 0V
- or -

- P-0-0238, Analog input, assignment B, signal value at 0V.

In addition, it is possible to define the reference point manually. To do this, enter the value, that is to be contained in the target parameter with an analog input voltage of 0 V, in P-0-0215 or P-0-0238.



Unit, decimal places and data type of the value in P-0-0215 or P-0-0238 depend on the target parameter selected in "P-0-0213, Analog input, assignment A, target parameter".

### Scaling

For scaling the analog input value to the desired range of values it is possible to use the automatic amplification adjust. To do this, command C2800 is started. With scaling, however, there are different starting conditions (cf. P-0-0218 and P-0-0219) and the following parameters are relevant:

- P-0-0218, Analog input, control parameter
  - Bit 0 → defines the step of adjust (bit 0 = 1 → amplification adjust)
  - Bit 1 → defines the assignment channel for the adjustment (A or B)

- P-0-0219, Analog input, maximum value for adjustment

This parameter indicates the value to which the analog input is set when the amplification adjust (P-0-0218, bit 0 = 1) is carried out.

The result of automatic amplification adjust is directly entered in parameter

- P-0-0214, Analog input, assignment A, scaling per 10V full scale
- or -
- P-0-0237, Analog input, assignment B, scaling per 10V full scale.

In addition, it is possible to define the scaling manually. To do this, enter a value, that corresponds to an analog input voltage difference of 10 V in the target parameter (→ pitch), in P-0-0214 or P-0-0237.



Unit, decimal places and data type of the value in P-0-0215 or P-0-0238 depend on the target parameter selected in "P-0-0213, Analog input, assignment A, target parameter".

### Parameterizable "Dead Zone"

"Stabilize" the analog signal in the zero range it is possible to parameterize a so-called "dead zone":

- P-0-0216, Analog input, assignment A, dead zone
- P-0-0239, Analog input, assignment B, dead zone



Parameterizing a "dead zone" is useful mainly for noisy analog values!

## Assignment to Internal Drive Parameters

### Assigning Analog Inputs to Parameters

The analog input values are stored in the parameters below for display and internal value processing (depending on the design of the control section, not all parameters are always available):

- P-0-0210, Analog input 1
- P-0-0211, Analog input 2

## Optional Device Functions

- P-0-0228, Analog input 3
- P-0-0229, Analog input 4
- P-0-0208, Analog input 5
- P-0-0209, Analog input 6

By the assignment mechanisms via the parameters P-0-0213 (assignment A) and P-0-0236 (assignment B), it is possible to assign two analog input values (cf. P-0-0210, P-0-0228 or P-0-0229) to other drive parameters and thereby process them cyclically (cf. "P-0-0212, Analog input, list of assignable parameters").

**Parameters to be Assigned**

Only parameters which are contained in the list parameter "P-0-0212, Analog input, list of assignable parameters" can be assigned.

**Configuring the Analog Input**

The assignment of an analog input to a parameter is activated when a value unequal "S-0-0000" (S-0-0000 corresponding to "Off") was parameterized in parameter P-0-0213 or P-0-0236.

## 9.5.3 Notes on Commissioning

### Carrying Out the Automatic Scaling (or Adjust)

Automatic adjustment takes place in 2 steps that have to be carried out one after the other in order to achieve reliable execution of the function.

1. **Zero point shifting**

(or reference point shifting, because reference is not obligatorily established to  $U_e = 0$  V)

2. **Amplification or amplitude scaling**

There is only one command for both assignment channels. In "P-0-0218, Analog input, control parameter" (bit 1), you have to define which channel is adjusted:

- Bit 1 = 0 → scaling of assignment channel A
- Bit 1 = 1 → scaling of assignment channel B

### Configuration and Assignment to Drive Parameters

**Assignment to Internal Channel  
(Assignment A or B)**

The assignment of an analog input to an internal analog channel (assignment A or B) takes place via parameter "P-0-0218, Analog input, control parameter":

- Bits 4 to 7 → selection of an analog input for assignment A
- Bits 8 to 11 → selection of an analog input for assignment B



See also Parameter Description "P-0-0218, Analog input, control parameter"

**Assignment to Drive Parameters**

By means of the assignment mechanism (assignment A or B), it is possible to assign the analog input values to drive parameters. Assignment of the target parameters takes place in the following parameters:

- P-0-0213, Analog input, assignment A, target parameter
- P-0-0236, Analog input, assignment B, target parameter



Assignment of the target parameters must be completed before the evaluation and the signal values for 0V can be carried out in the parameters P-0-0214, P-0-0215, P-0-0237 and P-0-0238 (for assignment A and B).

## Possibilities of Access via Master Communication and IndraMotion MLD

The analog input values of the analog inputs are stored in the parameters below for display and internal value processing (depending on the design of the control section, not all parameters are always available):

- P-0-0210, Analog input 1
- P-0-0211, Analog input 2
- P-0-0228, Analog input 3
- P-0-0229, Analog input 4
- P-0-0208, Analog input 5
- P-0-0209, Analog input 6

It is therefore possible to configure these digitized analog values into the cyclic telegram of the master communication (cf. S-0-0016 or P-0-4081) or to access one of the above parameters directly from a PLC program.

### Specific Features of Double-Axis Design (MPD)

Each analog input (1 and, if required, 3 to 6) can be used without restrictions by both axes of a double axis.

The evaluation and interpretation of the input voltage depends on how the individual axes have been parameterized (cf. assignment A and B).



The parameters P-0-0210 to P-0-0239 are available separately for each axis. The parameters P-0-3901, P-0-3904, P-0-3905 and P-0-3906 are only available once per device!

---

## 9.5.4 Diagnostic and Status Messages

As regards the "analog inputs" function, the following diagnostic command messages can occur:

- C2800Analog input adjustment command
- C2801Analog input not configured
- C2802Oscillations of input signal outside tolerance range
- C2803Measured values at zero point and max. value identical
- C2804Automatic adjustment failed



See descriptions of these diagnostic messages in the separate documentation "Troubleshooting Guide" (description of diagnostic messages)

## 9.6 Analog Outputs

### 9.6.1 Brief Description



Assignment to functional firmware package, see chapter "Availability of the Optional Device Functions".

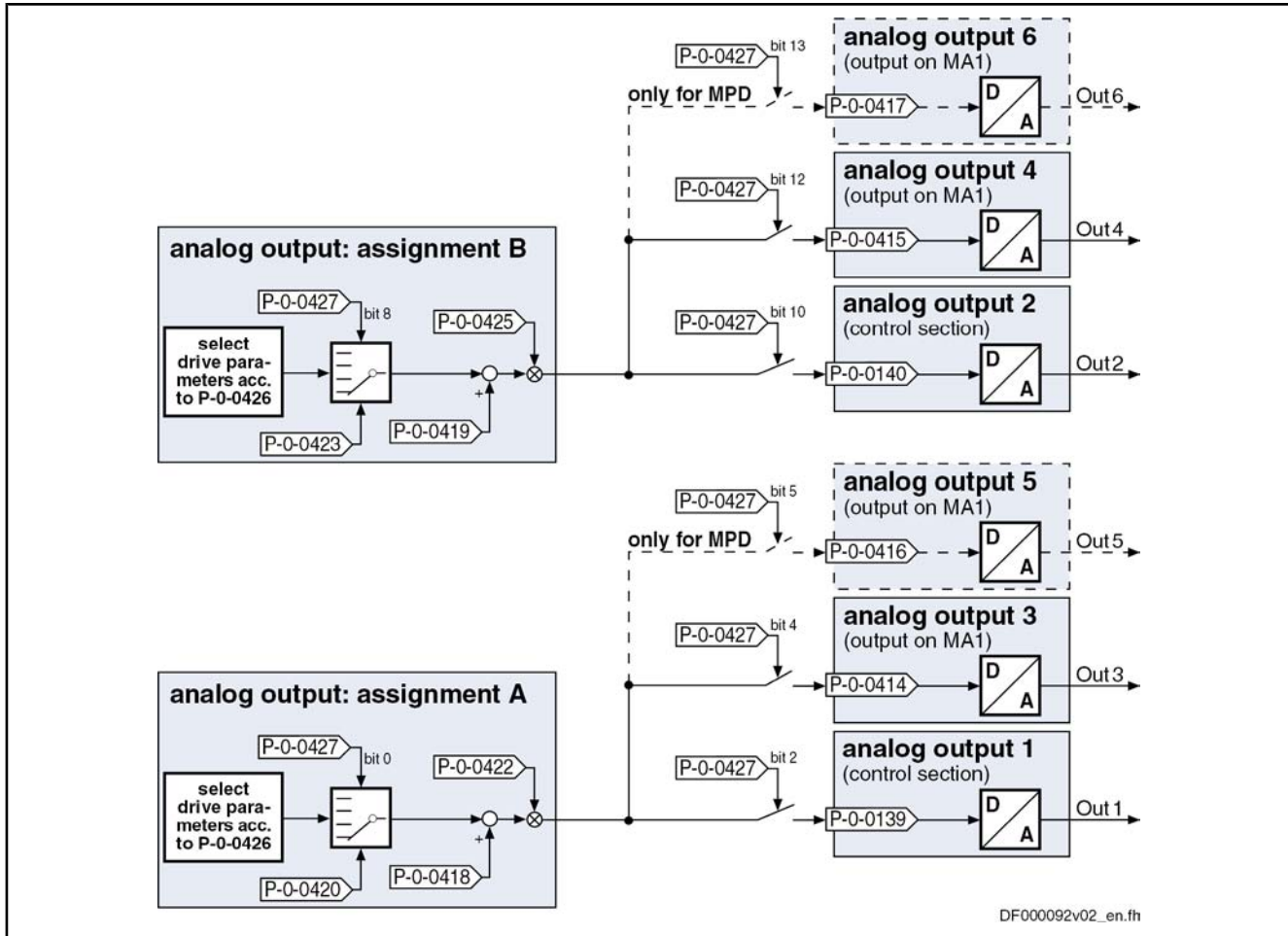
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#### Overview

According to the control section type, IndraDrive controllers already have analog outputs in their basic configuration (without optional modules). Configurable control sections can be upgraded with this function by using the optional module MA1. The number and function of the analog outputs differ according to the type and configuration of control section (see "Hardware Requirements" below).

Optional Device Functions

The figure below illustrates the interaction of the two analog output channels with the analog outputs.



MA1 Optional module MA1 (analog I/O extension)  
 Fig.9-55: Assignment Mechanism for the Analog Outputs

The drive function "analog outputs" allows using analog signal values for commissioning and optimizing drives with appropriate measuring devices (e.g. oscilloscope, multimeter), as well as for visualizing the contents of drive parameters.

Features

General features:

- Number and characteristics of analog outputs depending on type and configuration (with/without optional module MA1) of the control section
- Up to 6 analog outputs available according to control section design
- Update of analog outputs in velocity loop clock (see "Performance Data")
- Analog outputs can be written via master communication (cyclic or acyclic channel)
- Internal status variables and signals (= parameter contents) are output as analog voltage signals at output terminal connectors of the drive controller (see separate documentation "Drive Controllers, Control Sections; Project Planning Manual")
- Monitoring function with regard to double assignment of outputs
- Variable scaling of analog outputs



Optional Device Functions

- Switching of the behavior at the limits of voltage range that can be displayed between overflow and limitation
- Parameterizable output offset or parameterizable reference value

**Features of analog outputs at control section:**

- Number and resolution of analog outputs depend on control section design:
  - ADVANCED → 2 analog outputs with 8 bits
  - BASIC UNIVERSAL double-axis → 2 analog outputs with 8 bits
  - BASIC OPENLOOP → 2 analog outputs with 10 bits
- Output voltage range: 0 to 5 V  
(for BASIC OPENLOOP → 0 to 10V)
- Available quantization: 19.5 mV (= 5V/2<sup>8</sup>)

**Features of analog outputs at optional module MA1:**

The optional module MA1 was developed according to VDE 0411-part 500 (programmable logic controllers) and should be used according to the specifications contained in this standard.

Properties of analog outputs at optional module MA1:

- Connection via 15-pin D-Sub connector
- 2 analog outputs with 12 bits each
- Output voltage range: ±10V with reference to 0VA
- Available quantization: 5mV (= 10V/2<sup>11</sup>)

**Hardware Requirements**

The table below shows the hardware requirements of the analog outputs and their assignment to the connection points (terminal connectors) of the control section (on basic circuit board or at optional module MA1).

Control section type	Analog output no.					
	1	2	3	4	5	6
	... to be found ...					
	On basic circuit board		Optional module MA1			
CSH01.1C, CSH01.2C	X32 (1)	X32 (2)	Optional slot 2 X8 (5)	Optional slot 2 X8 (14)	--	--
	X32 (1)	X32 (2)	Optional slot 3 X10 (5)	Optional slot 3 X10 (14)	--	--
CSB01.1C	--	--	Optional slot 2 X8 (2/9)	Optional slot 2 X8 (4/11)	--	--
CDB01.1C	X32 (1)	X32 (2)	Optional slot 3 X8.1 (5)	Optional slot 3 X8.1 (14)	--	--
	X32 (1)	X32 (2)	Optional slot 4 X8.2 (5)	Optional slot 4 X8.2 (14)	--	--
	X32 (1)	X32 (2)	Optional slot 3 X8.1 (5)	Optional slot 3 X8.1 (14)	Optional slot 4 X8.2 (5)	Optional slot 4 X8.2 (14)

## Optional Device Functions

Control section type	Analog output no.					
	1	2	3	4	5	6
	... to be found ...					
	On basic circuit board		Optional module MA1			
CSB01.1N-AN	X32 (4/5)	X32 (1/2)	Control section type cannot be configured			
CSB01.1N-SE	--	--				
CSB01.1N-PB	--	--				
CSB01.1N-FC	X32 (9)	X35 (3)				

MA1 Optional module MA1 (analog I/O extension)

Fig. 9-56: Overview of Hardware Requirements of Analog Inputs (Incl. Assignment of Connection Points)



See also section "Optional Module MA1" in the documentation "Drive Controllers, Control Sections; Project Planning Manual"



In the case of double-axis devices (control section CDB01.1-...), the analog outputs are used by both axes, simultaneous use of an analog output by both axes is impossible.

## Pertinent Parameters

## Configuring the analog outputs:

- P-0-0426, Analog output IDN list of assignable parameters
- P-0-0427, Control parameter of analog output

## Analog output - assignment A:

- P-0-0418, Analog output, assignment A, signal value at 0V
- P-0-0420, Analog output, assignment A, signal selection
- P-0-0422, Analog output, assignment A, scaling [1/V]

## Analog output - assignment B:

- P-0-0419, Analog output, assignment B, signal value at 0V
- P-0-0423, Analog output, assignment B, signal selection
- P-0-0425, Analog output, assignment B, scaling [1/V]

## Analog output values:

- P-0-0139, Analog output 1
- P-0-0140, Analog output 2
- P-0-0414, Analog Output 3
- P-0-0415, Analog Output 4
- P-0-0416, Analog Output 5
- P-0-0417, Analog Output 6

## 9.6.2 Functional Description

### General Information

For assigning the signal sources for the analog outputs of the drive controller, it is basically possible to choose between two methods:

- Direct output of **voltage signals** independent of the drive (signals of control master or IndraMotion MLD)
  - Output parameters directly written via master communication or by IndraMotion MLD

- Output of the values of predefined **drive parameters** (contents of standard parameters of the drive)  
→ Free configuration of both analog channels A and B

For the selection of this signal source, there is the so-called "bit output" carried out for parameters with binary format; the content to be output in this case has to be determined by the bit number.

In addition, **extended output of internal storage locations** can be carried out under certain conditions.

#### Determining the Signal Source

The signal source is determined for each analog output in "P-0-0427, Control parameter of analog output".

### Direct Output of Voltage Signals



The selection of the signal source option "direct output of voltage signals" is the default setting for the analog outputs (basic parameter set). This setting can be changed or assigned again in "P-0-0427, Control parameter of analog output".

If this signal source has been assigned, the control master can use the drive as digital/analog converter. For this purpose, the parameters definitely assigned to the analog outputs can be directly written.

The following parameters used to display the output analog values are assigned to the individual analog outputs:

- P-0-0139, Analog output 1
- P-0-0140, Analog output 2
- P-0-0414, Analog Output 3
- P-0-0415, Analog Output 4
- P-0-0416, Analog Output 5
- P-0-0417, Analog Output 6

By writing data to the above parameters, the master can directly influence the analog signal to be output. For this purpose, the corresponding parameter is configured as cyclic data.

#### Behavior When Master Communication Fails

When cyclic communication fails, the value "0" is written to the parameters which causes 0 V to be output via the analog outputs.

### Output of Predefined Drive Parameters

#### List of Assignable Parameters

Values of drive parameters are output on the basis of a predefined selection list. "P-0-0426, Analog output IDN list of assignable parameters" contains all parameter IDNs of status variables and signals of the drive that can be output via analog outputs.

#### Assignment

The assignment is made by entering the IDN of the parameter in the respective signal selection parameter:

- P-0-0420, Analog output, assignment A, signal selection
- P-0-0423, Analog output, assignment B, signal selection



The parameters for "...assignment A..." act on the analog outputs 1, 3 and 5.

The parameters for "...assignment B..." act on the analog outputs 2, 4 and 6.

## Optional Device Functions

Via the parameters it is possible to determine, separately for each output channel, the reference definition (P-0-0418, P-0-0419) and the scaling (P-0-0422, P-0-0425) of the output values.

See also "Notes on Commissioning" in the same section

## Bit Output of Drive Parameters

Within the output of predefined drive parameters, the analog output of parameters in the binary format takes place as so-called "bit output".

The bit output allows outputting individual bits of a binary format parameter like, for example, parameter "S-0-0403, Position feedback value status".

Which bit of the respective parameter is to be output is determined in the following parameters:

- P-0-0422, Analog output, assignment A, scaling [1/V]
- P-0-0425, Analog output, assignment B, scaling [1/V]



The output voltage is 1V when the respective bit has been set; otherwise 0 V is output.

---

For bit output, the following parameters are not active:

- P-0-0418, Analog output, assignment A, signal value at 0V
- P-0-0419, Analog output, assignment B, signal value at 0V

## Extended Output of Internal Storage Locations

For diagnostic purposes, it is possible to extend the setting for the analog outputs, but using this setting requires knowledge of the structure of the drive firmware. Consequently, this function can only be used after approval by the drive development department.

See also "Extended Diagnostic Possibilities: Patch Function"

### 9.6.3 Notes on Commissioning

#### Sequence of Setting for Analog Outputs

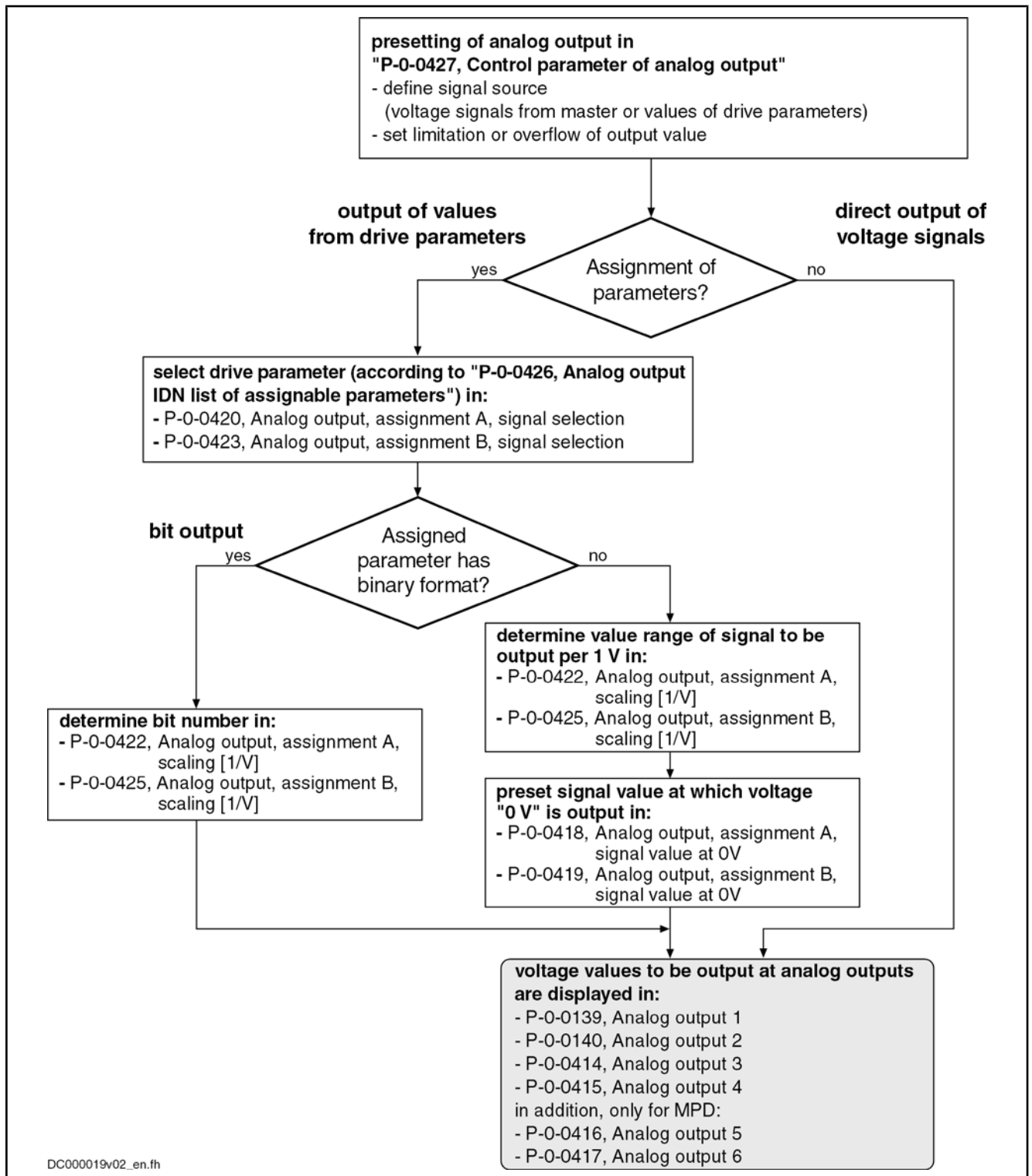


Fig.9-57: Commissioning the Analog Outputs

Optional Device Functions

### Signal Source for the Analog Outputs

For each of the possible analog outputs, the signal source for the voltage to be output can be determined:

- **Direct input of voltage signals** in the parameters P-0-0139, P-0-0140, P-0-0414, P-0-0415, P-0-0416 or P-0-0417
- or -
- Values of drive parameters according to **assignment A or assignment B**



The signal source for the analog outputs is determined in "P-0-0427, Control parameter of analog output".

### Scaling and Reference Point

#### Scaling the Analog Outputs

The two analog output channels are scaled (range of values per V) in the following parameters:

- P-0-0422, Analog output, assignment A, scaling [1/V]
- P-0-0425, Analog output, assignment B, scaling [1/V]

#### Example of "Scaleable" Output

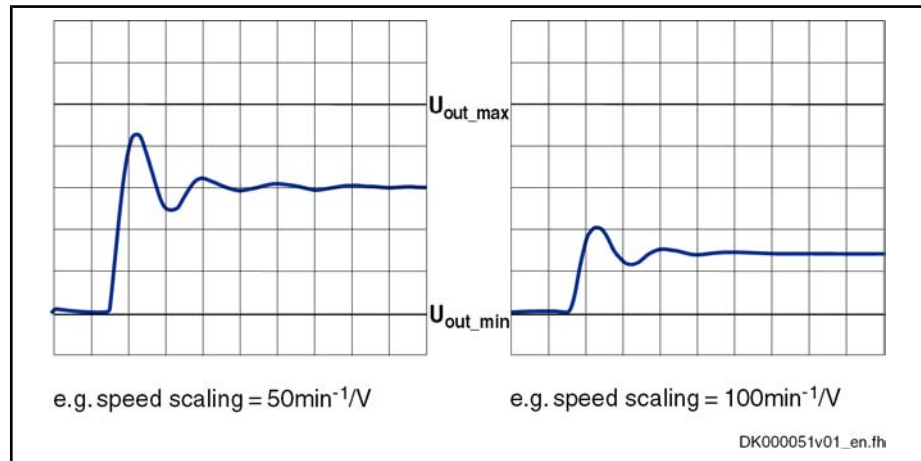


Fig.9-58: Example of Scaleable Analog Output

#### Reference Point

The reference of the analog outputs is defined (value at output of 0 V) in the following parameters:

- P-0-0418, Analog output, assignment A, signal value at 0V
- P-0-0419, Analog output, assignment B, signal value at 0V



The parameters for "...assignment A..." act on the analog outputs 1, 3 and 5.

The parameters for "...assignment B..." act on the analog outputs 2, 4 and 6.

Example of "Reference-Defined" Output for Analog Output 1 and 2

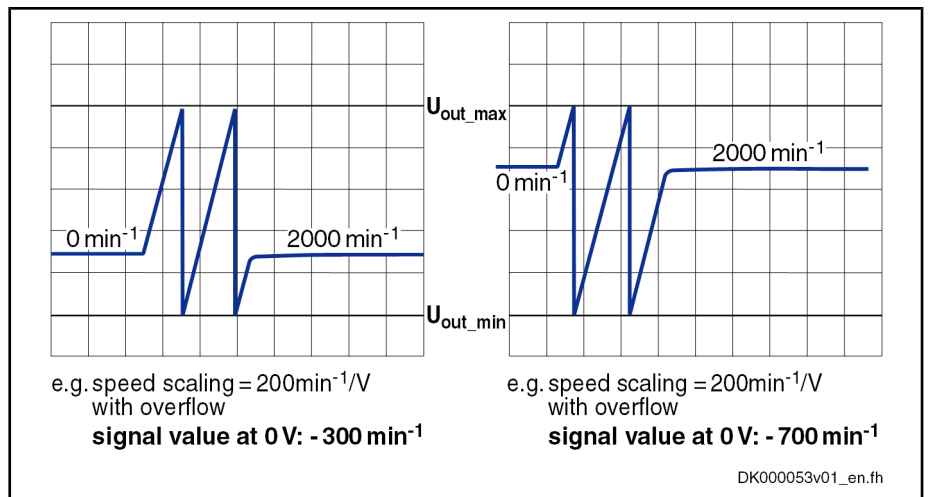


Fig.9-59: Example of Reference-Defined Analog Output

Determining the Overflow Behavior

Via "P-0-0427, Control parameter of analog output", it is possible to determine the output format of the analog outputs in the following ways:

- Limited or overflowing output due to the limited voltage range of the analog outputs
- Definable reference value for the output value

Example of "Limited" or "Overflowing" Output

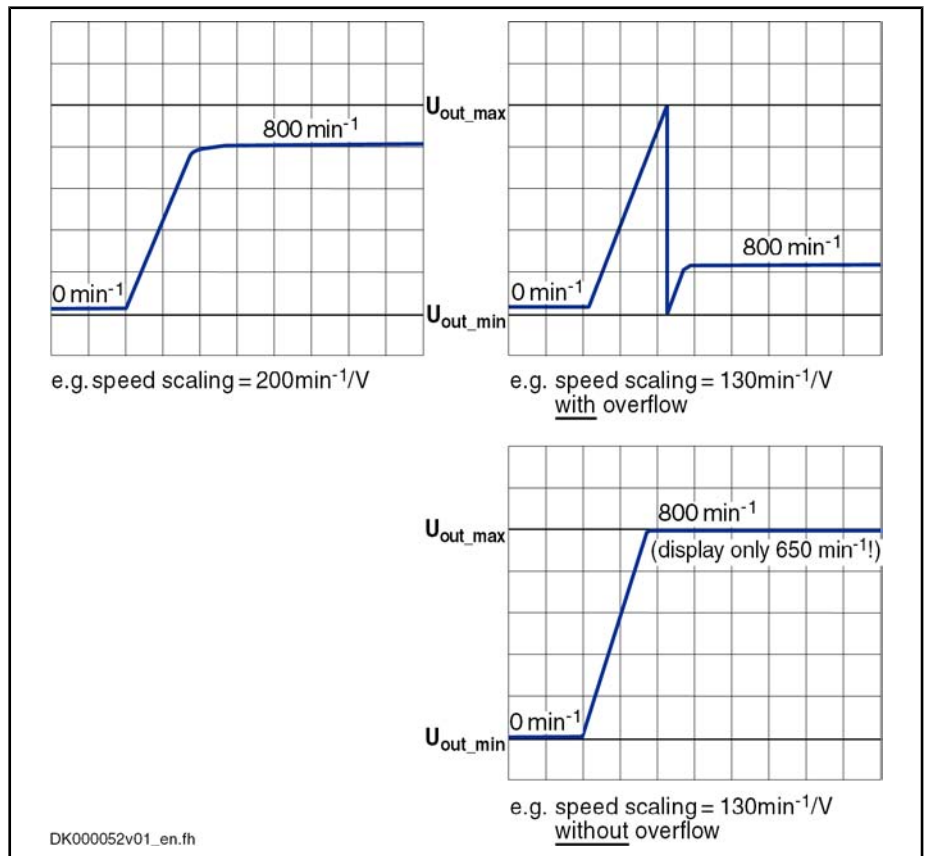


Fig.9-60: Example of Limited or "Overflowing" Analog Output

## Optional Device Functions



In the case of "overflowing" analog output, the assignment of a signal value to the output voltage is ambiguous due to the overflow!

The output of 0 V, for example, can be:

Signal value (at 0 V)  $\pm n \times$  output voltage range  $\times$  scaling (in 1/V)  
( $n = 1, 2, 3, \dots$ )

---

## 9.7 Virtual Master Axis Generator

### 9.7.1 Brief Description



Assignment to functional firmware package, see chapter "Availability of the Optional Device Functions".

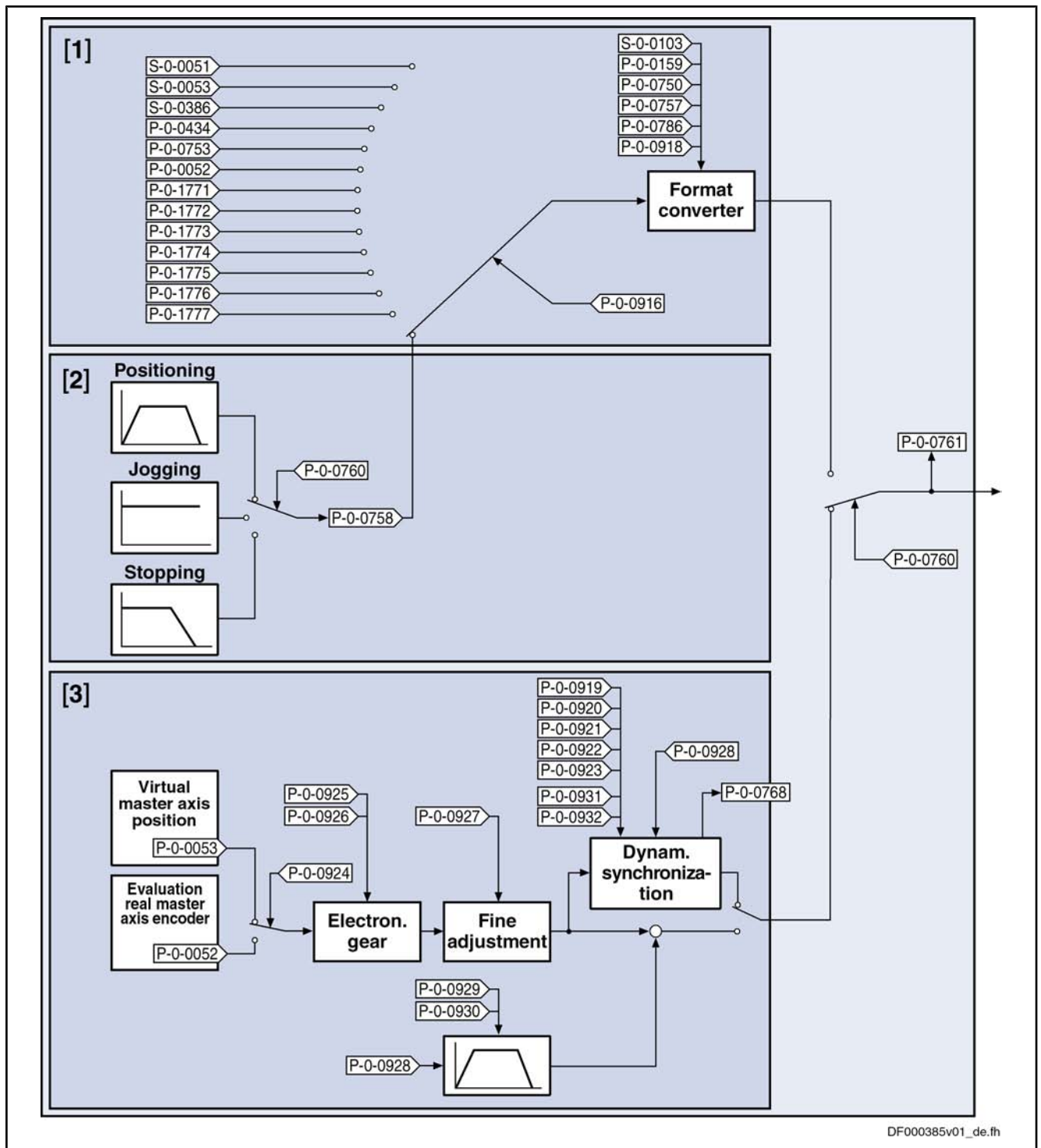
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The master axis generator serves for generating a master axis position, which is used as input variable for the position synchronization operation modes and the operation mode "velocity synchronization".

There are three ways of generating the master axis position:

- Format conversion of an actual position value or a command position value of the local axis or of an axis connected via CCD [1]
- Generating a virtual actual position value via a positioning motion and subsequent format conversion [2]
- Phase-synchronous motion of the master axis position to a primary master (secondary master mode) [3]





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Fig.9-61: Possibilities of Generating the Master Axis Position for the Slave Axis

**Features** Features of generating the virtual actual position value with the master axis generator:

- 2nd order command value interpolator with subsequent jerk limitation
- Absolute, relative and additive positioning capability
- "Infinite travel" (jogging) is possible

## Optional Device Functions

- Position data format to be set:
  - Linear → 0.0001 mm / 0.0001 inch
  - Rotary → 0.0001 degrees
- Modulo value to be set
- "Absolute" or "modulo" master axis
- Format conversion from position format "virtual master axis" to master axis format (modulo value "virtual master axis" →  $2^{P-0-0084} \times P-0-0750$ )
- Virtual master axis generator realized as virtual axis in IndraMotion MLD with individual scaling system
- Setting of virtual master axis generator, either directly via parameters or via the following function blocks:
  - MC\_MoveVelocity / MX\_MoveVelocity
  - MC\_MoveAbsolut / MX\_MoveAbsolut
  - MC\_MoveAdditiv / MX\_MoveAdditiv
  - MC\_MoveRelativ / MX\_MoveRelativ
  - MC\_Stop
  - MB\_Stop

**Note:**

The function blocks for the virtual axis must behave exactly like those for a real axis. The diagnostic and error messages, however, are different.

Features of the secondary master mode:

- Real and virtual primary master can be selected
- Electronic gear with fine adjust
- Dynamic synchronization to the primary master
- Additive master axis position can be changed as offset with parameterized acceleration and velocity
- Activating by means of the functional block "MB\_GearInPos"; deactivating by means of the functional block "MB\_GearOut"

**Pertinent Parameters**

- P-0-0756, Virtual master axis, scaling type
- P-0-0757, Virtual master axis, modulo value
- P-0-0758, Virtual master axis, actual position value
- P-0-0759, Virtual master axis, actual velocity value
- P-0-0760, Virtual master axis, positioning control word
- P-0-0761, Master axis position for slave axis
- P-0-0766, Virtual master axis, positioning command value
- P-0-0767, Virtual master axis, effective target position
- P-0-0768, Virtual master axis, positioning status
- P-0-0769, Virtual master axis, command value mode
- P-0-0770, Virtual master axis, positioning velocity
- P-0-0771, Virtual master axis, positioning acceleration
- P-0-0772, Virtual master axis, positioning deceleration
- P-0-0774, Virtual master axis, positioning window shortest distance
- P-0-0911, Virtual master axis, positioning window
- P-0-0912, Virtual master axis, standstill window

- P-0-0913, Virtual master axis, positioning jerk
- P-0-0914, Virtual master axis, velocity threshold positioning
- P-0-0917, Control word of master axis generator
- P-0-0919, Synchronization mode, secondary master
- P-0-0920, Synchronization acceleration, secondary master
- P-0-0921, Synchronization velocity, secondary master
- P-0-0922, Preferred synchronization direction, secondary master
- P-0-0923, Synchroniz. window for shortest distance, secondary master
- P-0-0924, Selection primary master
- P-0-0925, Master drive gear input revolutions, secondary master
- P-0-0926, Master drive gear output revolutions, secondary master
- P-0-0927, Master drive gear fine adjustment, secondary master
- P-0-0928, Additive master axis position, secondary master
- P-0-0929, Change velocity of add. master axis posit., secondary master
- P-0-0930, Change accel. of add. master axis posit., secondary master

#### Pertinent Diagnostic Messages

- E2100 Positioning velocity of master axis generator too high
- F2063 Internal overflow master axis generator
- F2064 Incorrect cmd value direction master axis generator

## 9.7.2 Functional Description

### Positioning Mode of Virtual Master Axis Generator

The virtual master axis generator is activated or deactivated via parameter "P-0-0917, Control word of master axis generator".

The figure below illustrates the functional principle of generating the virtual actual position value with the virtual master axis generator and the effect of the individual parameters.

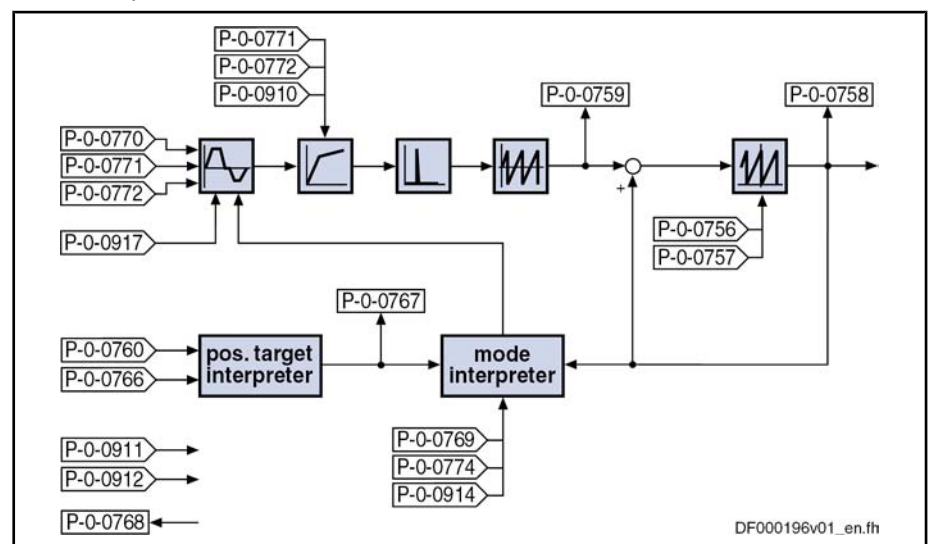


Fig. 9-62: Overview of Function "Virtual Master Axis Generator"

Positioning by means of the virtual master axis generator basically functions in the same way as for the positioning generator of the "drive-controlled positioning" mode (see description of the operating mode "Drive-Controlled Positioning").

## Optional Device Functions

Please note that the parameters which take effect for the virtual master axis generator are different from those for drive-controlled positioning (see comparative table below).

Name/significance of the parameter	Drive-controlled positioning	Virtual master axis generator
Positioning command value	S-0-0282	P-0-0766
Command value mode	S-0-0393	P-0-0769
Positioning velocity	S-0-0259	P-0-0770
Positioning acceleration	S-0-0260	P-0-0771
Positioning deceleration	S-0-0359	P-0-0772
Positioning control word	S-0-0346	P-0-0760
Positioning status	S-0-0437	P-0-0768
Positioning jerk	S-0-0193	P-0-0913
Positioning window shortest distance	S-0-0418	P-0-0774
Effective target position	S-0-0430	P-0-0767
Velocity threshold	S-0-0417	P-0-0914

Fig.9-63: Parameter Comparison

### Differences to operating mode "drive-controlled positioning"

#### "Jog" Mode

When the "jog" mode is activated, the following values are applied:

- Positioning command value
- Positioning velocity
- Positioning acceleration
- Positioning deceleration
- Positioning jerk

Afterwards, a new positioning velocity is immediately applied with active "jog" mode.

Via the toggle bit (P-0-0760, bit 0), new values for positioning acceleration, positioning deceleration and positioning jerk can be accepted. Acknowledgment of command value acceptance, if accepted via toggle bit, can be taken from parameter "P-0-0768, Virtual master axis, positioning status" (bit 1).

#### "Halt" Mode

When the "halt" mode is activated, the positioning deceleration and positioning jerk are accepted.

Via the toggle bit (P-0-0760, bit 0), new values for positioning deceleration and positioning jerk can be accepted. Acknowledgment of command value acceptance, if accepted via toggle bit, can be taken from parameter "P-0-0768, Virtual master axis, positioning status" (bit 1).

#### Processing Clock

The generator function of the master axis generator runs in a clock of 2 ms. The calculated values are fine interpolated in linear form with regard to the position loop clock.

#### Residual Path Processing

For the virtual master axis generator, there is no residual path processing available.

#### Intermediate Stop

The new position target is applied "on-the-fly" **without** the possibility of intermediate stop (positioning command value memory).



The conversion of the value of "P-0-0758, Virtual master axis, actual position value" to the master axis format ( $2^{P-0-0084}$  increments per master axis revolution) takes place by means of the master axis format converter. The converted value is displayed in parameter "P-0-0761, Master axis position for slave axis".

## Scaling System

**Features** The virtual master axis generator has its own scaling system with the following features:

- Position data format to be set:
  - Linear: 0.0001 mm / 0.0001 inch
  - Rotary: 0.0001 degrees
- Modulo value to be set
- Possible modulo ranges (0.0000 to 214748.3647)
- Fixed absolute range (-214748.3648 to 214748.3647)

**Scaling Parameters** There are the following scaling parameters for the virtual master axis generator:

- P-0-0756, Virtual master axis, scaling type
- P-0-0757, Virtual master axis, modulo value
- P-0-0758, Virtual master axis, actual position value
- P-0-0759, Virtual master axis, actual velocity value



When the master axis generator has been deactivated, the parameters "P-0-0758, Virtual master axis, actual position value" and "P-0-0759, Virtual master axis, actual velocity value" can be pre-initialized.

## Format Converter From Position Data Format to Master Axis Format

It is possible to generate the internal virtual master axis position "P-0-0761, Master axis position for slave axis" from different sources. The source signals are available in the position data format and have to be converted to the master axis format ( $2^{P-0-0084}$  increments per master axis revolution).



One master axis format converter and thus only one internal master axis is available per double-axis device. This master axis, however, can be used by both axes.

**Pertinent Parameters** The following parameters are relevant in conjunction with the format converter function:

- S-0-0103, Modulo value
- P-0-0084, Number of bits per master axis revolution
- P-0-0159, Slave drive feed travel
- P-0-0750, Master axis revolutions per master axis cycle
- P-0-0753, Position actual value in actual value cycle
- P-0-0757, Virtual master axis, modulo value
- P-0-0761, Master axis position for slave axis
- P-0-0786, Modulo value actual value cycle
- P-0-0915, Master axis format converter IDN list signal selection
- P-0-0916, Master axis format converter signal selection

## Optional Device Functions

**Pertinent Diagnostic Messages** • P-0-0918, Feed travel internal virtual master axis  
The following diagnostic message is relevant in conjunction with the format converter function:

- C0218 Double signal selection master axis format converter

**Signal Sources** The format converter can process the values of the following signal sources:

- S-0-0051, Position feedback value 1
- S-0-0053, Position feedback value 2
- S-0-0386, Active position feedback value
- P-0-0052, Actual position value of measuring encoder
- P-0-0434, Position command value of controller
- P-0-0753, Position actual value in actual value cycle
- P-0-0758, Virtual master axis, actual position value
- P-0-1270, PLC Global Register A0
- P-0-1271, PLC Global Register A1
- P-0-1272, PLC Global Register A2
- P-0-1273, PLC Global Register A3
- P-0-1274, PLC Global Register A4
- P-0-1275, PLC Global Register A5
- P-0-1276, PLC Global Register A6
- P-0-1277, PLC Global Register A7
- P-0-1771, CCD: Actual value data container 1, Slave 1 4Byte  
- to -  
P-0-1777, CCD: Actual value data container 1, Slave 7 4Byte

**Conversion** The master axis format converter is activated by selecting a parameter unequal S-0-0000 in parameter "P-0-0916, Master axis format converter signal selection"

The master axis format converter is deactivated, when the dummy parameter S-0-0000 is selected in parameter P-0-0916.

The following relations apply to the conversion of the actual position value format to the master axis format:

- **Signal source S-0-0051, S-0-0053 or S-0-0386**

$$\begin{aligned}
 P-0-0761 &= \frac{S-0-0051}{S-0-0103} \times P-0-0750 \times 2^{P-0-0084} \\
 P-0-0761 &= \frac{S-0-0053}{S-0-0103} \times P-0-0750 \times 2^{P-0-0084} \\
 P-0-0761 &= \frac{S-0-0386}{S-0-0103} \times P-0-0750 \times 2^{P-0-0084}
 \end{aligned}$$

Fig.9-64: Rotary/Linear Modulo Scaling of the Signal Source

$$\begin{aligned}
 P-0-0761 &= \frac{S-0-0051}{360^\circ} \times 2^{P-0-0084} \\
 P-0-0761 &= \frac{S-0-0053}{360^\circ} \times 2^{P-0-0084} \\
 P-0-0761 &= \frac{S-0-0386}{360^\circ} \times 2^{P-0-0084}
 \end{aligned}$$

Fig.9-65: Rotary Absolute Scaling of the Signal Source

$$\begin{aligned}
 P-0-0761 &= \frac{S-0-0051}{S-0-0159} \times 2^{P-0-0084} \\
 P-0-0761 &= \frac{S-0-0053}{S-0-0159} \times 2^{P-0-0084} \\
 P-0-0761 &= \frac{S-0-0386}{S-0-0159} \times 2^{P-0-0084}
 \end{aligned}$$

Fig.9-66: Linear Absolute Scaling of the Signal Source

- Signal source P-0-0052

$$P-0-0761 = P-0-0052$$

Fig.9-67: For all Scalings of the Signal Source

- Signal source P-0-0434 (special case)

$$P-0-0761 = \frac{P-0-0434}{360^\circ} \times 2^{P-0-0084}$$

Fig.9-68: Rotary Absolute Scaling

$$P-0-0761 = \frac{P-0-0434}{P-0-0159} \times 2^{P-0-0084}$$

Fig.9-69: Linear Absolute Scaling

$$P-0-0761 = \frac{P-0-0434}{S-0-0103} \times P-0-0750 \times 2^{P-0-0084}$$

Fig.9-70: Rotary/Linear Modulo Scaling and no Synchronous Position Control Mode Active

## Optional Device Functions

$$P-0-0761 = \frac{P-0-0434}{P-0-0786} \times P-0-0750 \times 2^{P-0-0084}$$

Fig.9-71: Rotary/Linear Modulo Scaling and a Synchronous Position Control Mode Active

- Signal source P-0-0753

$$P-0-0761 = \frac{P-0-0753}{P-0-0786} \times P-0-0750 \times 2^{P-0-0084}$$

Fig.9-72: Rotary/Linear Modulo Scaling of the Signal Source

$$P-0-0761 = \frac{P-0-0753}{360^\circ} \times 2^{P-0-0084}$$

Fig.9-73: Rotary Absolute Scaling of the Signal Source

$$P-0-0761 = \frac{P-0-0753}{P-0-0159} \times 2^{P-0-0084}$$

Fig.9-74: Linear Absolute Scaling of the Signal Source

- Signal source P-0-0758

$$P-0-0761 = \frac{P-0-0758}{P-0-0757} \times P-0-0750 \times 2^{P-0-0084}$$

Fig.9-75: Modulo Scaling of the Position Data Master Axis Generator (for P-0-0750 > 0)

$$P-0-0761 = \frac{P-0-0758}{P-0-0757} \times 4294967295 \text{ incr.} - 2147483648 \text{ incr.}$$

Fig.9-76: Modulo Scaling of the Position Data Master Axis Generator (for Special Case P-0-0750 > 0)

4096 master axis revolutions correspond to one modulo revolution of the virtual axis of the master axis generator.

$$P-0-0761 = \frac{P-0-0758}{P-0-0918} \times 2^{P-0-0084}$$

Fig.9-77: Absolute Scaling of the Position Data Master Axis Generator

- Signal sources P-0-1270 to P-0-1277



$$P-0-0761 = P-0-127x$$

x Selected parameter from range P-0-1270 to P-0-1277  
Fig.9-78: For all Scalings of the Signal Source



The parameters P-0-1270 to P-0-1277 are only available with the additional package MLD.

- Signal sources P-0-1771 to P-0-1777

$$P-0-0761 = P-0-177x$$

x Selected parameter from range P-0-1771 to P-0-1777  
Fig.9-79: For All Scalings of the Signal Source

## Secondary Master Mode

### Activation/Settings

For the output value of the format converter (P-0-0761, Master axis position for slave axis), the mode "secondary master" can be selected in bit 12 of the parameter "P-0-0760, Virtual master axis, positioning control word" .

If this option is selected, the master axis position for the slave axis (P-0-0761) synchronizes to a primary master and subsequently moves phase-synchronously to it.

In parameter "P-0-0924, Selection primary master", the real master axis, which is described by "P-0-0052, Actual position value of measuring encoder", or the external master axis position (P-0-0053) can be determined as primary master.

### Electric Gears and Fine Adjust

An electronic gear with fine adjust is arranged between the master-type master axis and the slave-type master axis. In this gear, the value of the primary master is multiplied with the quotient of the output and input revolutions of the gear as well as with the factor "1+ fine adjustment". The result is limited to the master axis cycle ( $2^{P-0-0084} \times P-0-0750$ ). After initializing the output of the electronic gear, the gear is differentially processed. An adjustment of the gear results in a velocity jump, not in a position jump.

### Offset of Secondary Master

Parameter "P-0-0928, Additive master axis position, secondary master" can be used to offset the secondary master with respect to the master axis position which is calculated from the primary master and the electronic gear with fine adjust.

For synchronization of the secondary master the value of the additive master axis position is taken into account and moved with the synchronization parameter values fro velocity and acceleration. The motion of the secondary master for a subsequent change of the additive master axis position is restricted by the parameters "P-0-0929, Change velocity of add. master axis posit., secondary master" and "P-0-0930, Change accel. of add. master axis posit., secondary master".

If relative synchronization has been set in the synchronization mode, only one velocity adjustment is made. In this case, the absolute value of "P-0-0928, Additive master axis position, secondary master" inactive. The following changes of this additive master axis position are processed in relative form. I. e. they result in corresponding changes of the secondary master.

### Synchronization of Secondary Master

#### Double-Step Synchronization

## Optional Device Functions

Synchronization is carried out in two steps. First, a velocity adjustment is carried out and then the position reference is established.

Relative or absolute synchronization can be selected for synchronization mode. With relative synchronization, only one velocity adjustment is carried out. The velocity of the secondary master is adjusted to the velocity of the primary master by acceleration or deceleration.

The value for acceleration or deceleration is determined in parameter "P-0-0920, Synchronization acceleration, secondary master".

With absolute synchronization, the velocity adjustment is followed by a position adjustment. The offset between the primary master and the secondary master is moved by an added motion of the secondary master with synchronization acceleration and synchronization velocity, so that subsequently the master axes are absolutely phase-synchronous.

At the end of the velocity adjustment with relative synchronization or of the position adjustment with absolute synchronization, Bit 8 of parameter "P-0-0768, Virtual master axis, positioning status" is set ("synchronization completed").

Subsequently, the value of parameter P-0-0761 is directly generated from the position of the primary master (differential processing). In this process the electronic gear and the fine adjustment is taken into account.

For the synchronization range, you can choose between a master axis revolution and the master axis cycle, which is determined by parameter "P-0-0750, Master axis revolutions per master axis cycle".

#### Single-Step Synchronization

As an alternative to the double-step synchronization a master-axis-synchronous, single-step synchronization method can be selected. Master-axis-synchronous means that the synchronization process of the secondary master is coupled to an area of the primary master to be passed.

It must be defined if the synchronization process is to start immediately (relatively master-axis-synchronous) or not until the primary master has passed a start angle (after gear and fine adjustment) (absolutely master-axis-synchronous). The start angle is the difference of the parameters "P-0-0931, Synchronous position, secondary master", and "P-0-0932, Synchronization range, secondary master".

This synchronization motion is added to the synchronous motion. The additive master axis positions causing the synchronization motions are calculated for the required velocity in rest – motion by a 5th order polynomial:  $f(x) = A_5 * x^5 + A_4 * x^4 + A_3 * x^3 + A_2 * x^2 + A_1 * x$ .

The coefficients of the polynomial are calculated from the states at the beginning of the synchronization motion (synchronization area of the primary master axis, synchronization distance of secondary master, velocities of primary and secondary master). The position within the parameterized synchronization range provides the argument for calculation of a functional value of the polynomial. The parameters "P-0-0922, Preferred synchronization direction, secondary master" and "P-0-0923, Synchroniz. window for shortest distance, secondary master" are taken into account for modulo scaling of the secondary master (internal virtual master axis) when determining the synchronization distance.

If master-axis-synchronous synchronization has been set, a velocity adjustment is performed until the master axis start angle is passed. I.e. the velocity of the secondary master is approximated to the velocity of the primary axis (after gear and fine adjustment) with the acceleration parameterized in parameter "P-0-0920, Synchronization acceleration, secondary master". If the synchroni-

zation acceleration has been set to 0, the slave axis maintains its velocity until the master axis start angle is passed (standstill at  $v=0$ )



The single-step synchronization is only possible in conjunction with absolute synchronization.

#### Deactivating the Slave-Type Master Axis Operation

For deactivating the slave-type master axis operation, bit 12 is reset in parameter "P-0-0760, Virtual master axis, positioning control word". On the basis of the current velocity, the mode, which has been selected by bit 1 and bit 2 is then switched (positioning, jog or stop).



For this switching, parameter "P-0-0758, Virtual master axis, actual position value" must be configured in the format converter.

## 9.8 Drive-Integrated Command Value Generator

### 9.8.1 Brief Description



Assignment to functional firmware package, see chapter "Availability of the Optional Device Functions".

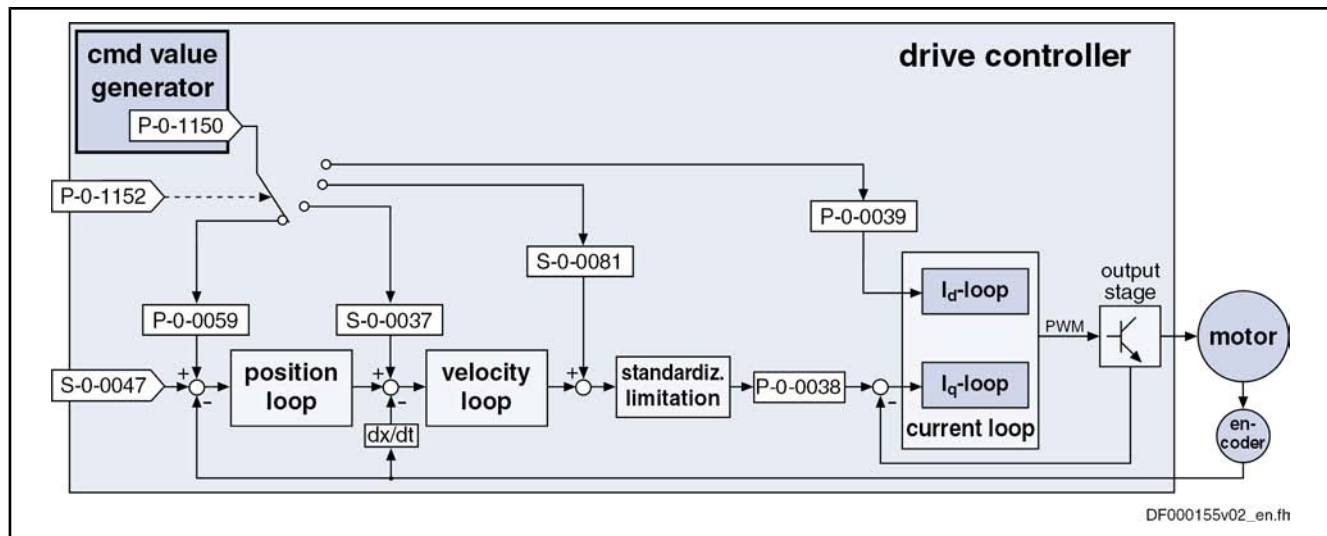
The drive-integrated command value generator can be used for commissioning and controller optimization of drives. The command value generator generates the command values required for the active operating mode in different shapes (square-wave, sine, noise); these command values are added to the main command value in the closed control loop.



In conjunction with the integrated oscilloscope function and an additional FFT calculation, the drive-integrated command value generator also provides the possibility of measuring the frequency response.

The figure below illustrates the points at which the drive-integrated command value generator can take effect:

Optional Device Functions



- S-0-0037 Additive velocity command value
- S-0-0047 Position command value
- S-0-0081 Additive torque/force command value
- P-0-0038 Torque-generating current, command value
- P-0-0039 Flux-generating current, command value
- P-0-0059 Additive position command value, controller
- P-0-1150 Command value generator output
- P-0-1152 Command value generator, target parameter assignment

Fig.9-80: Points at Which Function "Command Value Generator"

- Features**
- Possibility of generating different signal shapes that are added to the respective control loop command value (position, velocity or current)  
The following signal shapes are possible:
    - Square-wave signals
    - Sine signals
    - Noise signals
    - Modified sine signals
  - Generating **velocity and position command values** in the position loop clock; **current command values** in the velocity loop clock
  - With regard to **amplitude and frequency**, generated command values can be freely defined



The drive-integrated PLC (IndraMotion MLD) provides further possibilities of generating command values, but it can generate command values with a clock rate of 1 ms.

**Pertinent Parameters**

- P-0-1150, Command value generator output
- P-0-1151, Command value generator, list of possible target parameters
- P-0-1152, Command value generator, target parameter assignment
- P-0-1153, Command value generator, control word
- P-0-1154, Command value generator, offset
- P-0-1155, Command value generator, amplitude
- P-0-1156, Command value generator, duration 1
- P-0-1157, Command value generator, duration 2
- P-0-1158, Command value generator, periodic time

- P-0-0028, Oscilloscope: control word
- P-0-0031, Oscilloscope: time resolution
- P-0-0032, Oscilloscope: size of memory

## 9.8.2 Functional Description

### Setting/Activating the Function

**Clock Rate** The integrated command value generator provides the possibility of generating velocity and position command values in the position loop clock for commissioning and adding them to the respective main command value.

The current command values are generated in the velocity loop clock.

**Activation** The command value generator is activated and controlled via parameter "P-0-1153, Command value generator, control word" by setting the enable bit. When the enable signal has been set, the generator generates command values in the position loop clock (or velocity loop clock).

In parameter P-0-1153, you can also set that the enabling of the command value generator is automatically deactivated in the case of drive errors. In this case, you have to set the enable signal again after each drive error or after the control voltage has been switched on.

**Drive enable** In order that the generated command values take effect, the operation mode has to be selected and drive enable (bit "Drive On" = 1) has to be set.

This can be done in the following ways:

- Via a digital input
- Via the serial interface in "easy startup" mode
- Via the master communication
- Via the drive-integrated PLC (IndraMotion MLD)

**Selecting the Target Parameter** The IDN of that parameter is entered in parameter "P-0-1152, Command value generator, target parameter assignment" on which the output signal of the command value generator is to take effect.

The IDNs of the possible target parameters for the generator output are given in parameter "P-0-1151, Command value generator, list of possible target parameters".

The following list shows possible target parameters to which the output signal of the command value generator (P-0-1150) can be assigned:

- S-0-0036, Velocity command value
- S-0-0037, Additive velocity command value
- S-0-0080, Torque/force command value
- S-0-0081, Additive torque/force command value
- P-0-0039, Flux-generating current, command value
- P-0-0059, Additive position command value, controller



See also Parameter Description "P-0-1151, Command value generator, list of possible target parameters"



The unit and attribute of the generated signal are adjusted according to attribute and unit of the assigned parameter.

### Selecting the Signal Shape

The shape of the desired output signal is determined by means of the respective bits in parameter "P-0-1153, Command value generator, control word".

## Optional Device Functions

You can choose between the following signal shapes of the command value:

- **Square-wave signals**
  - Pulse generator with definable pulse/pause relationship, variable frequency and direct voltage component (offset)
- **Sine signals**
  - Sine generator generates signal up to theoretical maximum frequency of 2 kHz with variable frequency and direct voltage component (offset)
- **Noise signals**
  - Noise generator generates wide-band "white noise"; amplitude of the noise signal can be defined as mere factor or by means of envelope curve (= square-wave signal)
- **Modified sine signals**
  - Modified sine generator generates composite sine shape consisting of two joined half-waves of different signs and different periodic times

**Advanced Settings** Other possible settings in the control word of the command value generator:

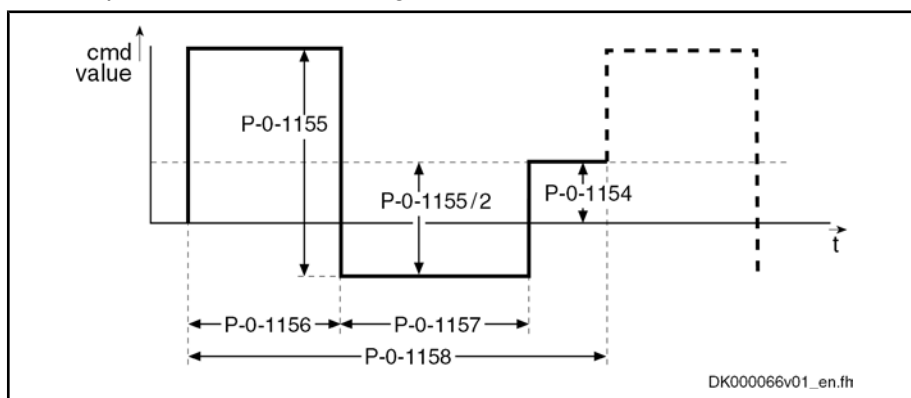
- **Activation of periodic signal generation**
  - Selected signal is cyclically generated and output with a periodic time (frequency) that can be defined
- **Switch-off delay**
  - Drive enable can be set with a delay, i.e. adjusted to the signal period

## Pulse Generator (for Square-Wave Signal)

The pulse generator generates a square-wave signal that can be varied in the following properties:

- Frequency or periodic time of the signal
- Amplitude
- Direct component (DC offset; positive/negative)
- Pulse/pause relationship

The exemplary figure below illustrates the output signal of the pulse generator with the possibilities of influencing:



- P-0-1154 Command value generator, offset
- P-0-1155 Command value generator, amplitude
- P-0-1156 Command value generator, duration 1
- P-0-1157 Command value generator, duration 2
- P-0-1158 Command value generator, periodic time

Fig.9-81: Output Signal of Pulse Generator



If periodic command value generation has been selected in the control word, parameter "P-0-1158, Command value generator, periodic time" determines the cycle time or periodic time.

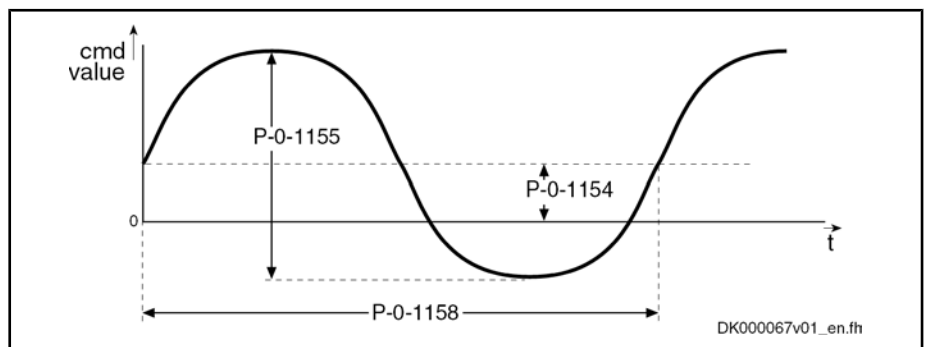
In the case of  $P-0-1158 = (P-0-1156) + (P-0-1157)$ , there is a periodic square-wave signal resulting, if the periodic output has additionally been activated in the control word.

## Sine Generator

A sine generator is available for checking the bandwidth; its output signal can be varied in the following properties:

- Frequency or periodic time of the signal
- Amplitude
- Direct component (DC offset; positive/negative)

The exemplary figure below illustrates the output signal of the sine generator with the possibilities of influencing:



P-0-1154	Command value generator, offset
P-0-1155	Command value generator, amplitude
P-0-1158	Command value generator, periodic time
Fig. 9-82:	Output Signal of Sine Generator



The target parameter selected in parameter P-0-1152 determines the initial angle of the signal. For currents and torque command values the initial angle is  $90^\circ$  so that the position deviation of the drive is zero again after a complete period.

### Advanced Settings

In many cases it is important that the sine signal contains no direct component. In parameter "P-0-1153, Command value generator, control word" it is possible to determine that switching off the command value generator is delayed until the period is complete.

## Noise Generator

The method of the feedback shift register is used for generating the random numbers. In each sequence a bit for the output is generated which is set or cleared at random so to speak. The periodic time of the noise signal in this case is set to 4095 clocks ( $T_{A\_position}$  or  $T_{A\_velocity}$ ).



The generated noise signal is free of mean values over an entire period so that the drive does not drift due to the additional noise.

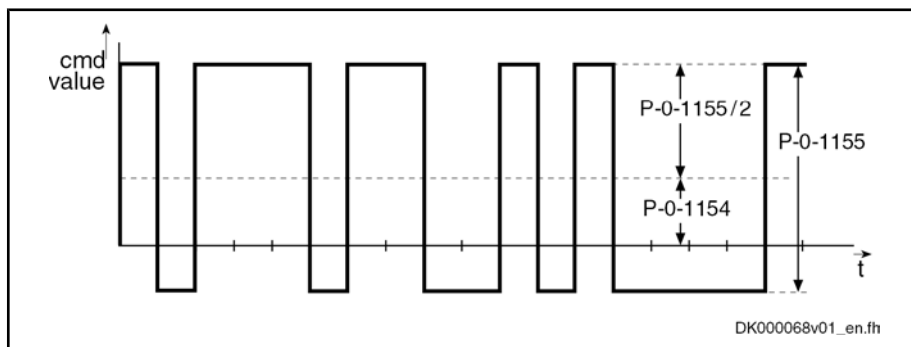
### Output Format (Amplitude Modulation)

For outputting the pulsed quantities there are the following possibilities:

## Optional Device Functions

- Noise signal as square-wave signal with parameterizable amplitude and, if necessary, offset component
  - Amplitude is set positive or negative according to the sign of the feedback shift register
- Noise signal with continuous amplitude
  - Feedback shift register is interpreted as numeric value and evaluated with amplitude

The exemplary figure below illustrates the output signal of the noise generator with the possibilities of influencing:



P-0-1154 Command value generator, offset  
 P-0-1155 Command value generator, amplitude

Fig. 9-83: Output Signal of Noise Generator



For an FFT calculation, P-0-1154 = 0 has to be set!

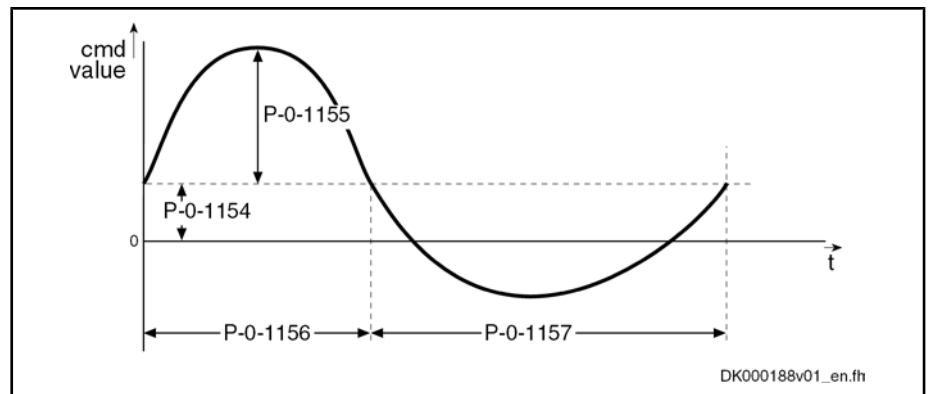
## Modified Sine Generator

In addition, a modified sine generator is available with two different half-waves of the same amplitude; the output signal of the generator can be varied in the following properties:

- Frequency or periodic time of the signal
- Duration of the first half-wave
- Duration of the second half-wave
- Amplitude
- Direct component (DC offset; positive/negative)

The exemplary figure below illustrates the modifiable output signal of the sine generator with the possibilities of influencing:





P-0-1154	Command value generator, offset
P-0-1155	Command value generator, amplitude
P-0-1156	Command value generator, duration 1
P-0-1157	Command value generator, duration 2

*Fig.9-84: Output Signal of Noise Generator*

### 9.8.3 Notes on Commissioning

#### Bandwidth and Frequency Response Measurement

Frequency response measurement always requires accordingly wide-band excitation that is made available by the noise generator. In addition to the generation of the noise signal, the recording of measured values (= sampling) is required which is carried out with the oscilloscope function integrated in the drive.

It is therefore necessary to adjust the periodic time of the noise signal to the recording duration of the oscilloscope function.

The periodic time of the noise signal results from the following relationship:

$$T_R = P-0-0031 \times P-0-0032$$

$T_R$	periodic time of noise signal
P-0-0031	Oscilloscope: time resolution
P-0-0032	Oscilloscope: size of memory

*Fig.9-85: Calculating the Periodic Time of the Noise Signal*



The actual calculation or determination of the frequency response is carried out by means of a technology function for IndraMotion MLD or with the service tool "IndraWorks Ds/D/MLD".

The overview below illustrates the possible excitation signals and measuring signals for the recording:

## Optional Device Functions

Control loop	Command value generator excitation signal	Generator clock frequency		Measuring signals of oscilloscope function
		Basic	Adv.	
torque	Additive torque/force cmd value (S-0-0081)	4 kHz	8 kHz	Additive torque/force cmd value (S-0-0081) Torque/force feedback value (S-0-0084)
Current (Iq)	Torque-generating Current, command value (P-0-0038)	4 kHz	8 kHz	Torque-gener. current, command value (P-0-0038) Torque-generating current, actual value (P-0-0043)
Current (Id)	Flux-generating current, cmd value (P-0-0039)	4 kHz	8 kHz	Flux-generating current, cmd value (P-0-0039) Flux-generating current, actual value (P-0-0044)
Velocity	Additive velocity command value (S-0-0037)	2 kHz	4 kHz	Effective velocity command value (P-0-0048) Velocity feedback value (S-0-0040)
Position	Additive position cmd val., controller (P-0-0059)	2 kHz	4 kHz	Position command value controller (P-0-0434) Position feedback 1 value (S-0-0051) or Position feedback 2 value (S-0-0053)

Fig.9-86: Signals for Excitation and Recording

The following has to be observed for parameterization:

- The bandwidth of the excitation signal depends on the clock frequency that differs according to the kind of signal and the available control performance (clock frequency).  
**Note:** The bandwidth of the "white noise" is limited to a maximum of half the clock frequency!
- The size of memory for the oscilloscope function has to be 4095 values (P-0-0032 = 4095) so that the necessary condition "periodic time of noise signal = recording time of oscilloscope" is fulfilled and 4095 values can be recorded.  
**Note:** The periodic time and clock frequency depend on the kind of signal (current, position, velocity) and performance.
- The periodic time depends on the excitation signal:
  - **Position and velocity excitation**  
→ With excitation via the parameters S-0-0036, S-0-0037 or P-0-0059, the resulting periodic time is  $T = 2.0475\text{s}$  (Basic) or  $T = 1.02375\text{s}$  (Advanced).
  - **Current excitation**  
→ With excitation via the parameters S-0-0081 or P-0-0039, the resulting periodic time is  $T = 1.02375\text{s}$  (Basic) or  $T = 0.511875\text{s}$  (Advanced).

## Control Loop Optimization

The drive-integrated command value generator is very well suited for optimizing the control loops (current, velocity and position), as it generates a defined command value characteristic (e.g. pulse or square-wave signals).

**Current Loop** The field-oriented current controller that takes effect in controlled operation ("closed loop"), realizes the following subfunctions:

- Closed-loop control of d-component (field-generating current)
- Closed-loop control of q-component (torque-generating current)

See "Motor Control: Field-Oriented Current Control"

To evaluate the current loop for the torque-generating current control loop, the excitation has to be carried out via parameter "S-0-0081, Additive torque/force command value" ("P-0-0038, Torque-generating current, command value" as an alternative) and the parameters S-0-0081 (or P-0-0038) and "S-0-0084, Torque/force feedback value" have to be recorded with the oscilloscope function.

To evaluate the current loop for the flux-generating current, the excitation has to be carried out via parameter "P-0-0039, Flux-generating current, command value" and the parameters P-0-0039 and "P-0-0044, Flux-generating current, actual value" have to be recorded with the oscilloscope function.



If current command values are generated, it is necessary to activate the so-called expert mode (P-0-0028, bit 4 = 1) for the recording with the oscilloscope function, in order to adjust the sampling frequency to the excitation frequency.

**Velocity Loop** To evaluate the velocity loop, the excitation has to be carried out via parameter "S-0-0037, Additive velocity command value" and the parameters "P-0-0048, Effective velocity command value" and "S-0-0040, Velocity feedback value".



For the output of velocity command values the command value generator takes effect in every position loop cycle (0.250 or 0.500 ms).

**Position Loop** To examine the position loop the drive has to be in one of the operation modes "position control with cyclic command value input", "drive-internal interpolation", "drive-controlled positioning" or in the status "Drive Halt".

Under this condition, the excitation via parameter "P-0-0059, Additive position command value, controller" can take place directly for the position loop and the parameters "P-0-0434, Position command value of controller" and "S-0-0051, Position feedback value 1" or "S-0-0053, Position feedback value 2" have to be recorded with the oscilloscope function.

## 9.9 Drive-Internal "Command Value Box"

### 9.9.1 Brief Description



Assignment to functional firmware package, see chapter "Availability of the Optional Device Functions".

With IndraDrive controllers, a so-called "command value box" is internally available for manual drive optimization. It offers the possibility to internally (independent of the master) generate a command value characteristic that can be defined by the user. By this, an axis drive can be moved in the same way as with an external command value box, without an external command value being effective (→ drive-internal "command value box"). The drive enable must merely be applied to the drive.

The command value characteristic that can be defined by the user, allows for an axis to be moved within determinable position limits in continuous sequence in the velocity control loop or position control loop. This can be made use of, in order to manually optimize the control loop parameters of the drive, by e.g.

## Optional Device Functions

moving the drive with a low velocity command value and by evaluating the status variables "actual current value" and "actual velocity value".



More details on the manual control loop setting are described in the "Overview of Drive Control: Notes on Commissioning for Control Loop Setting" .

By the internal command value box, an axis can be continuously moved in an "oscillating movement" (oscillating between two position limit values) or in "stepper mode" (unidirectional moving over a defined path or a travel range).

The internal command value box is configured via a command word, the command value characteristic is defined via the respective parameters. Activating the internal command value box is carried out via a command.

**Pertinent Parameters**

- P-0-0162, C1800 Command Drive optimization / command value box
- P-0-0165, Drive optimization, control word
- P-0-0166, Drive optimization, end position negative
- P-0-0167, Drive optimization, end position positive
- P-0-0169, Drive optimization, travel distance
- P-0-0170, Drive optimization, acceleration
- P-0-0171, Drive optimization, velocity
- P-0-0172, Drive optimization, dwell time

**Pertinent Diagnostic Messages**

- C1800Command Drive optimization / command value box
- C1801Start requires drive enable
- C1806Travel range exceeded

## 9.9.2 Functional Description

### Configuring and Activating the Function

The drive-internal command box is configured in the parameter "P-0-0165, Drive optimization, control word". In this parameter the presettings for a total of three functions are determined, which operate with internal command value input:

1. Recording table for cogging torque compensation (highest priority)
2. Configuring internal command value box (medium priority)
3. Configuring automatic control loop setting (lowest priority)

The functions mentioned above **cannot be used simultaneously**, although they can be selected simultaneously by means of the respective bits. Priorization is valid as stated in the list above.

The "internal command value box" function is activated, if the execution of "C1800 Command Drive optimization / command value box" is started with correct setting of parameter P-0-0165.

**Operating Mode**

With the function activated, the controller can move the drive in one of the following operating modes:

- Velocity control
- Position control

Velocity control takes place via the motor encoder, position control via the position encoder selected in parameter "S-0-0520, Control word of axis controller".

- Type of Motion** With both velocity control and position control, the types of motion below can be selected for the command value characteristic:
- Oscillating movement
  - Stepper mode

### Definition of the Internal Command Value Characteristic

- Oscillating Movement** With the oscillating movement, the drive reciprocates between two position limit values that can be set. The limit values are determined by the parameters below:
- P-0-0166, Drive optimization, end position negative
  - P-0-0167, Drive optimization, end position positive
- Between the subsequent reciprocating movements of the oscillating operation, the axis dwells in a standstill position for a period that can be set in parameter "P-0-0172, Drive optimization, dwell time".
- Stepper Mode** With stepper mode, the axis only moves in one direction. The distance or angle is preset by the value of parameter "P-0-0169, Drive optimization, travel distance", the direction is determined by the sign of the value in parameter P-0-0169.
- Between the subsequent travel motions of the stepwise operation, the axis dwells in a standstill position for a period that can be set in parameter "P-0-0172, Drive optimization, dwell time" .
- Velocity Command Value** For both velocity control and position control, the maximum velocity command value of the axis is preset in parameter "P-0-0171, Drive optimization, velocity".
- Acceleration Command Value** In position control, the maximum acceleration of the axis in parameter is preset in "P-0-0170, Drive optimization, acceleration".
- In velocity control, parameter P-0-0170 is ineffective; the velocity command value is preset in an abrupt manner!. A possibly required acceleration limitation can, however, be realized via the command value ramp parameters (P-0-1201, P-0-1202, ...)!.

### 9.9.3 Notes on Commissioning

- Configuration of the Function** The drive-internal command box function is configured in the parameter "P-0-0165, Drive optimization, control word". The following settings are to be made:
- Set operating mode "position control" or "velocity control"
  - Select type of motion "oscillating movement" or "stepper mode"
- Note:** The motion type "stepper mode" can only be used with axes with unlimited travel range (e.g. modulo axes). For axes with limited travel range, the motion type "oscillating movement" must be used!



It must be taken into account that the option "including the cogging torque compensation table", which can also be configured in parameter P-0-0165, has **not** been selected as it has a higher priority than the internal command value box.

- Motion Limits** For the oscillating movement the motion limits are set in the following parameters:
- P-0-0166, Drive optimization, end position negative
  - P-0-0167, Drive optimization, end position positive

## Optional Device Functions

	These limit values are effective for both position control and velocity control. In the velocity control mode, the limit values cause a change in polarity of the velocity command value.
<b>Travel Distance</b>	In the stepper mode, the travel distance or travel angle is set in parameter "P-0-0169, Drive optimization, travel distance" The sign determines the direction of movement!
<b>Dwell Time</b>	The standstill time of the axis between the individual travel movements is preset in parameter "P-0-0172, Drive optimization, dwell time".
<b>Velocity Command Value</b>	The maximum velocity command value for both control modes (operating modes) is preset in parameter "P-0-0171, Drive optimization, velocity".
<b>Acceleration Command Value</b>	For position control the acceleration command value is preset in parameter "P-0-0170, Drive optimization, acceleration". For velocity control the predefined command value ramps (P-0-1201, P-0-1202, ...) must be used, if necessary!

## 9.10 Encoder Emulation

### 9.10.1 Brief Description



Assignment to functional firmware package, see chapter "Availability of the Optional Device Functions".

By means of encoder emulation it is possible to convert available encoder signals (encoder 1, encoder 2 or measuring encoder) or internal position command values into one of the following two formats:

- **5V-TTL signal of an incremental encoder** with incremental encoder emulation (track A, track B and zero pulse)
- **Serial 24-bit position of an absolute encoder** (SSI format) with absolute encoder emulation

This allows, for example, evaluating the signals in a higher-level master in order to close the position loop in the external control unit in conjunction with the freely parameterizable resolution and the data reference.



Using the encoder emulation in **precision applications** (mostly in machine tool applications) is considered as **critical** and always **has to be carefully considered** beforehand!

For sophisticated applications for which the position control loop is closed by means of emulation, Bosch Rexroth recommends to use digital interfaces, such as SERCOS interface.

See "Restrictions" in section "Notes on Commissioning"



#### Incremental Encoder Emulation

Incremental encoder emulation is the simulation of a real incremental encoder by the drive controller.

With incremental encoder emulation we distinguish between

- Signal emulation
  - and -
- Motor encoder emulation.

In the form of **incremental encoder signals**, a higher-level numeric control (NC) receives information about the velocity of the motor connected to the controller. By integration of these signals, the control unit receives the required position information and it is thereby possible to close a higher-level position control loop.

	 Emulation takes place in scaling-dependent (see S-0-0076) or encoder-related form; the resolution is input in lines/revolution (1 line corresponding to 4 increments) or in mm or inch.
<b>Features of Incremental Encoder Emulation</b>	<ul style="list-style-type: none"> <li>• Cyclic calculation of the position or increments output by the emulator in the position loop clock (see "Performance data")</li> <li>• Freely selectable position signals for emulation (P-0-0900, P-0-0901)</li> <li>• Resolution that can be parameterized (lines/revolution or mm resp. inch)</li> <li>• Encoder-related emulation (incremental)</li> <li>• Dead time compensation that can be activated (P-0-0902, bit 3)</li> <li>• Shiftable zero pulse (P-0-0904)</li> <li>• Parameterizable cyclic zero pulse output for zero pulse distance (P-0-0904) and position data reference (P-0-0902)</li> <li>• Encoder emulation can be switched off in operation (→ pause)</li> <li>• Internal clock increase of incremental encoder emulation to reduce zero pulse jitter and frequency jitter (not for BASIC ANALOG control sections)</li> <li>• Signal-related or motor-encoder-related emulation to be freely selected (→ influence on position of zero pulse!)</li> </ul>
<b>Absolute Encoder Emulation</b>	<p>Absolute encoder emulation means that the drive controller has the option of simulating a real absolute encoder in <b>SSI data format</b>. It is thereby possible to transmit the position in the SSI data format to the connected control unit (NC) and to close the position control loop via the control unit.</p>
	 Emulation takes place in scaling-dependent form (see S-0-0076) and the resolution is input in bits.
<b>Features of Absolute Encoder Emulation</b>	<ul style="list-style-type: none"> <li>• Cyclic calculation of the position or increments output by the emulator in the position loop clock (see "Performance data")</li> <li>• Freely selectable position signals for emulation (P-0-0900, P-0-0901)</li> <li>• Resolution that can be parameterized (bits)</li> <li>• Scaling-related emulation (S-0-0076)</li> <li>• Synchronization of SSI emulation to SSI clock can be activated (only for ADVANCE control sections)</li> </ul>
<b>Hardware Requirements</b>	<p>The firmware encoder emulation function requires the following control section design:</p> <ul style="list-style-type: none"> <li>• Single-axis BASIC ANALOG (not configurable) (CSB01.1N-AN)</li> </ul> <p>In addition, it is possible to use the following <b>configurable control sections</b>, if they have been designed with the optional module for encoder emulation (MEM):</p> <ul style="list-style-type: none"> <li>• Single-axis BASIC UNIVERSAL (CSB01.1C)</li> <li>• Single-axis ADVANCED (CSH01.xC)</li> <li>• Double-axis BASIC UNIVERSAL (CDB01.1C)</li> </ul>

## Optional Device Functions



The encoder emulation is a device function. It can therefore only be used once per device, i.e. in the case of double-axis devices (CDB), it is only available for one of the two axes, as a standard.

**Special case:**

In the case of double-axes devices operated as purely analog devices with position feedback via encoder emulation, the encoder emulation can be used for each axis, if the control section configuration CDB01.1C-AN-EN\*-MEM-EN\*-MEM is available.

**In this case the following must be observed:** For assignment of optional slots to the respective axis see documentation "Control Sections for Drive Controllers; Project Planning Manual" .

**Pertinent Parameters**

- P-0-0900, Encoder emulation signal selection list
- P-0-0901, Encoder emulation signal selection
- P-0-0902, Encoder emulation control parameter
- P-0-0903, Encoder emulation resolution
- P-0-0904, Encoder emulation zero pulse offset
- P-0-0905, Encoder emulation zero pulse distance



If the encoder emulation is operated as device function in the double-axis device (no "analog inputs" extension plugged), these parameters are available once per device, except the control parameter (P-0-0902). If the "analog inputs" (AN) extension is plugged, these parameters are available once per axis.

**Pertinent Diagnostic Messages**

- C0242 Multiple configuration of a parameter (->S-0-0423)
- C0260 Incremental enc. emulator resol. cannot be displayed
- F2053Incr. encoder emulator: Pulse frequency too high
- F2054Incr. encoder emulator: Hardware error

## 9.10.2 Basic Information on the Function

### Activating the Function

The kind of encoder emulation including its activation is determined via bit 0 and bit 1 of "P-0-0902, Encoder emulation control parameter".

The following settings can be selected via parameter P-0-0902:

- No encoder emulation activated
- Incremental encoder emulation (IGS) activated
  - Signal emulation
  - Motor encoder emulation
- Absolute encoder emulation (SSI) activated
  - Signal emulation



The settings in parameter P-0-0902 only take effect after progression to the operating mode!



See also Parameter Description "P-0-0902, Encoder emulation control parameter"



## Selecting the Signal to be Emulated

**Supported Emulation Signals** The input of the signals that the drive supports for emulation is depending on the following factors:

- Firmware version and enabled functional packages
- Hardware of the control section and its configuration
- With double-axis device utilization as axis or device function



The emulation signals currently supported by the drive are contained in the list parameter "P-0-0900, Encoder emulation signal selection list".

### Determining the Kind of Emulation (for Incremental Encoder Emulation)

In bit 12 of "P-0-0902, Encoder emulation control parameter", determine whether it is directly the signal of the motor encoder that is to be emulated or the signal that was defined via the parameter P-0-0901 (see below).

### Selecting the Emulation Signal

If bit 12 = 0 in parameter P-0-0902, the emulation signal is determined by inputting the desired IDN from the list parameter P-0-0900 in parameter "P-0-0901, Encoder emulation signal selection".



The resolution of the emulated signal is determined for both kinds of emulation (SSI and IGS) in parameter "P-0-0903, Encoder emulation resolution".

## 9.10.3 Incremental Encoder Emulation

### General Information

The incremental encoder emulation provides a square-wave signal in TTL level with variable frequency. The position difference of the selected signal in the last position loop clock (see "Performance Data" ) is calculated. The number of lines to be output and therefore the periodic time of the square-wave signal for the next output interval is calculated depending on the input in parameter "P-0-0903, Encoder emulation resolution".

### Incremental Encoder Signals in TTL Format

**Tracks A and B** By outputting two signals offset by 90 degrees (track A and track B) the resolution is increased by the factor 4 when the two tracks are evaluated in differential form. One line is then corresponding to 4 increments.

**Zero Pulse** In addition, the incremental encoder outputs a third signal, the zero pulse. The zero pulse has a fixed reference to the emulated signal (e.g. of the encoder shaft, if an encoder signal is emulated) and can, in case position data reference is existing (axis homed), also be emulated with reference to the machine zero point.



It is possible to influence both the output frequency and the position of the zero pulse (see P-0-0905 and P-0-0904)!

The figure below illustrates the format and time flow of the incremental encoder signals:

## Optional Device Functions

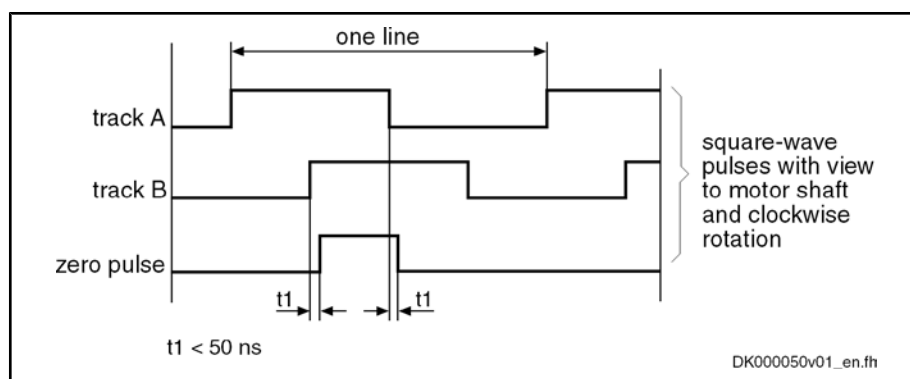


Fig.9-87: Time Flow of the Incremental Encoder Signals

## Resolution and Unit of the Emulated Signal

**Resolution** The number of increments of the emulated incremental encoder can be determined in "P-0-0903, Encoder emulation resolution" in lines/revolution (or mm or inch for linear motors).

**Unit of the Emulated Position** The input range and the unit of the value in parameter P-0-0903 depend on the following settings:

- Type of construction of motor
  - Rotary motors → lines/revolution
  - Linear motors → mm or inch
- Parameterized scaling (see "S-0-0076, Position data scaling type")



The emulated encoder therefore is parameterized according to the usual formats for rotary and linear square-wave encoders in lines/revolution or mm or inch.

## Reference of the Emulated Position - Zero Pulse Output

The zero pulses are output immediately after the drive was run up to the operating mode in the distance of the lines resp. mm or inch entered in parameter "P-0-0905, Encoder emulation zero pulse distance".

**Zero Pulse Offset** With parameter "P-0-0904, Encoder emulation zero pulse offset", the output of the zero pulse, with incremental encoder emulation having been selected, can be offset by the input value in lines (or mm or inch). The input range in P-0-0904 is determined by the setting in parameter "P-0-0903, Encoder emulation resolution", because the maximum offset for rotary motors, for example, is one revolution.

**Cyclic Zero Pulse Output** If the zero pulse is to be cyclically output depending on the travel distance, the distance between two zero pulses can be entered in lines (or mm or inch) in parameter "P-0-0905, Encoder emulation zero pulse distance".

The following applies to the zero pulse output:

- Parameter setting **P-0-0905 = P-0-0903** (standard case!)
  - **One zero pulse per revolution** (or per mm) is generated.
- Parameter setting **1 < P-0-0905 < P-0-0903** (cyclic zero pulse output)
  - **Several zero pulses per revolution** (or per mm) are generated (if a zero pulse is demanded after 180 degrees, for example, parameter setting has to be  $P-0-0905 = \frac{1}{2} \times P-0-0903$ ).



For cyclic output you have to take into consideration that a maximum of one zero pulse can be output per output cycle (i.e. position loop clock)!

- Parameter setting **P-0-0905 = n × P-0-0903**  
→ **One zero pulse within n revolutions** (or per n millimeters) is generated. This allows, for example, generating only one single zero pulse over the entire travel range at the machine zero point!



Inputting "0" in parameter P-0-0905 is not allowed!

**Kind of Emulation**

According to the kind of emulation, the zero pulse is emulated with relation to encoder mark or with relation to signal. The kind of emulation is selected in bit 12 of "P-0-0902, Encoder emulation control parameter".

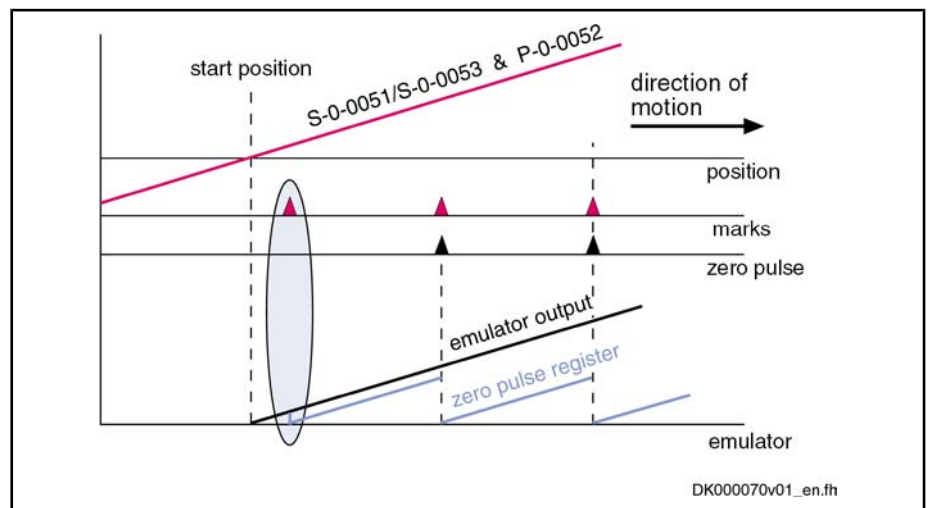
**Emulation With Relation to Motor Encoder (P-0-0902, Bit 12 = 1)**

In the case of emulation with relation to the motor encoder, emulation takes place with relation to the encoder shaft. With relation to the position of the encoder mark, the zero pulse is emulated under the following conditions:

- For relative measuring systems for which there is no absolute position reference when switching on, zero pulse output only takes place after an encoder mark of the encoder system has been passed for the first time (see figure below).
- For absolute measuring systems which have absolute position reference after switching on, output takes place immediately.



In case the drive has not been homed (see S-0-0403), zero pulses are generated without reference to the machine zero point existing!



- S-0-0051 Position feedback 1 value
- S-0-0053 Position feedback 2 value
- P-0-0052 Actual position value of measuring encoder

Fig.9-88: Zero Pulse Generation for Incremental Measuring System and Motor Encoder Relation (P-0-0902, Bit 12 = 1)

**Emulation With Relation to Signal (P-0-0902, Bit 12 = 0)**

In the case of emulation with relation to the signal, the zero pulse is emulated with reference to the coordinate system. The zero pulse is output with reference to the zero point at "position 0" plus zero pulse offset. There are the following possible settings:

- The further zero pulses are defined via parameter "P-0-0905, Encoder emulation zero pulse distance".

Optional Device Functions

- Via parameter "P-0-0904, Encoder emulation zero pulse offset", the emulated coordinate system can be shifted.



The zero pulse is only output when the drive has been homed (see S-0-0403). The generated zero pulses are then always referring to the actual machine zero point!

The emulation signals that can be selected via parameter "P-0-0901, Encoder emulation signal selection" are divided into two groups:

- **Emulation of actual values**
  - For the output of zero pulses "reference" (see S-0-0403) is obligatory. For relative measuring systems, zero pulse output only takes place when the corresponding actual position value was homed (see figure below).
- **Emulation of command values**
  - Command values can always be considered as homed so that zero pulse output takes place independent of the "reference" (see S-0-0403).

**Example: Incremental Measuring System and Actual Value Signal Output**

The figure below illustrates the emulation of an actual value signal with incremental measuring system and signal relation:

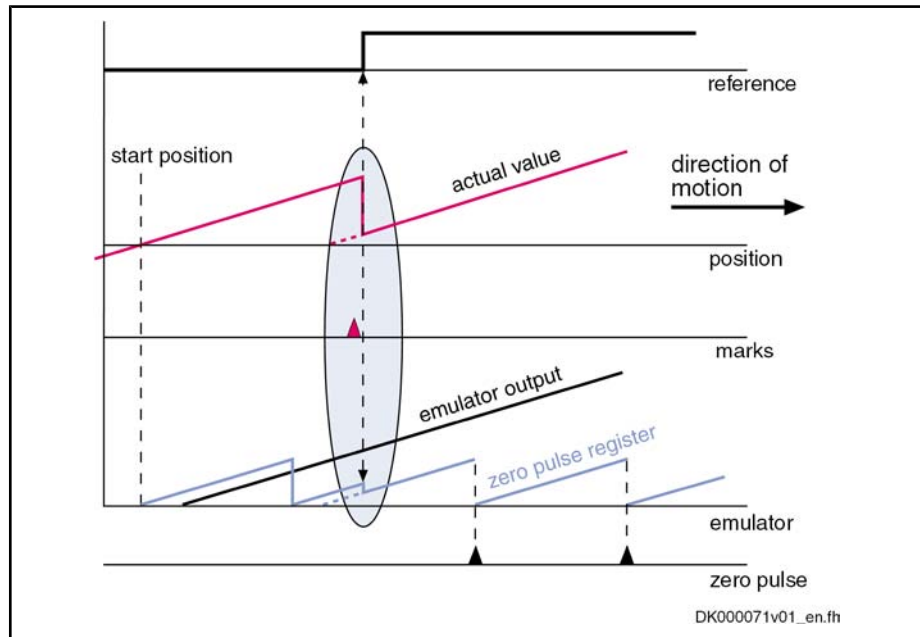
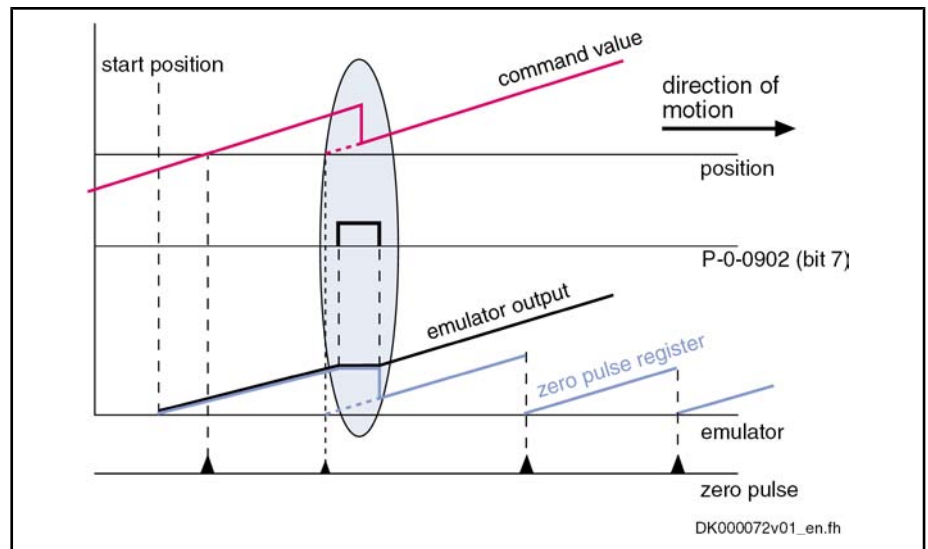


Fig.9-89: Zero Pulse Generation for Incremental Measuring System and Signal Relation (P-0-0902, Bit 12 = 0) With Actual Value Signals

**Example: Incremental Measuring System and Command Value Output With Command Value Jump**

For emulation of command values you have to take into account that the master might possibly want to preset command value jumps that are not to be emulated or cannot be emulated. For this case, it is possible to stop emulation for a short time (see P-0-0902, bit 7). During this time, a command value jump does neither cause the internal monitoring functions with regard to the emulation signals to trigger nor misadjustment of the emulator output.

After the stop is over, emulation can be enabled again via bit 7 and the emulator then follows the preset command value signal.



P-0-0902 Encoder emulation control parameter  
 Fig.9-90: Zero Pulse Generation for Incremental Measuring System and Signal Relation (P-0-0902, Bit 12 = 0) With a Command Value Jump

## Establishing the Position Data Reference (Drive-Controlled Homing)

For emulating actual values with relation to signal (P-0-0902, bit 12 = 0) and using incremental measuring systems, the drive must have been homed in order to output a zero pulse (see also above section "Zero Pulse Output").



When the homing procedure is carried out, the emulated signals jumps from the original position to the reference position. **In this case, the error message "F2053" is suppressed on purpose.**

See also "Establishing Position Data Reference for Relative Measuring Systems"

## 9.10.4 Absolute Encoder Emulation

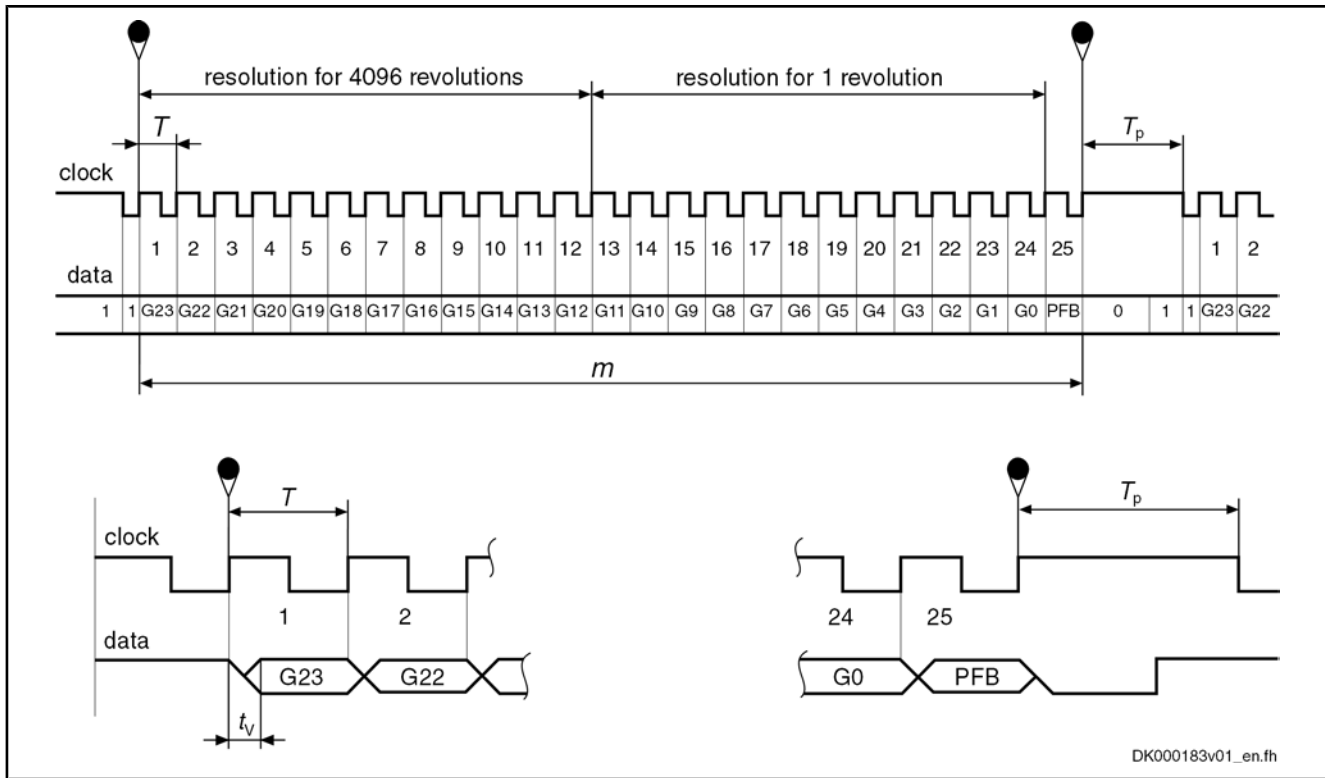
### General Information

The absolute encoder emulation provides a digital, coded, absolute position signal which in the position loop clock (see "Performance Data") can be serially read. The resolution of the absolute position and therefore the travel range that can be displayed in absolute form depend on the input in parameter "P-0-0903, Encoder emulation resolution".

### Absolute Encoder Signals in SSI Format

The figure below illustrates the format of the SSI data transmission of the absolute encoder emulation:

Optional Device Functions



DK000183v01\_en.fh

- G0 Least significant bit in Gray code
- G23 Most significant bit in Gray code
- m Stored parallel information
- T Clock time
- $T_p$  Clock break  $\geq 20 \mu s$
- $t_v$  Delay time max. 650 ns
- PFB Power failure bit (not used and always logically LOW)

Fig.9-91: Pulse Diagram SSI Format



IndraDrive controllers do not support the power failure bit!

Resolution and Unit of the Emulated Signal

**Resolution** The output data format (i.e. the resolution) for the emulated SSI position is determined in parameter "P-0-0903, Encoder emulation resolution".



The unit represented in parameter P-0-0903 is bits.

**Unit of the Emulated Position**

The input range and the unit of the value in parameter P-0-0903 depend on:

- Type of construction of motor:
  - Rotary motors → bits/revolution
  - Linear motors → bits/mm or bits/inch
- Parameterized scaling (see "S-0-0076, Position data scaling type")



The emulated digital position value is always displayed with 24 bits, the setting in P-0-0903 defining the resolution of one revolution (= decimal place). With P-0-0903 = 12 bits, 12 bits of places before decimal point and 12 bits of decimal places take effect, for example.

## Reference of the Emulated Position

The emulation of the signals "position feedback 1 value", "position feedback 2 value" and "position command value" depends on the scaling determined in parameter "S-0-0076, Position data scaling type".

The values of the emulator and the parameters "S-0-0051, Position feedback value 1", "S-0-0053, Position feedback value 2" or "S-0-0047, Position command value" are synchronous. This simplifies, among other things, emulation control, e.g. with the commissioning tool "IndraWorks Ds/D/MLD".

### Scaling-Dependent Emulation

If the option "motor reference" is set in parameter S-0-0076, emulation with relation to encoder is possible.

If the option "load reference" is set in parameter S-0-0076, the feed constant and gear ratio must be additionally entered according to the application.



The values for position feedback value 3 (measuring encoder) and master axis position are always emulated in encoder-related form. Parameter S-0-0076 in this case is irrelevant.

See also "Scaling of Physical Data"

## Establishing the Position Data Reference (Set Absolute Measuring)

Using parameter "P-0-0012, C0300 Set absolute position procedure command", it is possible to home the absolute position that is output by the absolute encoder emulator. When setting absolute measuring, the value of parameter "S-0-0052, Reference distance 1" is processed.

See also "Establishing Position Data Reference for Absolute Measuring Systems"

## 9.10.5 Notes on Commissioning

### General Information

In contrast to a "real" encoder, encoder emulation uses a simulated encoder. In motion the real encoder signal and the output of the emulator can differ. The causes for such differences can be:

- Application errors (e.g. inadequate wiring, exceeded frequencies, voltage dips, incorrect programming)
- Systematic errors due to the technical conditions (e.g. beat effects, position jitter)

The restrictions and limits described in the following sections have to be taken into account when encoder emulation is used.

### Restrictions of Incremental Encoder Emulation

In contrast to the conventional incremental encoder for which the pulse output frequency can be infinitely changed in fine increments (i.e. the pulses are always assigned to fixed positions), emulated incremental encoder signals are subject to certain restrictions which primarily result from the digital mode of operation of the drive controller.

#### Maximum Output Frequency

If the maximum pulse frequency is exceeded, pulses can be missing. A position offset of the emulated position in contrast to the real position occurs. Therefore, when the maximum pulse frequency is exceeded, the error message "F2053 Incr. encoder emulator: Pulse frequency too high" is output.

## Optional Device Functions



The max. output frequency always, i.e. independent of the selected number of lines, has to be taken into account for dimensioning the evaluation electronics.

The maximum output frequency  $f_{\max}$  depends on the hardware design and is reduced as the clock increase is increased (see P-0-0902):

- Clock increase of 8  $\rightarrow f_{\max} = 1 \text{ MHz}$
- Clock increase of 16  $\rightarrow f_{\max} = 500 \text{ KHz}$
- Clock increase of 32  $\rightarrow f_{\max} = 250 \text{ KHz}$

The maximum possible resolution of encoder emulation is scaling-dependent and calculated according to the following formulas:

$$\begin{aligned} \text{Linear scaling (P-0-0903)}_{\max} &= \frac{v_{\max}}{f_{\max}} \\ \text{Rotary scaling (P-0-0903)}_{\max} &= \frac{f_{\max}}{v_{\max}} \end{aligned}$$

P-0-0903

Encoder emulation resolution

$v_{\max}$

Demanded maximum velocity in mm/s or 1/s (For velocity in mm/min or 1/min, take factor 60 into account!)

$f_{\max}$

Allowed maximum frequency in Hz

Fig.9-92:

*Determining the Maximum Resolution of Encoder Emulation*

#### Delay Between Real and Emulated Position Value

Between the position detection and output of the emulated pulses there is a delay (dead time) between real and emulated position value.

#### Solution:

When incremental encoder emulation has been activated (see P-0-0902, bit 0 = 1), it is possible to activate dead time compensation in "P-0-0902, Encoder emulation control parameter" with bit 3 = 1. The dead time compensation is only effective and useful if there aren't any repeated acceleration and deceleration processes (ideal  $v = \text{constant}$ ).

#### Rounding Off the Number of Increments in Short Time Intervals

In a time interval of the internal control cycle  $T_A$  it is only possible to output an integer number of increments (1 increment =  $\frac{1}{4}$  line) at a time. The remainder that cannot be output is added in the next time interval. If there is another remainder of  $0 < \text{remainder} < 1$ , it is added again in the next interval etc.

This effect is the reason why the "emulated velocity" is exact on average, but can be by a maximum of **one increment too low** in each of the individual  $T_A$  time intervals.

#### Solution:

- Use the highest possible number of lines so that as many lines as possible can be output per control cycle  $T_A$ . The percentage error then is reduced accordingly.
- In addition, this effect can be reduced or nearly removed by means of the implemented, internal clock increase of the emulated signals (see P-0-0902, bits 8 and 9). By default, the clock increase has been set to factor 8. If required, it can be increased up to factor 32 which will clearly reduce the zero pulse and frequency jitter.



**Oscillating Signal Frequency Within One Output Cycle**

Due to the internal signal processing, the periodic time and duty cycle of the output signals are varying. The periodic time (or frequency) of the resulting cycles can therefore be shorter or longer, too.

This is why the signals of incremental emulation should **not** be used for measuring the speed by means of **frequency measurement**, but the signals may only be evaluated by **counting the increments**.

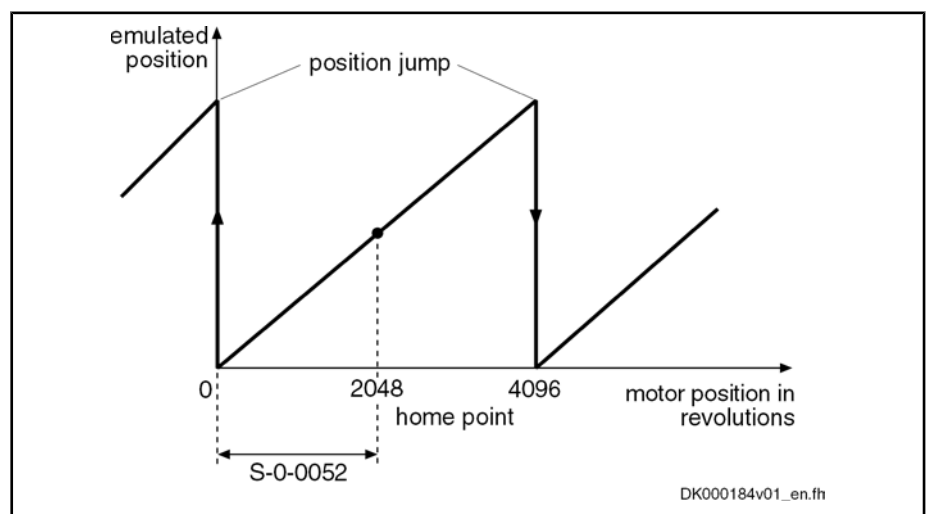
**Restrictions of Absolute Encoder Emulation**

Using absolute encoder emulation, it is possible to display 4096 revolutions in absolute form.

**Display Limits**

When using this kind of emulation at the display limits, small fluctuations of the actual position lead to overflow and a position jump in the emulated position.

This is the case, for example, at position 0 and 4096 revolutions after position zero.



S-0-0052 Reference distance 1

Fig.9-93: Display Limits With Absolute Encoder Emulation

This effect can be avoided by shifting the home point by executing "P-0-0012, C0300 Set absolute position procedure command".



**Note** By the respective setting in parameter "S-0-0052, Reference distance 1", shift the reference position to the middle of the display range. This allows moving 2048 revolutions to the left and to the right.

**Beat Effects in the Emulated Position**

In case the position processing in the control unit and the position detection (sampling) in the drive are not synchronized, beat effects can occur in the emulated signal with a periodic time according to the formula below, if the quartz frequencies on the drive and in the control unit cannot be exactly (integrally) divided:

$$T = \Delta t = \frac{1}{\Delta f}$$

T Periodic time for the occurring beat frequency  
 Δf Frequency deviation of the quartzes in control unit and drives

Fig.9-94: Determining the Periodic Time

## Optional Device Functions

This beat effect can be avoided by synchronizing the adjustment of the SSI emulation data in the drive to the SSI clock of the external control unit. The mechanism required for this purpose has to be activated via bit 10 of "P-0-0902, Encoder emulation control parameter".



Synchronization only works correctly, when the "sampling rate" of the external control unit is lower than the internal position loop clock which depends on the performance of the firmware variant used!

See "Performance Data"

---



You have to observe that the probe function (MT1) is occupied for this synchronization process and therefore no longer available for other purposes!

---

## 9.10.6 Diagnostic and Status Messages

The following diagnostic messages **can only occur with incremental encoder emulation**:

- **F2053 Incr. encoder emulator: Pulse frequency too high**
  - The output frequency resulting from the resolution that has been set (P-0-0903) and the travel velocity exceeds the value of the maximum pulse frequency of 1024 kHz.
- **F2054 Incr. encoder emulator: Hardware error**
  - At the end of each output interval (= position loop clock), a check is run to find out whether all increments to be output have been output before the next increment output is started. Exceeding the run time or hardware errors can cause overlapping that is detected during the check and signaled by this error message.
- **C0260 Incremental enc. emulator resol. cannot be displayed**
  - In the case of incremental encoder emulation, inadmissible overflow can occur for increment output. In order to avoid this overflow, P-0-0903 has to be parameterized accordingly.

## 9.11 Programmable Position Switch

### 9.11.1 Brief Description



Assignment to functional firmware package, see chapter "Availability of the Optional Device Functions".

---

The firmware function "programmable position switch" can be used instead of a mechanical position switch that has to be externally mounted.

- Features**
- Realization of a maximum of **8 dynamic position switch points** (switch cams) in the position loop clock
  - Freely **selectable reference signals** (P-0-0130) for generating the switch cams, all 8 cams are referring to the same signal (P-0-0131)
  - **Switch-on and switch-off position can be separately parameterized** via list parameters (P-0-0132, P-0-0133); corresponding position switch bit can be inverted by selecting the switch-on and switch-off threshold
  - **Lead time that can be separately parameterized** via list parameter (P-0-0134) for compensating internal processing times (dead time compensation)

- **8 position switch bits displayed** in the position switch status word (P-0-0135) which can be assigned to digital outputs or cyclically transmitted via master communication interface
- Permanently defined **switch hysteresis** to avoid position switch bit flicker when the switch-on or switch-off threshold is reached



"Programmable position switch" is a device function and therefore only available once for double-axis devices!

#### Pertinent Parameters

- P-0-0130, Position switch signal selection list
- P-0-0131, Position switch signal selection
- P-0-0132, Position switch switch-on threshold
- P-0-0133, Position switch switch-off thresholds
- P-0-0134, Position switch lead times
- P-0-0135, Position switch status word

#### Pertinent Diagnostic Messages

- C0242 Multiple configuration of a parameter (->S-0-0423)

## 9.11.2 Functional Description

### Basic Principle of Cam Generation

The basis of the "programmable position switch" function is the registration of the information whether the selected reference value is within the range between switch-on and switch-off threshold or not.

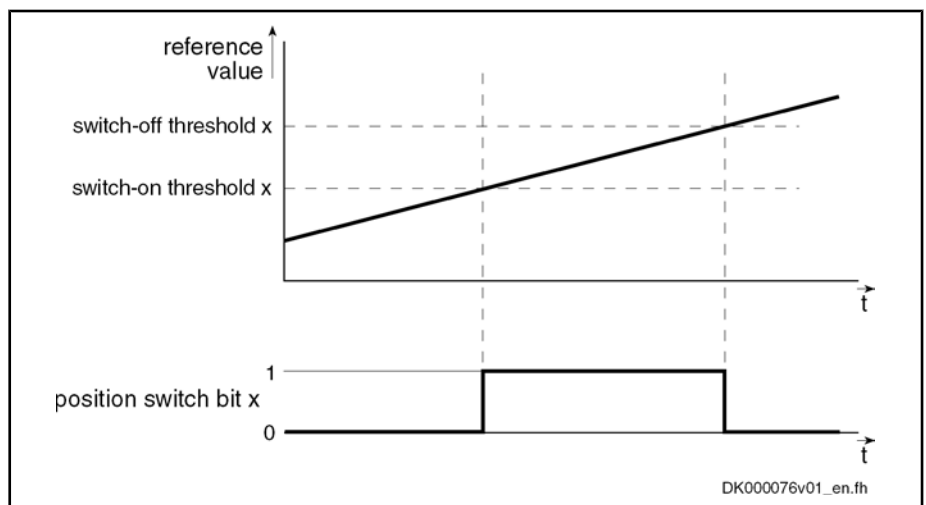


Fig.9-95: General Functional Principle of the Programmable Position Switch



By setting the switch-on and switch-off threshold the corresponding bit in the status word of the programmable position switch can be inverted.

We distinguish the following cases with regard to cam generation:

- Switch-on threshold < switch-off threshold
- Switch-on threshold > switch-off threshold

#### Switch-On Threshold Smaller than Switch-Off Threshold

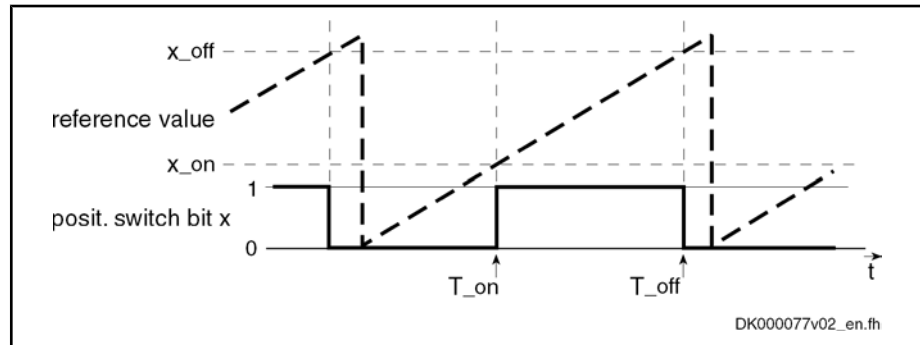
With "switch-on threshold < switch-off threshold" programmed, the position switch bit is set in parameter "P-0-0135, Position switch status word", if:

- Reference value > switch-on threshold [i] → P-0-0131 > P-0-0132 [i]

Optional Device Functions

- AND -

- Reference value < switch-off threshold [i] → P-0-0131 < P-0-0133 [i]



x\_on switch-on threshold of position switch (P-0-0132)

x\_off switch-off threshold of position switch (P-0-0133)

Fig.9-96: Position Switch bit With "Switch-on Threshold < Switch-off Threshold" (P-0-0132 [i] < P-0-0133 [i])

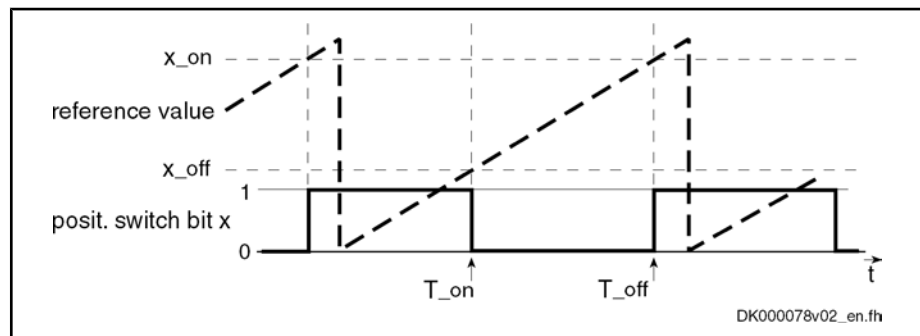
Switch-On Threshold Greater than Switch-Off Threshold

With "switch-on threshold > switch-off threshold" programmed, the position switch bit is set in parameter "P-0-0135, Position switch status word", if:

- Reference value > switch-on threshold [i] → P-0-0131 > P-0-0132 [i]

- OR -

- Reference value < switch-off threshold [i] → P-0-0131 < P-0-0133 [i]



x\_on switch-on threshold of position switch (P-0-0132)

x\_off switch-off threshold of position switch (P-0-0133)

Fig.9-97: Position Switch bit With "Switch-on Threshold > Switch-off Threshold" (P-0-0132 [i] > P-0-0133 [i])

Lead Time for Cam Generation

By setting a lead time the delay of an external switch element that is controlled by a position switch bit can be compensated. To do this, a theoretical correction value for the respective switch-on and switch-off threshold is calculated from the programmed lead time and the current drive velocity. The position switch bit switches by the lead time before reaching the corresponding threshold.



When using a lead time, the velocity of the drive in the (time) range between theoretical and actual switch-on and switch-off thresholds should be constant.

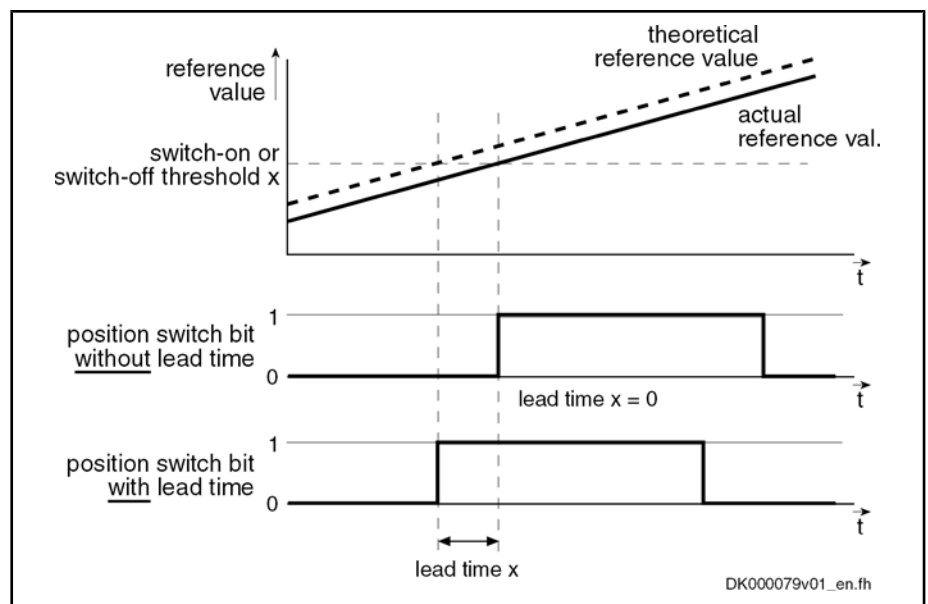


Fig.9-98: Functional Principle "Lead Time" for Programmable Limit Switch

### 9.11.3 Notes on Commissioning

#### General Information



The reference value selected in parameter "P-0-0131, Position switch signal selection" applies to all 8 cams, only the switch-on/switch-off thresholds and lead times can be individually parameterized for each cam!

#### Activating the Function and Signal Selection

To activate the position switch, the IDN of the parameter that maps the reference signal has to be entered in parameter "P-0-0131, Position switch signal selection".

The possible reference signals are given and listed in parameter "P-0-0130, Position switch signal selection list".



The units and attributes of the parameters P-0-0132 or P-0-0133 (switch-on threshold/switch-off threshold) depend on the signals selected in parameter "P-0-0131, Position switch signal selection"!



Inputting "S-0-0000" in parameter P-0-0131 deactivates the function!

#### Activation for Double-Axis Devices


For double-axis devices, the content of parameter P-0-0131 is available for both axes, but the configuration for P-0-0131 may only be made in one axis at a time.

#### Configuring Switch-On/Switch-Off Thresholds and Lead Time

The switch-on and switch-off thresholds and the corresponding lead time are parameterized via the following parameters:

- P-0-0132, Position switch switch-on threshold
- P-0-0133, Position switch switch-off thresholds
- P-0-0134, Position switch lead times

## Optional Device Functions

	Each of these list parameters contains 8 elements, element 1 being provided for position switch bit 1, element 2 for bit 2 etc.
<b>Determining the Switch-On/Switch-Off Thresholds</b>	According to the resolution of the measuring system, there must be a minimum distance between the switch-on and switch-off thresholds of the switch cams, as a switch hysteresis is internally used for generating the cam signal. For an MKD025 motor with 3-pin resolver this distance, for example, is at least 0.4°.
<b>Setting the Lead Time</b>	Parameter "P-0-0134, Position switch lead times" always should be parameterized completely (i.e. all 8 elements) even if the lead times are not used; if necessary, a lead time of "0" has to be entered.
	<hr/>
	 To compensate the internal processing dead time, a lead time of $t = T_{A\_position}$ has to be set!

## 9.11.4 Diagnostic and Status Messages

### Status Message of the Individual Cams

The status of the individual cam bits is displayed in parameter "P-0-0135, Position switch status word". The cams, beginning with bit 0, are assigned in ascending order (see Parameter Description P-0-0135).

### Error Message

In order to avoid multiple activation for double-axis devices, a check is run in the transition command P3 → P 4 to find out whether P-0-0131 ≠ S-0-0000 only has been configured once for each axis. Otherwise the error message "C0242 Multiple configuration of a parameter (->S-0-0423)" will be generated!

## 9.12 Probe Function

### 9.12.1 Brief Description



Assignment to functional firmware package, see chapter "Availability of the Optional Device Functions".

- Features**
- 2 probe inputs per axis; depending on the hardware design of the control section (CSH..., CSB..., CDB...) two rapid probe inputs or one rapid and one slow probe input
  - Measuring signals can be actual position values of motor encoder, external encoder or measuring encoder, in addition master axis position values
  - Simultaneous storage of two measuring signals when probe signal only via one probe input
  - For control sections with only one probe input (rapid digital input), another digital input can be used as probe input
  - Measurement of absolute actual position values, of actual position value differences, detection of time intervals between measuring signals
  - Measurement triggered by positive and/or negative probe signal edges
  - Single measurement or continuous measurement to be selected, measurement events are counted in the case of continuous measurement
  - Position value range ("expectation window") per probe can be defined within which measurement can take place (activation of a "failure counter" when expectation window is passed through without measuring event)
  - Quick stop triggered via probe input

- Sampling time for probe signals depends on performance which has been set or is available:
  - Approx. 0.0416  $\mu\text{s}$  for Advanced performance
  - Approx. 0.0833  $\mu\text{s}$  for standard performance
  - Approx. 0.1666  $\mu\text{s}$  for Economy performance

**Note:** For sufficient noise immunity, signal edge reversal must last for at least 4.0  $\mu\text{s}$  in order to be safely detected!

- dead time compensation can be set for every probe, separately for every positive or negative edge up to 50000 $\mu\text{s}$
- Accuracy of measurement depends on hardware design (see section "Probe" in the documentation "Control sections for drive controllers; project planning manual")

#### Hardware Requirements

The probe function is only possible in conjunction with control sections which have **at least one** "rapid" digital input.

A second, slower digital input (standard digital input) can be configured as probe input for BASIC control sections and for double axis control sections which have one "rapid" digital input per axis. Realize the assignment of this input for evaluation of probe 2 by means of corresponding parameter setting (see below).

The following control section designs are available:

- **No** rapid digital input ( $\rightarrow$  probe function **not** possible):
  - CSB01.1N-FC-...  $\rightarrow$  BASIC OPENLOOP
  - CSB01.1N-AN-...  $\rightarrow$  BASIC ANALOG
- **One** rapid digital input and **one** slow digital input **per axis**
  - CSB01.1N-SE-...  $\rightarrow$  BASIC SERCOS
  - CSB01.1N-PB-...  $\rightarrow$  BASIC PROFIBUS
  - CSB01.1C...  $\rightarrow$  BASIC UNIVERSAL (single-axis)
  - CDB01.1C-...  $\rightarrow$  BASIC UNIVERSAL (double-axis)
- **Two** rapid digital inputs:
  - CSH01.1C-...  $\rightarrow$  ADVANCED
  - IndraDrive Mi

The terminal designations of the "rapid" digital inputs are contained in section "I/O Extensions" in the documentation "Control Sections for Drive Controllers; Project Planning Manual".

#### Pertinent Parameters

- S-0-0130, Probe value 1 positive edge
- S-0-0131, Probe value 1 negative edge
- S-0-0132, Probe value 2 positive edge
- S-0-0133, Probe value 2 negative edge
- S-0-0169, Probe control parameter
- S-0-0170, Probing cycle procedure command
- S-0-0179, Probe status
- S-0-0401, Probe 1
- S-0-0402, Probe 2
- S-0-0405, Probe 1 enable
- S-0-0406, Probe 2 enable

## Optional Device Functions

- S-0-0409, Probe 1 positive latched
- S-0-0410, Probe 1 negative latched
- S-0-0411, Probe 2 positive latched
- S-0-0412, Probe 2 negative latched
- S-0-0426, Signal selection probe 1
- S-0-0427, Signal selection probe 2
- S-0-0428, Probe, IDN-list signal selection
- S-0-0524, Dead time compensation, positive edge, probe 1
- S-0-0525, Dead time compensation, negative edge, probe 1
- S-0-0526, Dead time compensation, positive edge, probe 2
- S-0-0527, Dead time compensation, negative edge, probe 2
- P-0-0200, Start position probe function 2 active
- P-0-0201, End position probe function 2 active
- P-0-0202, Difference probe values 1
- P-0-0203, Difference probe values 2
- P-0-0204, Start position probe function 1 active
- P-0-0205, End position probe function 1 active
- P-0-0206, Probe 1, max. number of marker failures
- P-0-0207, Probe 2, max. number of marker failures
- P-0-0224, Probe 1, number of marker failures
- P-0-0225, Probe 2, number of marker failures
- P-0-0226, Probe, extended control word
- P-0-0300, Digital I/Os, assignment list
- P-0-0301, Digital I/Os, bit numbers
- P-0-0302, Digital I/Os, direction

## Pertinent Diagnostic Messages

- A0403 Quick stop with probe detection is active
- C0250 Probe inputs incorrectly configured

## 9.12.2 Functional Description

### General Probe Function

The probe input evaluates the voltage level of the probe signal in digital form, i.e. only the signal states "high" (1) or "low" (0) are recognized. When the probe is activated, the signal status changes; the probe input signals a rising (positive) or falling (negative) switching edge.

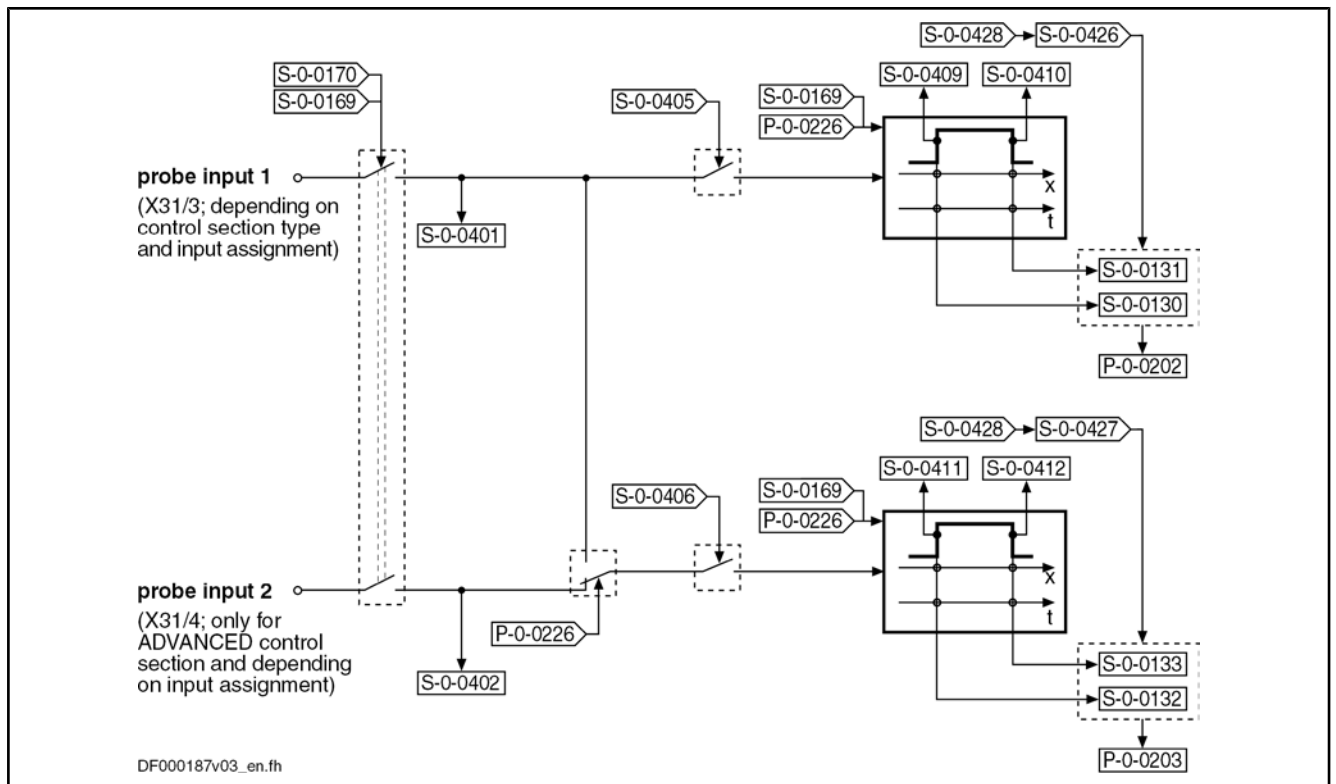


The ranges of the signal levels for "high" (1) and "low" (0) of the "rapid" digital inputs are described in the documentation "Project Planning Manual for Control Sections".

#### Operating Principle of Probe-Related Parameters

The figure below illustrates the operating principle of the probe-related parameters.





DF000187v03\_en.fh

S-0-0130	Probe value 1 positive edge
S-0-0131	Probe value 1 negative edge
S-0-0132	Probe value 2 positive edge
S-0-0133	Probe value 2 negative edge
S-0-0169	Probe control parameter
S-0-0170	Probing cycle procedure command
S-0-0401	Probe 1
S-0-0402	Probe 2
S-0-0405	Probe 1 enable
S-0-0406	Probe 2 enable
S-0-0409	Probe 1 positive latched
S-0-0410	Probe 1 negative latched
S-0-0411	Probe 2 positive latched
S-0-0412	Probe 2 negative latched
S-0-0426	Signal select probe 1
S-0-0427	Signal select probe 2
S-0-0428	Probe, IDN list signal selection
P-0-0202	Difference probe values 1
P-0-0203	Difference probe values 2
P-0-0226	Probe, extended control word

Fig.9-99: Overview and Operating Principle of Probe-Related Parameters

With active measured value detection (see below), the currently detected signal status at the respective probe input is displayed in the following parameters:

- S-0-0401, Probe 1
- S-0-0402, Probe 2

If both probe evaluations are triggered via probe input 1 (to be configured in parameter "P-0-0226, Probe, extended control word"), S-0-0402 is not written!

Optional Device Functions



The rapid digital inputs have to be assigned to the parameters S-0-0401 and S-0-0402 (default setting of parameter "P-0-0300, Digital I/Os, assignment list", etc.)!

If only one rapid digital input is available and another digital standard input is to be used as probe input 2, this input has to be assigned to bit 0 of parameter S-0-0402.

For assignment of digital inputs see "Digital Inputs/Outputs"

Activating the Measured Value Detection

A switching edge at the probe input can "trigger" the recording of a measured value. Switching edges, however, only cause a measured value to be recorded when the following requirements have been fulfilled:

- The presetting for measured value detection with positive and/or negative switching edge at the respective probe input was activated in "S-0-0169, Probe control parameter".
- The measured value detection was activated via "S-0-0170, Probing cycle procedure command". The following options are available to do this:
  - Directly write parameter S-0-0170 in the operating mode (OM)
  - Set bit 8 in "S-0-0169, Probe control parameter"
    - At the transition from parameter mode (PM) to operating mode (OM), command S-0-0170 is automatically set (see Parameter Description S-0-0169)
- The respective probe input for measured value detection was enabled (parameter "S-0-0405, Probe 1 enable" or "S-0-0406, Probe 2 enable").

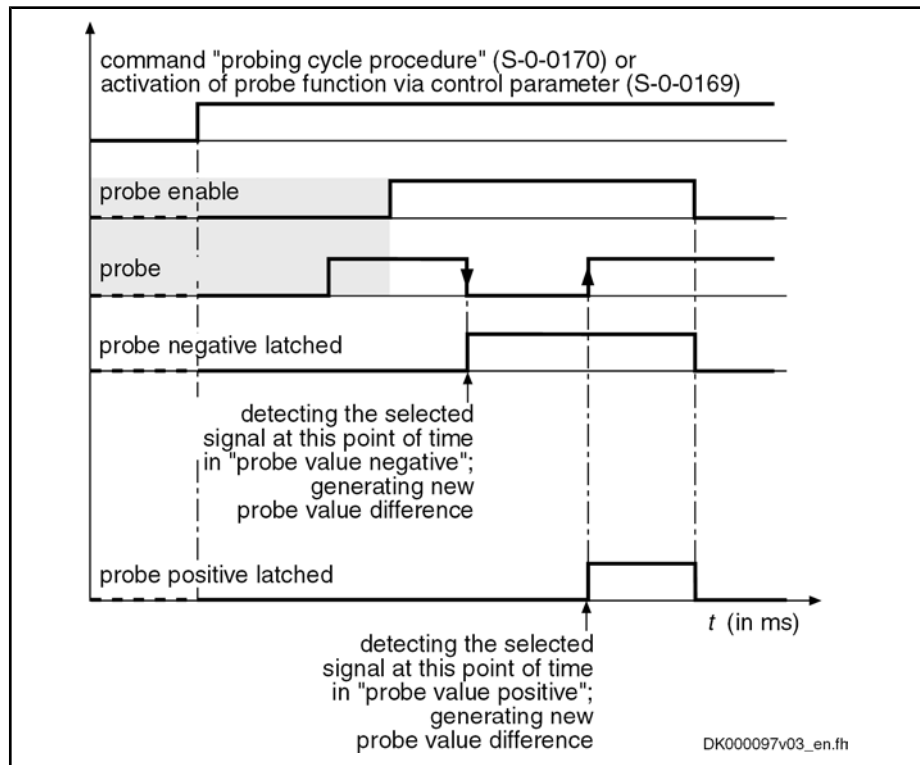


Fig.9-100: Evaluating the Probe Signal Edges (Evaluation of Positive and Negative Edges Activated in Parameter "S-0-0169, Probe Control Parameter")

Mode of Measured Value Recording

In parameter "S-0-0169, Probe control parameter", it is possible to set, separately for probe 1 and probe 2, in which mode the measurement is to take place. The measured value recording must have been activated.

The following enable modes are possible:

- **Single Measurement**  
→ After the respective probe has been enabled (S-0-0405 or S-0-0406), a value is only recorded at the first measured value trigger. Before every other measurement, repeated probe enable is required!
- **Continuous Measurement**  
After the respective probe has been enabled (S-0-0405 or S-0-0406), a new measured value is recorded at each measured value trigger.

#### Time Measurement, Monitoring, Simultaneous Triggering

In addition, other modalities of measured value detection can be preset in parameter "P-0-0226, Probe, extended control word" :

- Switching from position measurement to time measurement.
- Limitation of a range for actual position values ("expectation window") in which measurements can take place. A "trigger failure monitor" can be activated for the "expectation window" which registers the passing through of this range without probe event.
- Simultaneous triggering of both probe evaluations via probe input 1, e.g. for simultaneous position and time measurement.

#### Selecting the Measuring Signal

The selection of the signal the value of which is measured at the respective measured value trigger takes place by entering the respective IDN in the corresponding parameter

- S-0-0426, Signal selection probe 1
- S-0-0427, Signal selection probe 2

The IDNs of the parameters assigned to the selectable measuring signals are listed in parameter "S-0-0428, Probe, IDN-list signal selection":

- S-0-0051, Position feedback value 1
- S-0-0053, Position feedback value 2
- P-0-0052, Actual position value of measuring encoder
- P-0-0227, Cam table, access angle
- P-0-0753, Position actual value in actual value cycle
- P-0-0775, Resulting master axis position
- P-0-0776, Effective master axis position

Should the time measurement for a probe input have been activated in parameter "P-0-0226, Probe, extended control word", the signal selection made for this probe is inactive.



The time measurement is only relative! The generation of the measured value difference (P-0-0202, P-0-0203, see below) therefore is especially advantageous for the time measurement. Depending on the available hardware and firmware, as well as the performance setting in parameter "P-0-0556, Config word of axis controller", the following time differences can be measured (time in  $\mu$ s):

- Time differences up to 1000 s for Economy performance
- Time differences up to 1000 s for Basic performance
- Time differences up to 500 s for Advanced performance

#### Storing Measured Values and Measured Value Differences

Depending on the switching edge of the probe signal that was activated as measured value trigger (setting in S-0-0169), the measured value of the signal selected from the list parameter S-0-0428 is stored in one of the following parameters:

## Optional Device Functions

- S-0-0130, Probe value 1 positive edge
- S-0-0131, Probe value 1 negative edge
- S-0-0132, Probe value 2 positive edge
- S-0-0133, Probe value 2 negative edge

In the case of continuous measurement, as in the case of single measurement, the difference from the last two measured values of the same probe, that were measured with opposed (positive/negative/positive ...) measured value trigger, is always generated in addition (setting in S-0-0169). This difference is stored in the corresponding parameter:

- P-0-0202, Difference probe values 1
- P-0-0203, Difference probe values 2

**Measured Value Status**

With each measuring event, a status information is generated and incremented for each probe, depending on the polarity of the respective measured value trigger. This is particularly advantageous for continuous measurement in order to detect new measuring events. This status information is stored in the corresponding parameter:

- S-0-0409, Probe 1 positive latched
- S-0-0410, Probe 1 negative latched
- S-0-0411, Probe 2 positive latched
- S-0-0412, Probe 2 negative latched



By integration of the probe status information and the measured values or measured value differences in the cyclic data of the master communication, the current measuring processes are signaled to the control master and the corresponding measured values are supplied.

**Accuracy**

The controller generates the actual position values, depending on the available hardware and firmware as well as the performance setting in parameter "P-0-0556, Config word of axis controller", on a fixed time base:

- 1000  $\mu$ s for economy performance
- 500  $\mu$ s for basic performance
- 250  $\mu$ s for advanced performance

The measured signal value or relative time value corresponding to the time of the signal edge is determined by linear interpolation between the last and the next measured signal value or relative time value generated by the controller.

The accuracy of the measurement result depends mainly on the hardware used (controller type and periphery connected to the probe input, such as sensors, switches or line capacities). Depending on the controller type, a certain dead time is added to signal edge detection. This dead time is partly compensated by the firmware. The dependency of the measuring accuracy on the controller type A design is described in section "Probe" in the documentation "Control Sections for Drive Controllers; Project Planning Manual".

The additional dead time resulting from the connected periphery can also be compensated by the drive firmware for each edge of a probe within a range of up to 50000 $\mu$ s by presetting in the parameters

- S-0-0524, Dead time compensation, positive edge, probe 1
- S-0-0525, Dead time compensation, negative edge, probe 1
- S-0-0526, Dead time compensation, positive edge, probe 2
- S-0-0527, Dead time compensation, negative edge, probe 2

**Restart or Deactivation of Measured Value Recording**

A restart of the single measurement or the continuous measurement is triggered by resetting (1 → 0) and repeated setting (0 → 1) of the parameters for probe enable:

- S-0-0405, Probe 1 enable
- S-0-0406, Probe 2 enable

When doing this, the following data are cleared:

- Information on probe value trigger status (S-0-0409/S-0-0410 or S-0-0411/S-0-0412) and bits for respective probe in parameter "S-0-0179, Probe status"
- The counter in parameter "P-0-0224, Probe 1, number of marker failures" or "P-0-0225, Probe 2, number of marker failures" (see below)



By activating or deactivating the probe evaluation ("S-0-0170, Probing cycle procedure command" or via corresponding bit in "S-0-0169, Probe control parameter"), reinitialization (resetting all bits in parameter "S-0-0179, Probe status") is carried out.

**Using the "Expectation Window"**

The position range of an axis or shaft within which probe signal edges cause measured values to be recorded can be limited. In the case of limitation, measured value trigger signals are only expected within position limits that can be set, this range is therefore called "expectation window". The measured value detection limited to the "expectation window" is activated in parameter "P-0-0226, Probe, extended control word".

Detecting marker failures with activated "expectation window":

- If the actual position value is outside of the "expectation window", probe signal edges do not cause measured values to be recorded!

If no "marker" was detected causing a measuring value trigger, after completely passing through the expectation windows (both position limits exceeded), this status can be stored and displayed in parameter "P-0-0224, Probe 1, number of marker failures" or "P-0-0225, Probe 2, number of marker failures". For this purpose, it is necessary to activate the option "marker failure monitoring" in parameter P-0-0226! In case of recurrence, the value of P-0-0224 or P-0-0225 is incremented. When the value of P-0-0224 or P-0-0225 has reached a threshold that the user can set ("P-0-0206, Probe 1, max. number of marker failures" or "P-0-0207, Probe 2, max. number of marker failures"), one bit per probe is set in parameter "S-0-0179, Probe status".

- By registering a measured value trigger within the "expectation window", the value in parameter "P-0-0224, Probe 1, number of marker failures" or "P-0-0225, Probe 2, number of marker failures" is cleared.



The "expectation window" cannot be used with "time measurement"!

**Marker Detection**

The requirement for detecting a "marker" is determined by activating positive and/or negative signal edge for probe 1 or probe 2. A "marker" is detected when, while the measuring signal was passing through the complete "expectation window", the following event occurred depending on the setting in parameter "S-0-0169, Probe control parameter":

- At "activation negative edge of probe", a negative signal edge was detected
- At "activation positive edge of probe", a positive signal edge was detected

Optional Device Functions

- At "activation positive and negative edge of probe", positive and negative signal edges were detected



When the measuring signal only enters the "expectation window" and leaves it on the same side, all detected signal edges are cleared. The parameter values of the marker failure counters P-0-0224 and P-0-0225, however, aren't changed!

**Setting the Expectation Window**

The limitation values for the "expectation window" are set in the following parameters.

Setting for probe 1:

- P-0-0204, Start position probe function 1 active
- P-0-0205, End position probe function 1 active

Setting for probe 2:

- P-0-0200, Start position probe function 2 active
- P-0-0201, End position probe function 2 active

The "expectation window" has to cover a minimum range so that at least one actual position value generation can take place within the window after the probe signal edge has been detected:

Probe 1 $s_{\min} = (P-0-0205) - (P-0-0204) \geq v_{\max} \times \Delta t$ Probe 2 $s_{\min} = (P-0-0201) - (P-0-0200) \geq v_{\max} \times \Delta t$
--

$s_{\min}$	Minimum value for "expectation window"
P-0-0205	End position probe function 1 active
P-0-0204	Start position probe function 1 active
P-0-0201	End position probe function 2 active
P-0-0200	Start position probe function 2 active
$v_{\max}$	Maximum velocity of the axis with activated measured value detection (select time reference of v-unit as for $\Delta t$ -unit!)
$\Delta t$	$1.00 \times 10^{-3}$ s for Economy performance; $0.50 \times 10^{-3}$ s for Basic performance; $0.25 \times 10^{-3}$ s for Advanced performance (see P-0-0556)

*Fig.9-101: Determining the Minimum Value for the "Expectation Window"*

In the case of modulo scaling of the position data, a maximum value for the "expectation window" mustn't be exceeded, as otherwise it exceeds the modulo value range and therefore is without effect:

$s_{\max} = (S-0-0103) - s_{\min}$
------------------------------------

$s_{\max}$	Maximum value for "expectation window"
$s_{\min}$	Minimum value for "expectation window"
S-0-0103	Modulo value

*Fig.9-102: Determining the Maximum Value for the "Expectation Window" With Modulo Scaling*

**Quick Stop via Probe Input**

The edge reversal of a digital voltage signal can trigger the quick stop of an axis, if the drive is ready for this action. For quick stop, a velocity command value reset is internally triggered which causes the axis to decelerate. The following conditions are taken into account in this case:

- The current torque/force limit value for drives in closed-loop operation

- The maximum stator frequency slope (P-0-0569) for drives in U/f operation or in sensorless, flux-controlled motor operation

When the drive has detected the quick stop signal, it ignores the setting of command values by the control master, decelerates in a drive-controlled way and remains in a drive-internal operating mode until the readiness for quick stop is reset.

To keep the delay between edge reversal of the signal and triggering of quick stop as short as possible, the rapid digital input for probe 1 is used for this function.

The rapid digital input (probe input 1) evaluates the voltage level of the stop signal in digital form, i.e. only the signal states "high" (1) or "low" (0) are recognized.

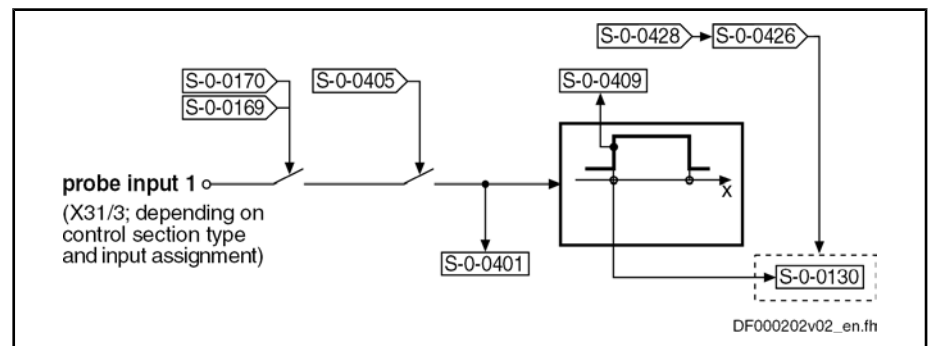
Quick stop is triggered at a rising (positive) switching edge.



The ranges of the signal levels for "high" (1) and "low" (0) of the "rapid" digital inputs are described in the section "I/O Extensions" in the documentation "Control Sections for Drive Controllers; Project Planning Manual".

**Operating Principle of Relevant Parameters**

The figure below illustrates the interaction of the parameters relevant for quick stop via probe input:



S-0-0130	Probe value 1 positive edge
S-0-0169	Probe control parameter
S-0-0170	Probing cycle procedure command
S-0-0401	Probe 1
S-0-0405	Probe 1 enable
S-0-0409	Probe 1 positive latched
S-0-0426	Signal select probe 1
S-0-0428	Probe, IDN list signal selection

Fig.9-103: Overview and Operating Principle of Parameters Relevant for Quick Stop via Probe

The currently detected signal status at the rapid digital input is displayed in parameter "S-0-0401, Probe 1", when readiness for quick stop (see below) is given.



The rapid digital input (probe 1) must have been assigned to parameter S-0-0401 (default setting of "P-0-0300, Digital I/Os, assignment list", etc.)!

See "Digital Inputs/Outputs"

**Selecting the Measuring Signal**

The status variable the value of which is measured when the quick stop edge is read, is selected by inputting the respective IDN in parameter "S-0-0426, Signal selection probe 1".

The IDNs of the selectable parameters assigned to the status variables are listed in "S-0-0428, Probe, IDN-list signal selection".

Optional Device Functions

**Storing Measured Values**

The value of the signal selected from list parameter S-0-0428 is stored in parameter "S-0-0130, Probe value 1 positive edge" when the signal edge occurs.

**Activating the Readiness for Quick Stop**

A positive switching edge (0 → 1) at the rapid digital input (probe input 1) triggers quick stop, when the following conditions have been fulfilled:

- Readiness for quick stop was activated by:
  - Starting "S-0-0170, Probing cycle procedure command"
  - or -
  - Setting the bit "activation of probe function" in "S-0-0169, Probe control parameter"
- Enabling of rapid digital input (probe 1) for signal evaluation in parameter "S-0-0405, Probe 1 enable"

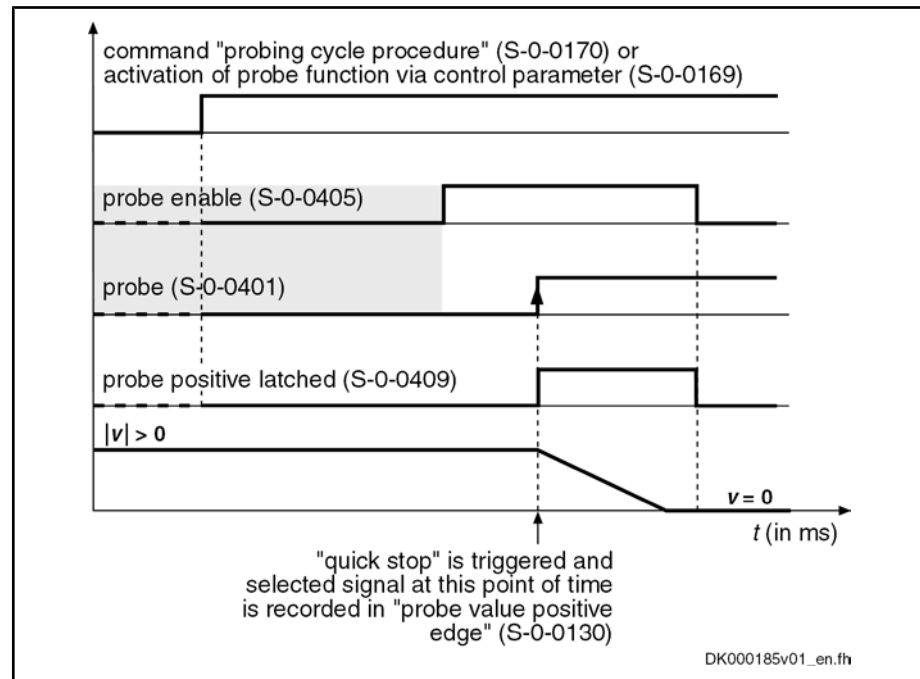


Fig.9-104: Evaluating the Signal for the Quick Stop Function

**Executing the Quick Stop Function**

The readiness for quick stop and the detection of the quick stop signal internally trigger the speed command value reset which causes the axis to be shut down. This happens taking the following values into account:

- The current torque/force limit value for drives in closed-loop operation
- The maximum stator frequency slope (P-0-0569) for drives in open-loop operation

In the case of quick stop, the drive ignores the setting of command values by the control master, decelerates in a drive-controlled way and remains in a drive-internal operating mode until the readiness for quick stop is reset. Quick stop is displayed by the drive by means of diagnostic status message "A0403 Quick stop with probe detection is active" in parameter "S-0-0095, Diagnostic message" and by means of the **operation status "AR" in the display** of the control panel.

**Behavior After Deactivation of Quick Stop Function**

At deactivation of the readiness for quick stop, the drive leaves the quick stop status and again follows the command value of the control master.



## 9.12.3 Notes on Commissioning

### Commissioning the Probe Function

<b>Presettings</b>	<p>Make the following settings in "S-0-0169, Probe control parameter":</p> <ul style="list-style-type: none"> <li>• Evaluation of probe signal edge as measured value trigger</li> <li>• Select enabling mode of probe (single measurement or continuous measurement)</li> </ul> <p>Make further settings in parameter "P-0-0226, Probe, extended control word":</p> <ul style="list-style-type: none"> <li>• Activation of expectation window and failure monitor</li> <li>• Activation of time measurement</li> <li>• Simultaneous triggering of both probe evaluations by probe 1</li> </ul> <p>How to assign a digital standard input to parameter "S-0-0402, Probe 2", if the rapid digital input (maybe the only one available) is not sufficient:</p> <ul style="list-style-type: none"> <li>• In parameter "P-0-0300, Digital I/Os, assignment list", assign the respective digital input to parameter S-0-0402</li> <li>• In parameter "P-0-0301, Digital I/Os, bit numbers", enter the bit number (bit 0) to be written in parameter S-0-0402</li> <li>• Configure connection of the digital input/output as input via parameter "P-0-0302, Digital I/Os, direction", if it is bidirectional</li> </ul> <p>Select measuring signals from "S-0-0428, Probe, IDN-list signal selection"; enter the selected parameters in:</p> <ul style="list-style-type: none"> <li>• S-0-0426, Signal selection probe 1</li> <li>• S-0-0427, Signal selection probe 2</li> </ul>
<b>Activating the Measurement</b>	<p>The measured value detection can be activated via:</p> <ul style="list-style-type: none"> <li>• "S-0-0170, Probing cycle procedure command" (only in operating mode)</li> </ul> <p>- or -</p> <ul style="list-style-type: none"> <li>• "S-0-0169, Probe control parameter" (bit 8) → S-0-0170 is automatically activated during transition PM → OM</li> </ul> <p>Then enable the probe input for triggering the measured value recording:</p> <ul style="list-style-type: none"> <li>• S-0-0405, Probe 1 enable</li> <li>• S-0-0406, Probe 2 enable</li> </ul>
<b>Single Measurement</b>	<p>Every repeated "single measurement" has to be enabled by resetting and repeatedly setting S-0-0405 or S-0-0406.</p>
<b>Continuous Measurement</b>	<p>If enabling of the probes via S-0-0405 or S-0-0406 has been set with "continuous measurement", a measured value is stored at every measured value trigger. How many measured values were stored by positive or negative trigger of the respective probe, is contained in the status information on the measured value trigger (see below "Identifying the Measured Value Detection").</p>
<b>Identifying the Measured Value Detection</b>	<p>When a measuring event took place, the measured value trigger status is updated, i.e. the value of the respective parameter is incremented, starting with the value "0":</p> <ul style="list-style-type: none"> <li>• S-0-0409, Probe 1 positive latched</li> <li>• S-0-0410, Probe 1 negative latched</li> <li>• S-0-0411, Probe 2 positive latched</li> <li>• S-0-0412, Probe 2 negative latched</li> </ul> <p>The corresponding measured value is stored in:</p>

## Optional Device Functions

- S-0-0130, Probe value 1 positive edge
- S-0-0131, Probe value 1 negative edge
- S-0-0132, Probe value 2 positive edge
- S-0-0133, Probe value 2 negative edge

In addition, after recording of a new measured value, the difference from the measured values of the positive and negative edges is automatically generated and the absolute value is stored:

$$P-0-0202 = |(S-0-0130) - (S-0-0131)|$$

$$P-0-0203 = |(S-0-0132) - (S-0-0133)|$$

P-0-0202	Difference probe values 1
S-0-0130	Probe value 1 positive edge
S-0-0131	Probe value 1 negative edge
P-0-0203	Difference probe values 2
P-0-0132	Probe value 2 positive edge
P-0-0133	Probe value 2 negative edge

Fig.9-105: Subtraction of the Measured Values



The differences from the measured values of the positive and negative edges are always generated, even if only one edge polarity has been activated for the measured value trigger!

## Setting the "Expectation Window"

Set the limits of the "expectation window" taking the minimum value and, if necessary, the maximum value (for modulo scaling) into account. The "expectation window" must have been activated in parameter P-0-0226.

Setting for probe 1:

- P-0-0204, Start position probe function 1 active
- P-0-0205, End position probe function 1 active

Setting for probe 2:

- P-0-0200, Start position probe function 2 active
- P-0-0201, End position probe function 2 active

If "marker failure monitoring" has been activated (P-0-0226), the number of times the "expectation window" is passed through without marker detection is displayed in:

- P-0-0224, Probe 1, number of marker failures
- P-0-0225, Probe 2, number of marker failures

The user can set a threshold for the counted marker failures:

- P-0-0206, Probe 1, max. number of marker failures
- P-0-0207, Probe 2, max. number of marker failures

When the number of marker failures has reached the threshold, the respective bit is set in:

- S-0-0179, Probe status

## Resetting

The measuring data, the measured value trigger status and the information on the marker failure are cleared by writing data to:

- S-0-0405, Probe 1 enable
- S-0-0406, Probe 2 enable

- S-0-0170, Probing cycle procedure command

All detected information on failed markers is cleared by writing data to:

- P-0-0226, Probe, extended control word

## Commissioning Quick Stop via Probe Input

<b>Requirements</b>	The probe function must have been parameterized for probe 1 with evaluation of positive edge (see "General Probe Function"). To use quick stop, additionally make the following setting in parameter "P-0-0226, Probe, extended control word": <ul style="list-style-type: none"> <li>• Set bit for activation "quick stop via probe input 1"</li> </ul> From "S-0-0428, Probe, IDN-list signal selection", you can select the parameter of the measuring signal the value of which is stored when the quick stop signal is read. Enter the selected parameter in: <ul style="list-style-type: none"> <li>• S-0-0426, Signal selection probe 1</li> </ul>
<b>Activating the Readiness for Quick Stop</b>	With the corresponding presetting, the readiness for quick stop can now be activated via the enable signal of the rapid digital input (probe 1) by setting: <ul style="list-style-type: none"> <li>• S-0-0405, Probe 1 enable</li> </ul>
<b>Measured Value at Quick Stop Request</b>	When quick stop is executed, the measured value belonging to the quick stop signal edge is stored in: <ul style="list-style-type: none"> <li>• S-0-0130, Probe value 1 positive edge</li> </ul>
<b>Deactivation</b>	The quick stop situation or the readiness for quick stop is deactivated by <ul style="list-style-type: none"> <li>• Resetting "S-0-0405, Probe 1 enable"</li> </ul> - or - <ul style="list-style-type: none"> <li>• Deactivating "S-0-0170, Probing cycle procedure command"</li> </ul> - or - <ul style="list-style-type: none"> <li>• Resetting bit 8 in "S-0-0169, Probe control parameter"</li> </ul> → Function only deactivated when changing to parameter mode



If the control master operates the drive in cyclic position control, set the actual position value of the drive as start value for the cyclic position command values, when the quick stop function is deactivated!

## 9.13 Measuring Encoder

### 9.13.1 Brief Description



Assignment to functional firmware package, see chapter "Availability of the Optional Device Functions".

<b>Position Measurement</b>	Measuring encoders are used for position evaluation of a rotary motion that takes effect as a command variable for drive control. The actual position value of the measuring encoder therefore is of command value nature for drive control, the measuring encoder acts as a master axis encoder, for example.
<b>Evaluating Position Measurement</b>	Depending on its design and the mechanical arrangement at the axis, the measuring encoder can be evaluated as <ul style="list-style-type: none"> <li>• Relative encoder (incremental encoder)</li> </ul> - or - <ul style="list-style-type: none"> <li>• Absolute encoder (absolute value encoder).</li> </ul>

## Optional Device Functions

**Relative Position Measurement** In the case of relative position measurement, only position differences can be evaluated by means of the measuring system. The actual position values signaled by the measuring system refer to the (mostly undefined) position at the time the drive is switched on. If the actual position value is to refer to an axis or shaft, it is necessary to establish position data reference ("homing").

**Absolute Position Measurement** In the case of absolute position measurement, the encoder signals actual position values with a fixed encoder-dependent reference point to the controller. After the drive is switched on, the correct actual position value is immediately available for each axis or shaft position. Due to the mostly undefined mounting situation of the encoder, it is necessary during initial commissioning to once adjust the actual position value to the axis or shaft ("set absolute measuring").

**Precision, Resolution** The precision of the position measurement depends on

- the resolution of the measuring system (division periods = DP),
- the absolute encoder precision,
- the digitalization quality of the analog encoder signals,
- the size of the selected modulo range of the encoder.

**Monitoring Functions** The correct position information of the measuring encoder is required for correct recording of a command variable. The encoder signals are therefore monitored for validity and compliance with the allowed tolerances.

In addition, it is possible to monitor drives with an encoder that can be evaluated in absolute form for compliance with the position when switching on compared to the last time the drive was switched off.

See "Monitoring the Measuring Systems"

**Hardware Requirements** For connecting the measuring systems to the controller, the control section has to be equipped with the corresponding interfaces. Parameter "P-0-0079, Assignment measuring encoder->optional slot" is used to determine the interface to which the respective encoder is connected.

For controllers with a double-axis control section (CDB01.1-...), it is only possible to assign a measuring encoder to one axis. The assignment is made in parameter "P-0-0076, Encoder type 3 (measuring encoder)". If a measuring encoder was assigned to both axes, an error message will be displayed!



See also separate documentation "Drive Controllers, Control Sections; Project Planning Manual"

**Pertinent Parameters**

- P-0-0052, Actual position value of measuring encoder
- P-0-0076, Encoder type 3 (measuring encoder)
- P-0-0079, Assignment measuring encoder->optional slot
- P-0-0084, Number of bits per master axis revolution
- P-0-0087, Actual position value offset of measuring encoder
- P-0-0097, Absolute encoder monitoring window for measuring encoder
- P-0-0127, Input revolutions of measuring gear
- P-0-0128, Output revolutions of measuring gear
- P-0-0179, Absolute encoder buffer 3 (measuring encoder)
- P-0-0326, Multiplication of measuring encoder
- P-0-0327, Encoder resolution of measuring encoder
- P-0-0328, Type of position encoder for measuring encoder
- P-0-0329, Smoothing of actual position value 3 of measuring encoder

- P-0-0330, Control word of measuring encoder
  - P-0-0331, Status of measuring encoder
  - P-0-0332, Actual velocity value of measuring encoder
  - P-0-0334, Absolute encoder range of measuring encoder
  - P-0-0347, Encoder 3, cosine signal
  - P-0-0348, Encoder 3, sine signal
  - P-0-0765, Modulo factor measuring encoder
  - P-0-1020, Kind of encoder 3, encoder memory
  - P-0-1021, Encoder 3 resolution, encoder memory
  - P-0-1022, Absolute encoder offset 3, encoder memory
- Pertinent Diagnostic Messages**
- C0161 Incorr. parameterization of measuring enc. (hardware)
  - C0162 Measuring encoder unknown
  - C0163 Modulo value for measuring encoder cannot be displayed
  - C0227 Error when initializing position of measuring encoder
  - C0228 Initialization velocity measuring encoder too high
  - E2076 Measuring encoder: Encoder signals disturbed
  - F2043 Measuring encoder: Encoder signals incorrect
  - F2076 Actual pos. value 3 outside absolute encoder window
  - F2176 Loss of measuring encoder reference
  - F2179 Modulo limitation error of measuring encoder

## 9.13.2 Functional Description

### Basics on Measuring Encoder, Resolution

The measuring encoder is mechanically connected to an axis or shaft and detects its position data. These position data can be used as measured values or command variable, but not as control variable.

**Encoders to be Used** Only rotary encoders can be used as measuring encoders. The assignment is made in parameter "P-0-0076, Encoder type 3 (measuring encoder)".

**Scaling of Measuring Encoder Position Data** The scaling of the position data generated with a measuring encoder is rotary and axis- or shaft-related. Due to the infinite motion range of the measuring encoder and the limited value range of the position data, modulo scaling is set automatically.

See also "Scaling of Physical Data"

The modulo range can only be selected as an integral multiple of an axis- or shaft-side revolution and has an upper limit:

Modulo range =  $n \times$  (axis or shaft revolutions)

$$n = (P-0-0765) \leq 2^{31-(P-0-0084)} - 1; \quad n \in \mathbf{N}$$

$$\text{If } (P-0-0765) = 0 \rightarrow n = 2^{32-(P-0-0084)}$$

n                      Number of revolutions at axis or shaft  
P-0-0084              Number of bits per master axis revolution  
P-0-0765              Modulo factor measuring encoder  
*Fig. 9-106:            Modulo Range at Axis or Shaft*

Optional Device Functions

**Absolute Precision of Measuring Encoder**

The absolute precision is a feature of the encoder and is determined by its construction and the quality of its components. The data for the absolute precision are indicated by the manufacturer.

**Resolution (Division Periods)**

The resolution of the measuring system (division periods or cycles per encoder revolution) is input in parameter

- P-0-0327, Encoder resolution of measuring encoder.

**Maximum Measuring Encoder Resolution After Digitalization**

The analog encoder signals are converted to digital position data via A/D converter. This increases the resolution of the position data available for the axis compared to the resolution of the measuring system (see above)!

$$\text{Measuring encoder (rotary only): } (P-0-0327) \times 2^{15}$$

P-0-0327 Encoder resolution of measuring encoder  
 Fig. 9-107: *Maximum Possible Encoder Resolution of Measuring Encoder per Encoder Revolution*

**Value Range of Position Data**

The value range of the position data of the measuring encoder depends on the modulo factor of the measuring encoder (P-0-0765):

$$\begin{aligned} \text{Modulo range} &= n \times 2^{(P-0-0084)} (\text{increments}) \\ n = (P-0-0765) &\leq 2^{31-(P-0-0084)} - 1; \quad n \in \mathbf{N} \\ \text{If } (P-0-0765) &= 0 \rightarrow n = 2^{32-(P-0-0084)} \end{aligned}$$

n Number of revolutions at axis or shaft  
 P-0-0084 Number of bits per master axis revolution  
 P-0-0765 Modulo factor measuring encoder  
 Fig. 9-108: *Modulo Value Range at Axis or Shaft*

Depending on "P-0-0327, Encoder resolution of measuring encoder" and the gear ratio of the measuring encoder (P-0-0127, P-0-0128), a multiple of position data results from one division period of the measuring encoder due to digitalization. By adjusted multiplication, the available range of measuring encoder position data of  $(2^{30}-1)$  values is observed.

**Drive-Internal Resolution of Measuring Encoder Position Data**

The resulting drive-internal encoder resolution is as follows:

$$\begin{aligned} \text{Measuring encoder resolution} &= (P-0-0326) \times (P-0-0327) \\ \text{internal limitation:} \\ P-0-0326 &= 2^{30} \times \frac{(P-0-0128)}{(P-0-0127) \times (P-0-0327) \times (P-0-0765)} \leq 2^n \\ n &\leq 15 (\text{in round numbers}) \end{aligned}$$

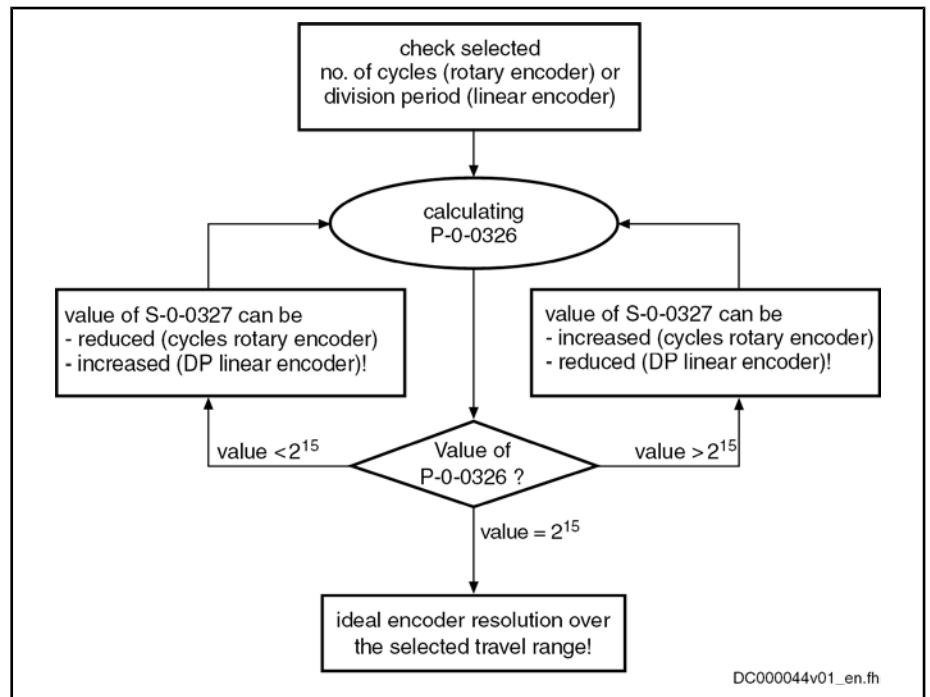
P-0-0326 Multiplication of measuring encoder  
 P-0-0327 Encoder resolution of measuring encoder  
 P-0-0128 Output revolutions of measuring gear  
 P-0-0127 Input revolutions of measuring gear  
 P-0-0327 Encoder resolution of measuring encoder  
 P-0-0765 Modulo factor measuring encoder  
 n Number of revolutions at axis or shaft  
 Fig. 9-109: *Drive-Internal Measuring Encoder Resolution*



The multiplication of the measuring encoder (P-0-0326) is determined automatically and drive-internally!

**Encoder Dimensioning**

The multiplication value (P-0-0326) calculated according to the formulas "drive-internal measuring encoder resolution" characterizes the encoder dimensioning.



P-0-0326  
P-0-0327

Multiplication of measuring encoder  
Encoder resolution of measuring encoder

Fig. 9-110:

*Checking the Selected Resolution and Determining the Ideal Resolution for the Measuring Encoder*



The value of P-0-0326 calculated according to the formulas "drive-internal measuring encoder resolution" normally will never be exactly  $2^{15}$  (= 32768). With results that are, depending on the encoder, as little as possible greater than  $2^{15}$ , the conditions with regard to the selected number of cycles and the possibilities of encoder evaluation are ideal!

**Real Resolution of Measuring Encoder**

The lower value from "drive-internal resolution of master axis position data" and "maximum measuring encoder resolution after digitalization" is the real resolution of the position data.

**Smoothing the Actual Measuring Encoder Position Value**

The actual position value of the measuring encoder (P-0-0052) can be smoothed via a filter. The time constant of smoothing is entered in parameter "P-0-0329, Smoothing of actual position value 3 of measuring encoder". Smoothing can also be deactivated (see Parameter Description).

**Velocity of the Axis or Shaft to be Measured**

The velocity of the axis or shaft to be measured is displayed in parameter "P-0-0332, Actual velocity value of measuring encoder". The scaling of the velocity is axis or shaft revolutions per minute.

**Monitoring Functions for Measuring Encoder**

For the measuring encoder there are signal monitoring functions that are corresponding to the monitoring functions for motor encoder and optional encoder. The drive, however, outputs warnings or error messages specific to the measuring encoder.

See "Monitoring the Measuring Systems"

## Optional Device Functions

<b>Signal Monitoring for Sine Encoders</b>	<p>For signal monitoring of sine encoders as measuring encoders the following diagnostic messages can be generated:</p> <ul style="list-style-type: none"> <li>• E2076 Measuring encoder: Encoder signals disturbed</li> <li>• F2043 Measuring encoder: Encoder signals incorrect</li> </ul>
<b>Monitoring the Axis or Shaft Position</b>	<p>When the drive is switched off, the current encoder data of an absolute measuring encoder are stored in parameter</p> <ul style="list-style-type: none"> <li>• P-0-0179, Absolute encoder buffer 3 (measuring encoder).</li> </ul> <p>When switching on a drive with an absolute measuring encoder, a check is run to determine in how far the current actual position value of the measuring encoder differs from the actual position value at the time the drive was switched off the last time. The maximum allowed difference is determined in parameter</p> <ul style="list-style-type: none"> <li>• P-0-0097, Absolute encoder monitoring window for measuring encoder.</li> </ul> <p>If the difference exceeds the determined value, the following error message is output:</p> <ul style="list-style-type: none"> <li>• F2076 Actual pos. value 3 outside absolute encoder window</li> </ul> <p>This monitoring function can be deactivated!</p>
<b>Monitoring the Position Data Reference</b>	<p>The position data reference of a measuring encoder that can be evaluated in absolute form gets lost after the following measures have been taken:</p> <ul style="list-style-type: none"> <li>• Change of parameter values of mechanical connection</li> <li>• Change of encoder resolution</li> <li>• Change of modulo range</li> <li>• Replacement of measuring encoder</li> </ul> <p>During the transition from communication phase "P2" to "P4" (bb), the drive recognizes that the former position data reference of the encoder does no longer exist. It sets "P-0-0331, Status of measuring encoder" to "not homed" and signals the loss of position data reference by the error message "F2176 Loss of measuring encoder reference".</p>

**Establishing the Position Data Reference to the Axis or Shaft****Procedures for Establishing the Position Data Reference**

Whether absolute evaluation is possible or not depends on the encoder type (P-0-0076, P-0-0327), the resolution of the measuring encoder and on the modulo range that was set (P-0-0765). This is displayed by a bit in parameter "P-0-0328, Type of position encoder for measuring encoder".



The value range of position data, that can be displayed in absolute form, of the encoder used is displayed in parameter "P-0-0334, Absolute encoder range of measuring encoder". If the value range of the measuring encoder determined by the modulo factor is smaller, absolute evaluation is possible!

---

Depending on relative or absolute evaluation of the measuring encoder, the controller makes available different procedures for establishing the position data reference. Depending on the kind of evaluation there are the following possibilities:

- "Set absolute measuring" for measuring encoders to be evaluated in absolute form
- "Homing" for measuring encoders to be evaluated in relative form





After having successfully established the position data reference, the actual position value refers to the axis or shaft. The measuring encoder then is "in reference" or has been "homed".

**CAUTION**

**When the position data reference is established, the actual position value of the measuring encoder can change abruptly!**

⇒ If the actual position value is used as the command variable of the drive, the control master has to take this into account when establishing the position data reference!

### Establishing Position Data Reference for Measuring Encoder to be Evaluated in Absolute Form

#### Activating "set Absolute Measuring"

The position data reference of a measuring encoder to be evaluated in absolute form (see respective bits of P-0-0328) to an axis or shaft is established by "P-0-0012, C0300 Set absolute position procedure command".

As it is possible to connect several encoders to be evaluated in absolute form to the controller, the absolute encoder to be homed is selected by a bit in parameter "P-0-0612, Set absolute position control". The command "set absolute measuring" only takes effect for the selected encoder.

#### Dedicated Position

By starting the "set absolute measuring" command, the previous incremental actual position value of the measuring encoder at a dedicated position of the axis or shaft is set to a defined value. The dedicated position corresponds to the current axis position at the start of the command.

The new actual position value at the dedicated position after "set absolute measuring" is the value of parameter "P-0-0087, Actual position value offset of measuring encoder".

$$[P-0-0052]_{NEW} = P-0-0087$$

P-0-0052 Actual position value of measuring encoder

P-0-0087 Actual position value offset of measuring encoder

*Fig.9-111: Actual Position Value of the Measuring Encoder After "Set Absolute Measuring"*

#### Storing the Absolute Encoder Offset

In order that an encoder to be evaluated in absolute form maintains the position data reference to the axis or shaft after "set absolute measuring", the absolute encoder offset is stored in the encoder data memory ("P-0-1022, Absolute encoder offset 3, encoder memory") and in the parameter memory ("P-0-0179, Absolute encoder buffer 3 (measuring encoder)").



Storing the absolute encoder offset in the encoder data memory and in the parameter memory allows recognizing whether the absolute encoder that had been homed was replaced!

#### Storage Mode

If the command "set absolute measuring" is cyclically used in the operational sequence, it makes sense to store the absolute encoder offset temporarily only. This kind of storage does not affect the service life of the encoder data memory and the parameter memory. In parameter "S-0-0269, Storage mode", it is possible to select whether parameter values are to be stored permanently or temporarily.

## Optional Device Functions



When the absolute encoder offset is stored temporarily, the measuring encoder loses the position data reference to the axis when the controller is switched off or when the parameter mode ("P2") is activated.

**"Set Absolute Measuring" Procedure**

For the measuring encoder the command "set absolute measuring" can only be activated when the drive is ready for operation but inactive ("bb", "AB").

When the "set absolute measuring" command is started, the reference of the selected encoder is cleared first ("P-0-0331, Status of measuring encoder"). After the reference was cleared, the new actual position value ("P-0-0087, Actual position value offset of measuring encoder") takes effect immediately and the reference bit is set again.

**Establishing Position Data Reference for Relative Measuring Encoder****Activating the Homing Procedure**

The position data reference of a relative measuring encoder to an axis or shaft is established by means of a reference mark signal of the encoder. To do this, it is first necessary to activate the reference mark evaluation for the measuring encoder in the respective bit of "P-0-0330, Control word of measuring encoder".

If the reference mark evaluation is still active, it first has to be deactivated and then activated again.



In the case of rotary encoders, reference mark signals usually occur once per encoder revolution!

**Dedicated Position**

When the reference mark signal is read the next time, the previous, encoder-related actual position value at a dedicated position of the axis or shaft is set to a defined value. The dedicated position corresponds to the current axis position at the occurrence of the reference mark signal.



When reference mark evaluation has been activated, only the reference mark that was read first is evaluated, other reference marks are ignored!

The new actual position value at the dedicated position after homing is the value of parameter "P-0-0087, Actual position value offset of measuring encoder".

$$[P-0-0052]_{NEW} = P-0-0087$$

P-0-0052 Actual position value of measuring encoder

P-0-0087 Actual position value offset of measuring encoder

*Fig. 9-112: Actual Position Value of the Measuring Encoder After Homing Procedure*

When the position reference of the measuring encoder has been successfully established, this is displayed in parameter "P-0-0331, Status of measuring encoder". The reference mark evaluation for the measuring encoder should then be deactivated in the respective bit of parameter "P-0-0330, Control word of measuring encoder"!



When a measuring encoder gear is used, the occurrence of the reference mark of the encoder with reference to the actual position value of the axis or shaft to be measured mostly isn't unequivocal! On the control side, it is necessary to make sure that the reference mark evaluation is activated at the appropriate axis or shaft position (identification via initiator or the like)!

## Shifting the Position Data Reference

**Operating Principle** Shifting the position data reference affects the current actual position value of the measuring encoder connected to the drive. Whether the current actual position value has position data reference to the axis or not is irrelevant for the shifting of the position data reference! The shifting is triggered on the master side by writing "P-0-0087, Actual position value offset of measuring encoder" and is immediately carried out on the drive side.



The reference status of the actual position values is not affected by the shifting of the position data reference.

When the drive is switched on the first time, the offset, set by the current value of P-0-0087, with regard to the original actual position value of the measuring encoder takes immediate effect.

If the position data reference is shifted several times in succession, each new value in P-0-0087 refers to the original actual position value of the measuring encoder, i.e. the shifted values do not act in an additive way!

**Resetting the Offset** The offset of the position data reference is reset by entering the old value (before the value was shifted) in parameter P-0-0087.

## 9.13.3 Notes on Commissioning

### Configuration and Setting

**Configuring the Controller** The optional interfaces have to be assigned to the measuring encoder connection:

- P-0-0079, Assignment measuring encoder->optional slot

**Configuring the Encoder** Setting the measuring encoder type:

- P-0-0076, Encoder type 3 (measuring encoder)

Setting the resolution (number of lines, division period) of the measuring encoder:

- P-0-0327, Encoder resolution of measuring encoder

Setting the type of encoder and the rotational direction of the measuring encoder:

- P-0-0328, Type of position encoder for measuring encoder

**Setting the Modulo Value Range** Entering modulo range of the axis or shaft to be measured:

- P-0-0765, Modulo factor measuring encoder

Message if the entered value is too high:

- C0163 Modulo value for measuring encoder cannot be displayed

**Setting the Smoothing of Actual Position Value** Setting or deactivating the time constant of the smoothing:

- P-0-0329, Smoothing of actual position value 3 of measuring encoder

### Possibility of Absolute Evaluation and Position Monitor (Position When Drive Switched On)

**Checking Possibility of Absolute Evaluation** Checking absolute encoder range of measuring encoder:

## Optional Device Functions

- P-0-0334, Absolute encoder range of measuring encoder



The scaling of parameter P-0-0334 is incremental!

When the value range (modulo) is smaller than the absolute encoder range of the measuring encoder, it can be evaluated as absolute encoder. This is displayed in the respective bit of the parameter

- P-0-0328, Type of position encoder for measuring encoder.

By means of this parameter, it is possible to deactivate the absolute evaluation of an encoder. The actual position values then are only relative, i.e. the encoder has to be homed again each time the machine is restarted or the drive changes to communication phase "P2"!

#### Setting the Axis or Shaft Position Monitor (Only With Absolute Encoder)

If position monitoring of the axis or shaft to be measured is required when the drive is switched on, enter the threshold value for the error message in parameter

- "P-0-0097, Absolute encoder monitoring window for measuring encoder".



Incremental scaling! The threshold of the error message depends on application-specific aspects of operational safety. The monitor is deactivated by the value "0"!

If the change of actual position value between the switching off and switching on is greater than the threshold value that was set, the following error message is generated:

- F2076 Actual pos. value 3 outside absolute encoder window.

#### Information on Measuring Encoder and Position Evaluation

Current information on measuring encoder and position evaluation is stored in the following parameters:

- P-0-0052, Actual position value of measuring encoder
- P-0-0331, Status of measuring encoder
- P-0-0326, Multiplication of measuring encoder



When parameter P-0-0326 has the value "32768", encoder evaluation is ideal!

### Establishing Position Data Reference for Measuring Encoder to be Evaluated in Absolute Form

#### Making the Presetting

Make the presetting for "set absolute measuring" by determining the measuring encoder for "set absolute measuring" in parameter "P-0-0612, Set absolute position control".

#### Actual Position Value at Dedicated Position

Determine the actual position value at the dedicated position in parameter

- P-0-0087, Actual position value offset of measuring encoder.

#### Executing "Set Absolute Measuring"

Start "P-0-0012, C0300 Set absolute position procedure command"; after its execution the command has to be cleared again.

See also "Basic Functions of Master Communication: Command Processing"

#### Checking the Position Data Reference

The position status of the measuring encoder is displayed in parameter

- P-0-0331, Status of measuring encoder.

#### Loss of Reference

If the position data reference of the measuring encoder evaluated in absolute form got lost, the following message appears:

- F2176 Loss of measuring encoder reference.

The position data reference has to be established again!

## Establishing Position Data Reference for Relative Measuring Encoder

- |   |  |
|---|--|
| <b>Activating Homing Procedure of Measuring Encoder</b>                   | Activate reference mark detection in the respective bit of parameter <ul style="list-style-type: none"><li>• P-0-0330, Control word of measuring encoder.</li></ul>  |
| <b>Actual Position Value at Dedicated Position</b>                        | Determine the actual position value at the dedicated position in parameter <ul style="list-style-type: none"><li>• P-0-0087, Actual position value offset of measuring encoder.</li></ul>  |
| <b>Checking Position Data Reference and Deactivating Homing Procedure</b> | The reference mark signal first read sets the actual position value of the measuring encoder in reference. This is displayed in parameter <ul style="list-style-type: none"><li>• P-0-0331, Status of measuring encoder.</li></ul> |

## Shifting the Position Data Reference

Master-side writing of parameter

- P-0-0087, Actual position value offset of measuring encoder.

Shifting the position data reference already takes effect as of communication phase "P2".

The shifting of the actual position values can be checked in parameter

- P-0-0052, Actual position value of measuring encoder.

## Other Diagnostic Messages Relevant to Measuring Encoder

- C0161 Incorr. parameterization of measuring enc. (hardware)
- C0162 Measuring encoder unknown
- C0227 Error when initializing position of measuring encoder
- C0228 Initialization velocity measuring encoder too high
- E2076 Measuring encoder: Encoder signals disturbed
- F2043 Measuring encoder: Encoder signals incorrect
- F2179 Modulo limitation error of measuring encoder



# 10 Handling, Diagnostic and Service Functions

## 10.1 Parameters, Basics

### 10.1.1 Properties/Features of Parameters

#### Brief Description

The controller firmware via data maps the drive to an internal mathematical model. All operating data relevant therefor are mapped to parameters. An identification number (IDN) is assigned to each parameter. The IDN allows accessing operating data via

- the serial interface

- or -

- a master communication interface suited for data transfer.

The operating data stored in parameters can be identified by means of the IDN. They can be read and transferred, if required. The user write access to parameters depends on the properties of the respective parameter and the current communication phase. Specific parameter values (operating data) are checked for validity by the drive firmware.

#### Functional Description

##### Parameter Structure

Each parameter consists of seven data block elements.

Element No.	Description	Notes
1	Identification number (IDN)	Parameter identification/reading of data status
2	Name	Can be changed by means of language selection
3	Attribute	Contains decimal places, data length, data type and display format, function
4	Unit	Can be changed by means of scaling or language selection
5	Minimum input value	Minimum input value of operating data
6	Maximum input value	Maximum input value of operating data
7	Operating data	Parameter value

Fig. 10-1: Data Block Elements of a Parameter



See also "Definitions" in the separate documentation "Parameter Description for IndraDrive Drive Controllers".

##### Writing and Reading a Parameter

All data block elements can be read via an appropriate master communication interface or serial interface. Only the operating data can be written, too.

The operating data of a parameter can be permanently write-protected or always resp. temporarily be written. This write access depends on

- the communication phase

- and -

- the activation of a password.

## Handling, Diagnostic and Service Functions



When reading and writing the operating data, error messages can occur (see "Terms, Basic Principles: Errors").

**Data Status**

Each Parameter has a data status. The data status contains information on:

- Validity/invalidity of the operating data (parameter value)
- Status of commands (command acknowledgment) for parameters used for activating commands (see "Terms, Basic Principles: Commands").

The controller checks the data status of the parameters for validity of the operating data when changing from parameter mode to operating mode. When this happens, the operating data (parameter values) of the parameters contained in the following list parameters are checked for validity:

- S-0-0018, IDN-list of operation data for CP2
- S-0-0019, IDN-list of operation data for CP3

The control master can query the IDNs of the parameters with invalid operating data (parameter values) via:

- S-0-0021, IDN-list of invalid operation data for CP2
- S-0-0022, IDN-list of invalid operation data for CP3
- S-0-0423, IDN-list of invalid data for parameterization levels

The data status is signaled when the control master executes a write command to the data block element no. 1 of a parameter. This allows the control master to recognize the status of a command started.

See "Basic Functions of Master Communication: Command Processing"

**Language Selection**

In parameter "S-0-0265, Language selection", you can set the language in which parameter names and text in units of parameter values will be displayed.



The language selection made via parameter S-0-0265 will only take effect in parameter "S-0-0095, Diagnostic message", when the diagnostic message changes, too, after language selection.

**Notes on Commissioning**

During the drive-internal check of parameter values carried out when changing from parameter mode to operating mode, the following command errors can be signaled:

- C0201 Invalid parameters (->S-0-0423)
- C0202 Parameter limit error (->S-0-0423)

- or -

- C0201 Invalid parameters (->S-0-0423)
- C0202 Parameter limit error (->S-0-0423)
- C0203 Parameter conversion error (->S-0-0423)

When errors of this category are detected, the IDNs of the parameters with the incorrect operating data are listed in:

- S-0-0021, IDN-list of invalid operation data for CP2
- S-0-0022, IDN-list of invalid operation data for CP3
- S-0-0423, IDN-list of invalid data for parameterization levels

A valid value has to be written to the listed IDNs. The value range limits are contained in the data block elements no. 5 and no. 6. When inputting single parameters, the limits are directly displayed via the "IndraWorks Ds/D/MLD" commissioning tool.



- Setting the Language** The desired display language of parameter names and text in units of parameter values has to be set in parameter
- S-0-0265, Language selection.

## 10.1.2 Loading, Storing and Saving Parameters

### Brief Description

<b>Parameters</b>	All relevant operating data are mapped to parameters and stored in the controller.
<b>Data Memory</b>	Several non-volatile data memories are available in an IndraDrive device: <ul style="list-style-type: none"> <li>• In the controller</li> <li>• In the motor encoder (depending on motor type)</li> <li>• As a MultiMediaCard (MMC), optional</li> </ul> <p>In addition, the controller has a volatile data memory (working memory).</p>
<b>Condition as Supplied</b>	Condition as supplied of the Rexroth drive components: <ul style="list-style-type: none"> <li>• The controller memory contains the drive firmware and the controller-specific parameter values.</li> <li>• The motor encoder memory contains the encoder-specific and, depending on the motor type, the motor-specific parameter values.</li> <li>• The MMC contains the drive firmware.</li> </ul>
<b>Storing the Application-Specific Parameter Values</b>	The application-specific parameter values are stored in the controller. Due to the limited number of writing cycles of non-volatile storage media, application-specific parameter values can be stored in the working memory (volatile memory), too.
<b>Saving Parameter Values</b>	Saving application-specific parameter values is required in the following cases: <ul style="list-style-type: none"> <li>• After initial commissioning of the machine axis or the motor</li> <li>• Before replacing the controller for servicing (if possible)</li> </ul> <p>Application-specific parameter values can be saved via:</p> <ul style="list-style-type: none"> <li>• MMC → copying the parameter values by command</li> <li>• "IndraWorks Ds/D/MLD" commissioning tool → Saving the parameter values on external data carrier</li> <li>• Control master → saving parameter values on master-side data carrier</li> </ul>
<b>Parameter IDN Lists</b>	The drive supports master-side saving of parameter values by listing parameter identification numbers (IDNs). Using these lists guarantees complete storage of the application-specific parameter values. It is also possible to determine IDN lists defined by the customer.
<b>Loading Parameter Values</b>	Loading parameter values is required in the following cases: <ul style="list-style-type: none"> <li>• Initial commissioning of the motor (loading basic parameter values and motor-specific parameter values)</li> <li>• Serial commissioning of machine axes at series machines (loading the values saved after initial commissioning)</li> <li>• Reestablishing a defined initial status (repeated loading of the values saved after initial commissioning)</li> <li>• Replacing the controller for servicing (loading the current parameter values saved before servicing)</li> </ul> <p>Possibilities of loading parameter values to the controller:</p> <ul style="list-style-type: none"> <li>• Motor encoder data memory → loading the parameter values by command or via the control panel during initial motor commissioning</li> </ul>

## Handling, Diagnostic and Service Functions

- MMC → loading the parameter values by command
  - "IndraWorks Ds/D/MLD" Commissioning tool → Loading the parameter values from external data carrier
  - Control master → loading the parameter values from master-side data carrier
- Checksum of Parameter Values** By means of checksum comparison, the control master can determine whether the values of the application-specific parameter values currently active in the drive correspond to the values saved on the master side.
- Pertinent Parameters**
- S-0-0017, IDN-list of all operation data
  - S-0-0192, IDN-list of all backup operation data
  - S-0-0262, C07\_x Load defaults procedure command
  - S-0-0263, C2300 Load working memory procedure command
  - S-0-0264, C2200 Backup working memory procedure command
  - S-0-0269, Storage mode
  - S-0-0270, IDN-list of selected backup operation data
  - S-0-0293 , C2400 Selectively backup working memory procedure command
  - S-0-0326, Parameter checksum
  - S-0-0327, IDN list of checksum parameter
  - S-0-0531, Checksum of backup operation data
  - P-0-0013, List of all IDNs not corresponding to default value
  - P-0-4023, C0400 Communication phase 2 transition
  - P-0-4065, Active non-volatile memory
  - P-0-4070, Parameter storage configuration
  - P-0-4090, Configuration for loading default values
  - P-0-4091, C2500 Copy IDN from optional memory to internal memory
  - P-0-4092, C2600 Copy IDN from internal memory to optional memory
- Pertinent Diagnostic Messages**
- Load defaults procedure (loading controller parameters):
- C0700 Load defaults procedure com. (load controller param.)
  - C0702 Default parameters not available
  - C0703 Default parameters invalid
  - C0704 Parameters not copyable
  - C0706 Error when reading the controller parameters
- Load defaults procedure (loading basic parameters):
- C0750 Load defaults procedure com. (load basic parameters)
  - C0751 Parameter default value incorrect (-> S-0-0423)
  - C0752 Locked with password
- Backup working memory procedure:
- C2202 Error when writing data to non-volatile memory
  - C2200 Backup working memory procedure command
- Loading working memory:
- C2300 Load working memory procedure command
  - C2301 Error when reading non-volatile memory

- C2302 Error when converting parameters

Selectively backup working memory procedure:

- C2400 Selectively backup working memory procedure command
- C2402 Error when saving parameters

Copy parameters from MMC to flash:

- C2500 Copy IDN from optional memory to internal memory
- C2502 Error when accessing the MMC
- C2504 Error when writing data to internal memory

Copy parameters from flash to MMC:

- C2600 Copy IDN from internal memory to optional memory
- C2602 Error when accessing the MMC
- C2604 Error when reading the internal memory

Other diagnostic messages:

- F2100 Incorrect access to command value memory
- F2101 It was impossible to address MMC
- F2102 It was impossible to address I2C memory
- F2103 It was impossible to address EnDat memory

## Functional Description

### Storage Media in the Drive Controller

All operating data referring to hardware are stored in the drive controller. They cannot be changed by the user.

Each circuit board is provided with a non-volatile memory. It carries the circuit board code and circuit board-specific operating data.

On the main circuit board there is a non-volatile memory (flash) and a volatile memory (working memory). The flash memory contains the circuit board-specific operating data. The drive firmware is stored in the flash memory, too. The values of the application-specific parameters can be stored either in the flash memory or in the working memory.

### Storage Medium in the Motor Encoder

In the case of the MHD, MKD, MKE, MAD and MAF motor lines, the data memory of the motor encoder contains all motor- and motor-encoder-specific parameter values. In addition, motor-specific control loop parameter values are stored in this data memory; the controller can easily be adjusted to the motor by means of these parameter values.


### Storage Medium MultiMediaCard (MMC)

The MultiMediaCard (MMC) is a non-volatile storage medium that can be permanently or temporarily plugged in the slot provided for this purpose at the front of the drive controller. The MMC is not obligatory!

Depending on the setting in parameter "P-0-4070, Parameter storage configuration" the MMC can be used as:

- Programming module
  - Permanently plugged medium for saving the firmware and the application-specific parameter values
- or -
- Update/init medium
  - Temporarily plugged medium for firmware update or for transmission of application-specific parameter values
- or -
- Backup medium

## Handling, Diagnostic and Service Functions

	→ Temporarily plugged medium for intermediate storage of backup data (access via command or by file services)
<b>Parameter and Operating Mode</b>	<p>Parameters the operating data of which can be changed, can be written with values in one or possibly several communication phases. We basically distinguish between</p> <ul style="list-style-type: none"> <li>• Parameter mode (PM) and</li> <li>• Operating mode (OM).</li> </ul> <p>As a matter of principle, all parameters that can be changed can be written in the parameter mode.</p>
<b>"Load Defaults Procedure" Command (Loading Basic Parameters)</b>	<p>Via the command "S-0-0262, C07_x Load defaults procedure command", it is possible to set a defined initial status of the parameter values.</p> <p>The scope of functions of this command can be determined by means of the configuration of parameter "P-0-4090, Configuration for loading default values":</p> <ul style="list-style-type: none"> <li>• <b>Command selection</b> (bits 0...3): <ul style="list-style-type: none"> <li>– "Load defaults procedure" <ul style="list-style-type: none"> <li>→ Loads the motor-specific default parameter values for the control loop available in the motor encoder data memory (if available) (see "Axis Control: Default Settings in the Motor Encoder Data Memory ("Load Defaults Procedure")")</li> </ul> </li> <li>– "Load basic parameters"</li> <li>– "Load MLD parameters" <ul style="list-style-type: none"> <li>→ Resets/clears the parameters of the drive-integrated PLC (program and register)</li> </ul> </li> <li>– "Load profile parameters" <ul style="list-style-type: none"> <li>→ See "Profile Types (With Field Bus Interfaces)"</li> </ul> </li> <li>– "Load def. proc. for safety techn." <ul style="list-style-type: none"> <li>→ See separate documentation "Integrated Safety Technology"</li> </ul> </li> </ul> </li> <li>• <b>Scaling of command execution</b> (bits 4...7): <p>With the command "load basic parameters", you have the option to load default values for all parameters or to selectively exclude the following groups, for example:</p> <ul style="list-style-type: none"> <li>– Default values for all parameters except for the communication parameters</li> <li>– Default values for all parameters except for the PLC parameters</li> </ul> </li> </ul> <p> See also Parameter Description "P-0-4090, Configuration for loading default values"</p>
<b>Storage Mode</b>	<p>Depending on "S-0-0269, Storage mode", the application-specific parameter values are stored in the controller in volatile form (in the working memory) or non-volatile form (in the flash memory).</p> <p>Non-volatile storage is carried out with each write access to the respective operating data.</p> <p>Volatile storage of parameter values is recommended when application-specific parameters are cyclically written. Otherwise, the service life of the non-volatile storage media is affected.</p>



### Damage to the internal memory (flash) caused by cyclic command execution (write access to the flash)!

⇒ During the execution of some commands (see description of the respective diagnostic command message; e.g. C0500), data are written to the internal memory (flash), too. This memory, however, only allows a limited number of write access. For this reason, you should make sure that such write access is not carried out too often.

#### Parameter IDN Lists

For saving the relevant application-specific parameter values the drive makes lists of IDNs available that support the complete storage of the values of parameter groups:

- S-0-0192, IDN-list of all backup operation data
- S-0-0270, IDN-list of selected backup operation data

Parameter S-0-0192 contains a list of IDNs that cannot be modified. Parameter S-0-0270 contains an empty list in which it is possible to enter certain IDNs according to application-specific requirements.

For saving all parameter values, the drive makes available the list of the IDNs of all parameters in

- S-0-0017, IDN-list of all operation data.

To identify the parameters the value of which has changed compared to their default value, the drive makes available the parameter

- P-0-0013, List of all IDNs not corresponding to default value.

#### Command "Backup Working Memory" or "Selectively Backup Working Memory"

If the option "volatile storage" has been set in parameter "S-0-0269, Storage mode", the values of the parameters contained in the list parameter S-0-0192 can be saved in the non-volatile flash memory by starting "S-0-0264, C2200 Backup working memory procedure command".

If the parameter values of the list of S-0-0270 are to be saved, "S-0-0293, C2400 Selectively backup working memory procedure command" has to be activated. Unless the storage mode (S-0-0269) is changed, the values once saved in the flash memory via the commands C2200 or C2400 remain unchanged.

#### Command "Load Working Memory Procedure"

Via "S-0-0263, C2300 Load working memory procedure command" the values from the non-volatile flash memory are copied to the volatile working memory.




This only makes sense when volatile storage mode was set (S-0-0269) and parameter values were saved in the controller-internal flash memory!

#### Saving Application-Specific Parameter Values

To save the application-specific parameter values, e.g. after initial commissioning, there are the following possibilities:

- **Start command "P-0-4092, C2600 Copy IDN from internal memory to optional memory"**
  - The parameter values of the list of S-0-0192 are copied to an MMC card plugged in the controller (in the case of volatile storage mode, command C2200 must have been executed!).
- **"IndraWorks Ds/D/MLD" commissioning tool**
  - The parameter values of the list of S-0-0192 are stored on an external data carrier (hard disk, floppy disk or the like); target assignment is carried out via the menu of the tool (serial communication with the controller or via SYSDA SERCOS interface).
- **Control master**

## Handling, Diagnostic and Service Functions

	<p>→ The parameter values of the list of S-0-0192 or S-0-0270 and/or other parameters, if necessary, are stored on a master-side data carrier by command of the control master.</p>
<b>Loading Application-Specific Parameter Values</b>	<p>To load saved parameter values or transmit axis-specific parameter values to controllers of other axes, there are the following possibilities:</p> <ul style="list-style-type: none"> <li>• <b>Start command "P-0-4091, C2500 Copy IDN from optional memory to internal memory"</b> <p>→ The parameter values (according to list of S-0-0192) stored on a plugged MMC are loaded to the device-internal, non-volatile flash memory.</p> </li> <li>• <b>"IndraWorks Ds/D/MLD"commissioning tool</b> <p>→ The parameter values (according to list of S-0-0192) stored on an external data carrier (hard disk, floppy disk or the like) are loaded to the controller; source assignment is carried out via the menu of the tool (serial communication with the controller or via SERCANS-Box/SERCOS interface).</p> </li> <li>• <b>Control master</b> <p>→ The parameter values of the list of S-0-0192 or S-0-0270 and/or other parameters, if necessary, are loaded from a master-side data carrier to the controller by command of the control master.</p> </li> </ul>
<b>Parameter Check Sum via List Parameter S-0-0327</b>	<p>When reading the parameter "S-0-0326, Parameter checksum", the checksum of all parameter values is generated the IDNs of which are contained in parameter "S-0-0327, IDN list of checksum parameter". Changes in the parameter settings can be detected by comparing the checksums.</p> <p>By comparing the checksum of the parameter values currently active in the drive to a checksum value stored at the time of parameter saving, it is possible to determine whether the active application-specific parameter values are correct.</p> <p>By default, there haven't any IDNs been entered in parameter S-0-0327!</p>
<b>Parameter Checksum via List Parameter S-0-0192</b>	<p>When reading the parameter "S-0-0531, Checksum of backup operation data", the checksum of the active non-volatile memory of the parameters, the IDs of which are contained in parameter "S-0-0192, IDN-list of all backup operation data".</p> <hr/> <p> In list parameter S-0-0192, the IDNs of those parameters are stored the values of which are axis-specific and for regular operation have to be loaded to the drive of the respective axis.</p> <hr/> <p>When the installation has been completely set up, the checksum for each drive can be read via the parameter S-0-0531. The control master can store these values. By comparing the checksum which was saved to the new checksum which was read, it is possible to find out whether data relevant to operation have changed.</p>
<b>Notes on Commissioning</b>	
<b>Initial Commissioning</b>	<p>At the beginning of the initial commissioning of a motor or a machine axis, first make sure the desired firmware is active in the drive. To do this, read parameter</p> <ul style="list-style-type: none"> <li>• S-0-0030, Manufacturer version.</li> </ul> <p>If the desired firmware is not available in the controller, carry out firmware update or firmware upgrade (see "Firmware Replacement").</p>
<b>Load Basic Parameters</b>	<p>If the desired firmware is available in the controller, load basic parameter values of the firmware by carrying out the following steps:</p>

**Load Motor-Specific Control Loop  
Parameter Values**

1. Make definitions in parameter "P-0-4090, Configuration for loading default values".

2. Start of "S-0-0262, C07\_x Load defaults procedure command"

Respective diagnostic command message:

- C07\_1 Load defaults procedure com. (load basic parameters)

Respective diagnostic messages in the case of possible command errors:

- C0751 Parameter default value incorrect (-> S-0-0423)
- C0752 Locked with password

See also "Initial Commissioning/Serial Commissioning"

After loading the basic parameters, the controller signals "RL", if a Rexroth motor with motor encoder data memory was connected. By one of the following actions, the motor-specific control loop parameter values saved in the motor encoder are loaded for adjusting the controller to the motor:

- Pressing the "Esc" key at the control panel

- or -

- Starting the command "S-0-0099, C0500 Reset class 1 diagnostics"

If the initial status of the motor-specific control loop parameter values is to be reestablished during commissioning, this is done, in the case of motors with encoder data memory, by starting

- S-0-0262, C07\_x Load defaults procedure command.



**CAUTION**

**By executing this command, control loop parameter values that have already been optimized are possibly overwritten!**

⇒ Enter optimized control loop parameter values again!



By automatic reset, the parameter "P-0-4090, Configuration for loading default values" is correctly preset!



In the case of motors without encoder data memory, loading the motor-specific control loop parameter values by means of the "load defaults procedure" command is impossible! The values can be loaded from a database of the "IndraWorks Ds/D/MLD" commissioning tool.

Respective diagnostic command message:

- C0700 Load defaults procedure com. (load controller param.)

Respective diagnostic messages in the case of possible command errors:

- C0702 Default parameters not available
- C0703 Default parameters invalid
- C0704 Parameters not copyable
- C0706 Error when reading the controller parameters

See also "Initial Commissioning/Serial Commissioning"

**With Storage Mode "Volatile Storage"**

When the option "volatile storage" has been set in parameter "S-0-0269, Storage mode", the parameter values are not automatically stored in the drive-internal flash memory. After complete input, the application-specific parameter values therefore have to be saved drive-internally in the flash memory by

## Handling, Diagnostic and Service Functions

- Start of "S-0-0264, C2200 Backup working memory procedure command".

This guarantees that the parameter values suitable for the axis are automatically loaded to the controller's working memory from the flash memory after the drive is switched on again.

Respective diagnostic command message:

- C2200 Backup working memory procedure command

Respective diagnostic messages in the case of possible command errors:

- C2202 Error when writing data to non-volatile memory

After all application-specific parameter values are saved (C2200), it is also possible to only save selected parameter values in the flash memory. These parameters are overwritten with a current value. This is done by

- Start of "S-0-0293, C2400 Selectively backup working memory procedure command"..

The C2400 command can be used for internally saving a parameter group the values of which have to be optimized again during operation, for example. It is advisable to determine the IDNs of this parameter group by clearing IDNs that are not required from the default setting of the list parameter

- S-0-0270, IDN-list of selected backup operation data.



In the case of the "volatile storage" mode, the command C2200 has to be executed at least once before starting the command C2400, because otherwise basic parameter values are maintained for some parameter values in the flash memory.

Respective diagnostic command message:

- C2400 Selectively backup working memory procedure command

Respective diagnostic messages in the case of possible command errors:

- C2402 Error when saving parameters

#### Saving and Loading Parameter Values With MMC

For saving and loading parameter values with MMC, see "MultiMediaCard (MMC)"!

#### Loading and Saving Parameter Values via Control Master or "IndraWorks Ds/D/MLD"

An appropriate master communication interface or the serial interface can be used for loading and saving parameter values via the control master or "IndraWorks Ds/D/MLD".

Loading saved parameter values acc. to list parameter S-0-0192 to reestablish the initial status after initial commissioning is impossible in the case of drives with absolute value encoder and modulo scaling (see note).



In the case of drives with absolute value encoder and modulo scaling, the backup of parameter values made after initial commissioning acc. to S-0-0192 mustn't be loaded for reestablishing the initial parameter status! **The actual position value after the loading process would be incorrect, but this cannot be detected on the controller side!**

For how to reestablish the initial status of parameters for drives with absolute value encoder and modulo scaling, see "Initial Commissioning/Serial Commissioning"!

If other interfaces than SERCOS interface are used for loading and storing, communication phase "P2" has to be activated for loading parameter sets:

- P-0-4023, C0400 Communication phase 2 transition



Respective diagnostic command message:

- C0400 Activate parameterization level 1 procedure command



The drive is returned to operating mode by subsequently starting the commands "S-0-0127, C0100 Communication phase 3 transition check" and "S-0-0128, C5200 Communication phase 4 transition check"!

---

When reading and writing individual parameters via the control master or "IndraWorks Ds/D/MLD" (without command), the following error messages can possibly occur:

- F2100 Incorrect access to command value memory
- F2101 It was impossible to address MMC
- F2102 It was impossible to address I2C memory
- F2103 It was impossible to address EnDat memory

### 10.1.3 IDN Lists of Parameters

#### General Information

Some of the parameters stored in the drive contain, as their operating data (parameter value), a list of IDNs of drive parameters corresponding to a specific, given criterion. These so-called IDN lists enable the master or a commissioning software to handle drive parameters in a specific way.

#### IDN-List of All Operation Data (S-0-0017)

The parameter "S-0-0017, IDN-list of all operation data" contains the IDNs of all parameters available in the drive.

#### IDN-List of Backup Operation Data (S-0-0192)

The parameter "S-0-0192, IDN-list of all backup operation data" contains the IDNs of all parameters that are stored in the non-volatile memory [MultiMedia-Card (MMC) or flash memory]. These parameters are required for correct operation of the drive. With the master or a commissioning software, it is possible to use this IDN list for making a backup copy of the drive parameters.

#### IDN List of Invalid Operating Data for Communication Phase 2 (S-0-0021)

In parameter "S-0-0021, IDN-list of invalid operation data for CP2" the IDNs of those parameters are automatically entered which the drive software detects as being invalid when executing the command "S-0-0127, C0100 Communication phase 3 transition check".

Parameters are detected as being invalid, if:

- Their checksum does not match the operating data [the checksum is stored together with the operating data in a non-volatile memory (MultiMedia-Card/MMC, flash memory, amplifier or motor encoder data memory)]
- or -
- Their operating data is outside of the minimum or maximum input limits
- or -
- Their operating data violates specific validation rules.

In any event, the parameters entered in "S-0-0021, IDN-list of invalid operation data for CP2" upon negative acknowledgement of command "S-0-0127, C0100 Communication phase 3 transition check" must be corrected.

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### **IDN List of Invalid Operating Data for Communication Phase 3 (S-0-0022)**

In parameter "S-0-0022, IDN-list of invalid operation data for CP3" the IDNs of those parameters are automatically entered which the drive software detects as being invalid or unduly configured when executing the command "S-0-0128, C5200 Communication phase 4 transition check".

Parameters are detected as being invalid, if:

- Their checksum does not match the operating data [the checksum is stored together with the operating data in a non-volatile memory (MultiMedia-Card/MMC, flash memory, amplifier or motor encoder data memory)]

- or -

- Their operating data is outside of the minimum or maximum input limits

- or -

- Their operating data violates specific validation rules.

Parameters are detected as being unduly configured, if

- they were configured more than once for writing by a cyclic interface.

In any event, the parameters entered in "S-0-0022, IDN-list of invalid operation data for CP3" upon negative acknowledgement of command "S-0-0128, C5200 Communication phase 4 transition check" must be corrected.

### **IDN-List of Invalid Op. Data for Parameterization Level (S-0-0423)**

When the command "C0200 Exit parameterization level procedure command" is executed, the drive parameters are checked and converted. If errors occur during this check, the IDNs of the faulty parameters are written to the list parameter "S-0-0423, IDN-list of invalid data for parameterization levels".

### **IDN List of Operating Data for Communication Phase 2 (S-0-0018)**

The IDNs that are checked for validity when the command "S-0-0127, C0100 Communication phase 3 transition check" is executed are stored in the operating data of parameter "S-0-0018, IDN-list of operation data for CP2".

### **IDN List of Operating Data for Communication Phase 3 (S-0-0019)**

The IDNs that are checked for validity when the command "S-0-0128, C5200 Communication phase 4 transition check" is executed are stored in the operating data of parameter "S-0-0019, IDN-list of operation data for CP3".

### **IDN List of All Command Parameters (S-0-0025)**

The IDNs of all the command parameters available in the drive are stored in the operating data of parameter "S-0-0025, IDN-list of all procedure commands".

### **Selected IDN List of Operation Data to Backup (S-0-0270)**

The IDNs of parameters that are to be saved when command "S-0-0293 , C2400 Selectively backup working memory procedure command" is executed are stored in the parameter "S-0-0270, IDN-list of selected backup operation data".

### **IDN-List of Password-Protected Operation Data (S-0-0279)**

The parameter "S-0-0279, IDN-list of password-protected operation data" contains the IDNs of those parameters that can be protected by a customer password (S-0-0267). By default, there haven't been any IDNs entered in this parameter.

## IDN List of Checksum Parameter (S-0-0327)

The parameter "S-0-0327, IDN list of checksum parameter" contains the IDNs of those parameters from which the content of parameter "S-0-0326, Parameter checksum" is to be generated. By default, there haven't been any IDNs entered in this parameter.

## IDN List of All Parameter Values not Corresponding to Default Value (P-0-0013)

All parameters the operating data of which was changed with regard to the default value are stored in "P-0-0013, List of all IDNs not corresponding to default value".

## 10.1.4 Using a Password

### Brief Description

IndraDrive controllers provide the possibility to protect parameter values against accidental or unauthorized change by means of a password. With regard to write protection, there are 3 groups of parameters that can be written:

- Parameters that are write-protected as a standard, such as motor parameters, hardware code parameters, encoder parameters, error memory, etc. ("administration parameters"). The values of these parameters guarantee correct function and performance of the drive.
- Parameters the customer can combine in groups and protect them with a so-called customer password. This allows protecting parameter values, that are used for adjusting the drive to the axis, after having determined them.
- All other parameters that can be written and are not contained in the above-mentioned groups. They are not write-protected.

The drive firmware allows activating and deactivating the write protection for parameter values by means of three hierarchically different passwords:

- **Customer password**  
→ The parameter values of a parameter group combined by the customer can be protected.
- **Control password**  
→ Parameters protected by a customer password can be written; "administration parameters" remain write-protected.
- **Master password**  
→ All parameters that can be written, including "administration parameters" and parameters protected by a customer password, can be changed.



The customer password can be defined by the customer, the control password and the master password are defined by the manufacturer!

### Pertinent Parameters

- S-0-0192, IDN-list of all backup operation data
- S-0-0267, Password
- S-0-0279, IDN-list of password-protected operation data
- P-0-4064, Password level

### Functional Description

The activation and deactivation of the write protection for parameter values by the three hierarchically different passwords is carried out by an input in parameter "S-0-0267, Password".

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**Customer Password** By a password defined by the customer, the parameters of a parameter group to be defined can be protected against unauthorized or accidental write access.

The customer password has to comply with the following conditions:

- At least 3 characters long
- A maximum of 10 characters long
- May only include the characters a...z, A...Z and the numbers 0...9

The group of parameters the values of which can be protected by the customer password is defined in "S-0-0279, IDN-list of password-protected operation data". In the condition as supplied the parameter S-0-0279 does not yet contain any data. In the list parameter S-0-0279 it is possible to enter parameter IDNs according to application-specific requirements.



The customer password is not obligatory! If it has not been activated, the values of the parameters listed in the list parameter S-0-0279 can still be written.

---

**Control Password** After entering the firmware-specific control password defined by the manufacturer, it is also possible to write parameters protected by a customer password. The control password therefore allows the NC control unit to ignore the write protection established by the individual (unknown) customer password.



The control password valid for the respective firmware is only available from the manufacturer on demand!

---

**Master Password** The master password is defined by the manufacturer, too, but is exclusively available to the Bosch Rexroth development and service staff.



The master password is secret! It must not be used on the control unit side or by the customer, because it also allows changing the values of "administration parameters" (motor parameters, hardware code parameters, encoder parameters, error memory, etc.).

---

**Activating/Deactivating the Write Protection**

In the condition as supplied "S-0-0267, Password" contains the value "007". The write protection is activated and deactivated by means of the customer password according to the following procedure:

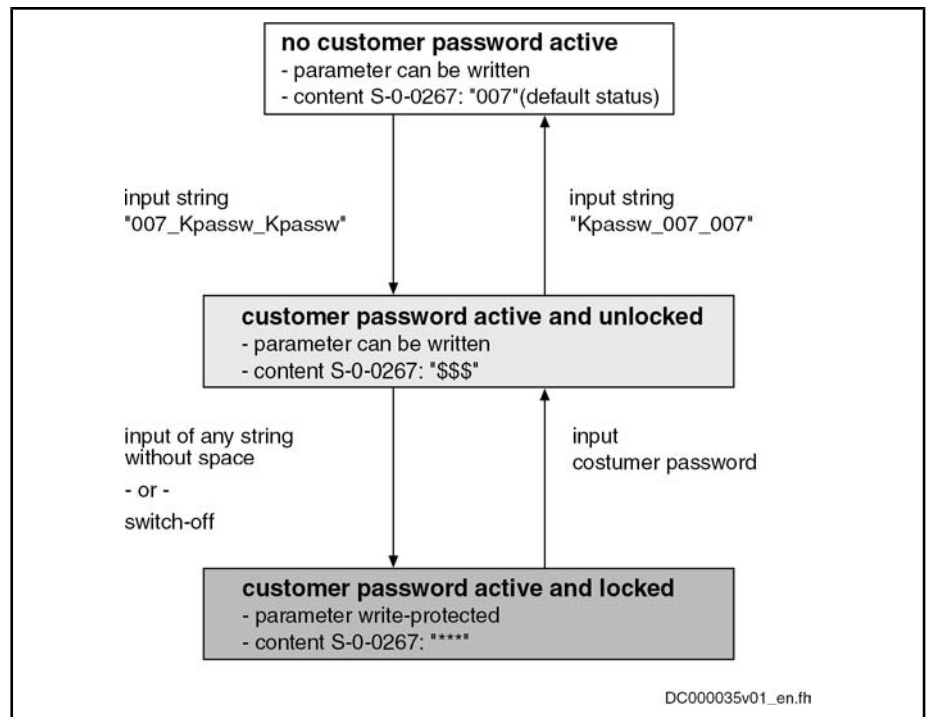


Fig. 10-2: Activating and Deactivating the Write Protection by Means of the Customer Password

The write protection activated via customer password is deactivated by means of the control password by entering the control password in S-0-0267. The write protection required by the customer can be activated again by entering any string in S-0-0267.

The write protection for all parameters that can basically be written can only be deactivated by means of the master password and the right to do this is exclusively reserved to the Bosch Rexroth development and service staff!



**WARNING**

**Incorrect control of motors when changing parameter values write-protected on the firmware side ("administration parameters")!**

⇒ The master password mustn't be used on the control unit side or by the customer!

## Notes on Commissioning

Define the IDNs of the group of parameters the values of which are to be write-protected in parameter

- S-0-0279, IDN-list of password-protected operation data.

The customer-side write protection via the customer password for the parameters contained in S-0-0279 can be activated and deactivated by writing the parameter

- S-0-0267, Password.



Observe the conditions for defining the customer password!

If the active write protection for the parameters defined in S-0-0279 is to be deactivated on the master side or without knowledge of the customer password, enter the control password in parameter

- S-0-0267, Password.

Handling, Diagnostic and Service Functions



Ask the manufacturer for the control password!

**Status Query for Write Protection** The current status of the write protection can be queried via parameter

- P-0-4064, Password level.

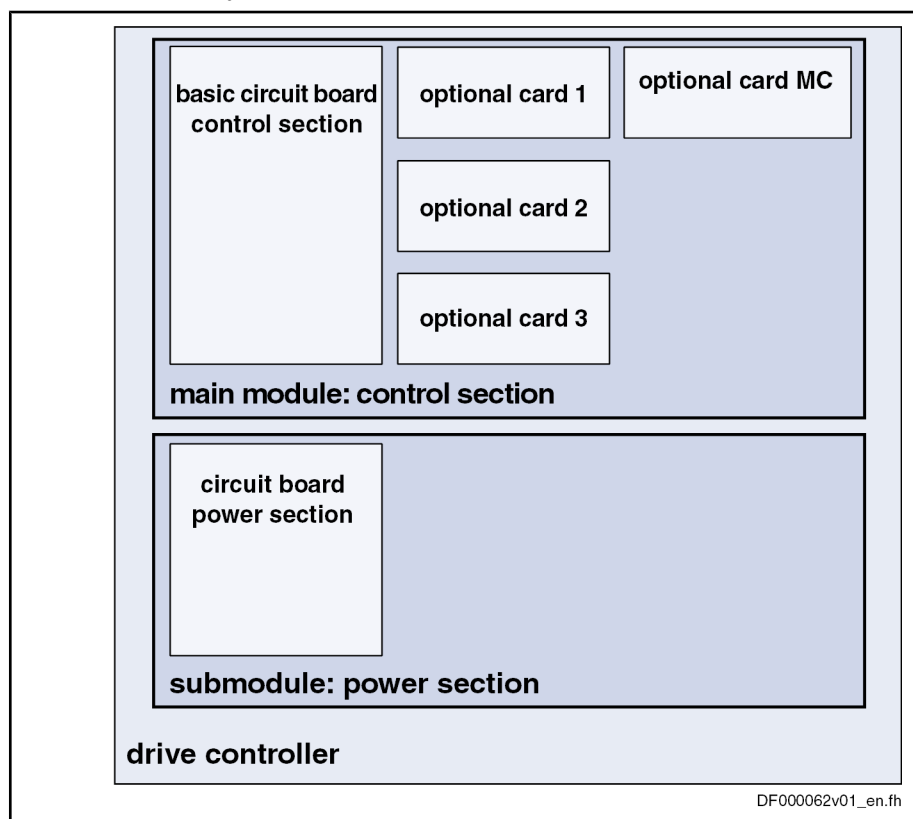
**Diagnosis** When trying to write data to a write-protected parameter, an error code is sent to the SERCOS master via the non-cyclic data channel, according to the SERCOS specification. The master then recognizes that the respective parameter is write-protected and that it is impossible to write data to it.

## 10.2 Device Configuration

### 10.2.1 Controller Design

The drive controllers of the IndraDrive range consist of several modules. We basically distinguish between:

- **Main module**  
→ Module directly communicates with the master
- **Submodule**  
→ Module only communicates with the master via main module



MC Master communication

Fig. 10-3: Example of Design Including Device, Modules and Circuit Boards for IndraDrive Controllers

The modular structure of the IndraDrive controllers allows a combinations of control sections and power sections.

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Control section	Power section					
	HMS01	HMS02	HMD01	HCS02	HCS03	HCS04.2 (preliminary)
CSH01.1C <sup>1)</sup>	■	■	-	■	■	-
CSH01.2C <sup>1)</sup>	■	■	-	■	■	-
CSH01.3C <sup>1)</sup> (preliminary)	■	■	-	■	■	■
CSB01.1N <sup>2)</sup>	■	■	-	■	■	■
CSB01.1C <sup>1)</sup>	■	■	-	■	■	■
CDB01.1C <sup>1)</sup>	-	-	■	-	-	-

- Allowed
  - Not allowed
  - 1) Control section can be configured
  - 2) Control section cannot be configured
- Fig. 10-4: Combination Control Section - Power Section*



**Do not exceed maximum number of plug-in actions!**

For a drive controller, the control section mustn't be mounted and dismantled more than a maximum of **20 times**. If this number is exceeded, the electrical data of the internal connection can be above the specified minimum requirements. This can cause malfunction of the drive controllers.

Power sections require control sections with appropriate firmware.

Control section type <sup>1)</sup>				Firmware version
CSB01	.	1	N -FC	as of MPB-02VRS
CSB01	.	1	N -AN	as of MPB-02VRS
CSB01	.	1	C	as of MPB-02VRS
CDB01	.	1	C	as of MPD-02VRS
CSH01	.	1	C	as of MPH-02VRS
CSH01	.	2	C	as of MPH-04VRS to MPH-05VRS
CSH01	.	3	C	as of MPC-06V06

- 1) Basic type without configuration
- Fig. 10-5: Required Firmware Version for Control Sections*

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Product Line	Type	current		Design	Supported as of firmware version	
HMS01.1N	-	W0020	-	A-07-	NNNN	MPH-02VRS; MPB-02VRS
	-	W0036	-	A-07-	NNNN	MPH-02VRS; MPB-02VRS
	-	W0054	-	A-07-	NNNN	MPH-02VRS; MPB-02VRS
	-	W0070	-	A-07-	NNNN	MPH-02VRS; MPB-02VRS
	-	W0110	-	A-07-	NNNN	MPH-02VRS; MPB-02VRS
	-	W0150	-	A-07-	NNNN	MPH-02VRS; MPB-02VRS
	-	W0210	-	A-07-	NNNN	MPH-02VRS; MPB-02VRS
HMS02.1N	-	W0350	-	A-07-	NNNN	MPH-02VRS; MPB-02VRS
	-	F0028	-	A-07-	NNNN	MPH-05V16; MPB-05V16
	-	F0070	-	A-07-	NNNN	MPH-05V16; MPB-05V16
	-	F0110	-	A-07-	NNNN	MPH-05V16; MPB-05V16
	-	F0110	-	A-07-	S003	MPH-05V16; MPB-05V16
	-	F0150	-	A-07-	NNNN	MPH-05V16; MPB-05V16
	-	F0210	-	A-07-	NNNN	MPH-05V16; MPB-05V16
	-	W0028	-	A-07-	NNNN	MPH-02V24; MPB-02V24 MPH-03V12; MPB-03V12
HMD01.1N	-	W0054	-	A-07-	NNNN	MPH-02V24; MPB-02V24 MPH-03V12; MPB-03V12
	-	W0012	-	A-07-	NNNN	MPD-02VRS
	-	W0020	-	A-07-	NNNN	MPD-02VRS
	-	W0036	-	A-07-	NNNN	MPD-02VRS

Fig.10-6: Required Firmware Versions for Inverters



## Handling, Diagnostic and Service Functions

Product Line	Type current		Design	Supported as of firmware version
HCS02.1E	- W0012	- A-03-	LNNN	MPH-02VRS; MPB-02VRS
	- W0012	- A-03-	NNNN	MPH-02VRS; MPB-02VRS
	- W0012	- A-03-	NNNV	MPH-02V20; MPB-02V20
	- W0028	- A-03-	LNNN	MPH-02VRS; MPB-02VRS
	- W0028	- A-03-	NNNN	MPH-02VRS; MPB-02VRS
	- W0028	- A-03-	NNNV	MPH-02V20; MPB-02V20
	- W0028	- S-03-	NNNN	MPH-02VRS; MPB-02VRS
	- W0054	- A-03-	LNNN	MPH-02VRS; MPB-02VRS
	- W0054	- A-03-	NNNN	MPH-02VRS; MPB-02VRS
	- W0054	- A-03-	NNNV	MPH-02V20; MPB-02V20
	- W0070	- A-03-	LNNN	MPH-02VRS; MPB-02VRS
	- W0070	- A-03-	NNNN	MPH-02VRS; MPB-02VRS
- W0070	- A-03-	NNNV	MPH-02V20; MPB-02V20	
HCS03.1E	- W0070	- A-05-	LNBV	MPH-02VRS; MPB-02VRS
	- W0070	- A-05-	LNNV	MPH-02V11; MPB-02V11
	- W0070	- A-05-	NNBV	MPH-02VRS; MPB-02VRS
	- W0070	- A-05-	NNNV	MPH-02V11; MPB-02V11
	- W0070	- A-15-	PSPV	MPH-02VRS; MPB-02VRS
	- W0100	- A-05-	LNBV	MPH-02VRS; MPB-02VRS
	- W0100	- A-05-	LNNV	MPH-02V11; MPB-02V11
	- W0100	- A-05-	NNBV	MPH-02VRS; MPB-02VRS
	- W0100	- A-05-	NNNV	MPH-02V11; MPB-02V11
	- W0150	- A-05-	LNBV	MPH-02VRS; MPB-02VRS
	- W0150	- A-05-	LNNV	MPH-02V11; MPB-02V11
	- W0150	- A-05-	NNBV	MPH-02VRS; MPB-02VRS
	- W0150	- A-05-	NNNV	MPH-02V11; MPB-02V11
	- W0210	- A-05-	LNBV	MPH-02VRS; MPB-02VRS
	- W0210	- A-05-	LNNV	MPH-02V11; MPB-02V11
	- W0210	- A-05-	NNBV	MPH-02VRS; MPB-02VRS
- W0210	- A-05-	NNNV	MPH-02V11; MPB-02V11	
HCS04.1E	- F0500	- A-05-	NNBV	MPH-04V10; MPB-04V10
	- W0500	- A-05-	NCBV	MPH-04V10; MPB-04V10
	- W0500	- A-05-	NNBV	MPH-04V10; MPB-04V10

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Product Line	Type current		Design	Supported as of firmware version
HCS04.2E	- W0290	- N-04-	NNNN	MPH-06V08; MPB-06V08
	...			
	- W1540	- N-04-	NNBN	MPB-06V08

Fig.10-7: Required Firmware Versions for Converters

Distributed Servo Drives KSM01

Product Line	Size, length		Other features	Supported as of firmware version
KSM01.2B	- 041C	-	-	MPB-04V20
	- 061C	-		
	- 071C	-		
	- 076C	-		

Fig.10-8: Required Firmware Versions for Distributed Servo Drives

Distributed Drive Controllers KMS01

Product Line	Features	Supported as of firmware version
KMS01	B-A018-P-D7-SE-ENH-NN-NN	MPB-06VRS
	B-A018-P-D7-SE-NNN-NN-NN	

Fig.10-9: Required Firmware Version for Distributed Drive Controllers



The devices are configured at the factory and can be read via parameters, if required.

## 10.2.2 Circuit Board Code

### Brief Description

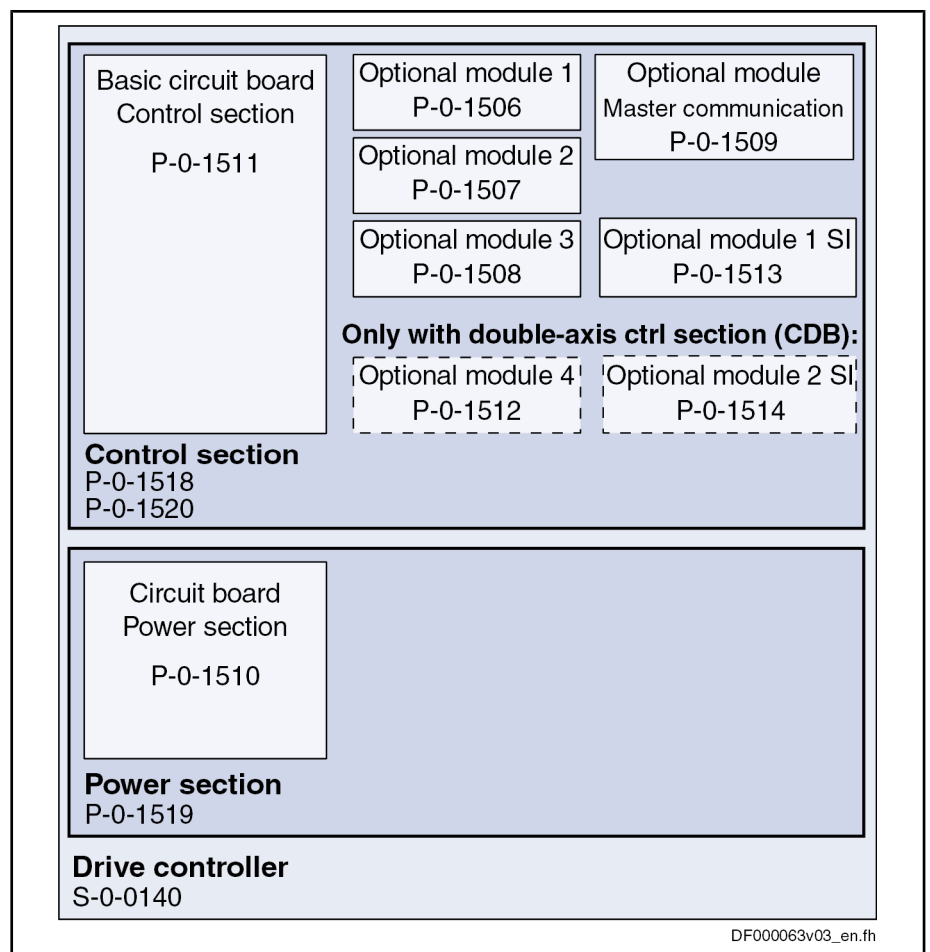
The configurable control section of a drive controller consists of the basic control section circuit board and one or several optional modules (see type code in the documentation "Drive Controllers, Control Sections; Project Planning Manual").

An individual parameter is assigned to each slot for circuit board or optional module (cf. P-0-1506 to P-0-1514). The specific data (circuit board code) of the circuit board that has been plugged are stored in these parameters.



The circuit board codes are stored directly on the circuit board or the respective optional module.

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S-0-0140	Controller type
P-0-1506	Circuit board code optional module 1
P-0-1507	Circuit board code optional module 2
P-0-1508	Circuit board code optional module 3
P-0-1509	Circuit board code master communication
P-0-1510	Circuit board code power section
P-0-1511	Circuit board code control section
P-0-1512	Circuit board code optional module 4
P-0-1513	Circuit board code optional module 1 for safety technology
P-0-1514	Circuit board code optional module 2 for safety technology
P-0-1518	Module code of control section
P-0-1519	Module code of power section
P-0-1520	Control section type

Fig. 10-10: Device Configuration and Circuit Board Code for IndraDrive

In the initialization phase (when booting), the drive firmware automatically checks the arrangement (configuration) of the control section by means of the individual circuit board codes, and on this basis generates the content of parameter "P-0-1520, Control section type". The configuration of the control section used can be read via this parameter.



The control section is configured at the factory and the configuration is displayed in parameter P-0-1520 for diagnostic purposes (type designation in plain text)!

Pertinent Parameters

- S-0-0140, Controller type

## Handling, Diagnostic and Service Functions

- P-0-1506, Circuit board code optional module 1
- P-0-1507, Circuit board code optional module 2
- P-0-1508, Circuit board code optional module 3
- P-0-1509, Circuit board code master communication
- P-0-1510, Circuit board code power section
- P-0-1511, Circuit board code control section
- P-0-1512, Circuit board code of optional module 4
- P-0-1513, Circuit board code optional module 1 for safety technology
- P-0-1514, Circuit board code optional module 2 for safety technology
- P-0-1518, Module code of control section
- P-0-1519, Module code of power section
- P-0-1520, Control section type

**Pertinent Diagnostic Messages**

During the initialization phase the drive, apart from checking the existing configuration, carries out some additional checks. Errors detected during the checks are classified according to their cause.

General malfunction of a circuit board with specific error messages:

- F8091 Power section defective
- F8122 Control section defective

Configuration of control section not allowed, i.e. an optional card was plugged into a slot that does not support this card (observe allowed combinations of the individual optional modules; see documentation "Drive Controllers, Control Sections; Project Planning Manual"):

- F8118 Invalid power section/firmware combination
- F8120 Invalid control section/firmware combination

## 10.2.3 Operating Hours Counter

### Brief Description

There are operating hours counters available in the drive that separately record the operating time for control section and power section. The respective operating time is displayed in the parameters P-0-0190 or P-0-0191. These times are directly stored from the control section or power section so that assignment is maintained also for servicing.

**Pertinent Parameters**

- P-0-0190, Operating hours control section
- P-0-0191, Operating hours power section

Parameter "P-0-0190, Operating hours control section" displays the operating time of the control section of the drive. The unit is seconds.

The time the drive has been switched on is considered to be the operating time of the control section.

Parameter "P-0-0191, Operating hours power section" displays the operating time of the power section of the drive with drive enable having been set. The unit is seconds.

The time during which the output stage has been enabled is considered to be the operating time of the power section.



Before delivery, the operating hours counters are set to a defined value at the factory. They can therefore indicate the total runtime of a component in field duty.

In addition, there is an operating hours counter for motors with which the dynamic operating data of the motor are collected and stored.

See section "Diagnostic Data of Motor Operation"

## 10.2.4 Error Memory (Power Section and Control Section)

### Brief Description

In the drive, all errors occurred are recorded in an error memory on the control section. If an error occurs in the power section, it is additionally stored in a separate error memory on the power section. It is thereby made sure that the relevant information is still available on the power section after separating the power section and control section.



When an error occurs, the diagnostic message number and the current count of the operating hours counter are automatically stored.

#### Pertinent Parameters

- S-0-0390, Diagnostic message number
- P-0-0190, Operating hours control section
- P-0-0191, Operating hours power section
- P-0-0192, Error memory of diagnostic numbers
- P-0-0193, Error memory operating hours of control section



The contents of the parameters P-0-0192 and P-0-0193 are stored on the control section. The content of parameter P-0-0194 is stored on the power section.

### Functional Description

#### Error Memory in Control Section

When the drive detects a class 1 diagnostics error, a bit is set in parameter "S-0-0011, Class 1 diagnostics" and bit 13 for "error in class 1 diagnostics" is set in the drive status word.

In order to allow a more detailed diagnosis

- the diagnostic message number appears on the display and is stored in parameter "S-0-0390, Diagnostic message number" (in "hex format"),
- the corresponding error number is stored in parameter "P-0-0009, Error number" (in "decimal format"),
- the plain text of the diagnostic message is stored in parameter "S-0-0095, Diagnostic message",
- the content of parameter "P-0-0190, Operating hours control section" at the time the error is detected is stored in parameter "P-0-0193, Error memory operating hours of control section",
- the diagnostic message number belonging to the error according to parameter "S-0-0390, Diagnostic message number" is stored in parameter "P-0-0192, Error memory of diagnostic numbers" in the same order.

The parameters P-0-0192 and P-0-0193 have a stack structure and contain, in chronological order, the diagnostic message numbers or the counts of the operating hours counter of the last **50 errors** that occurred.

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The count of the operating hours counter at the time the last error occurred is entered at the top of parameter P-0-0193, and the diagnostic message number of the last error occurred at the top of parameter P-0-0192.

**Error Memory in Power Section**

If the error concerns the power section, it is additionally stored in parameter "P-0-0194, Error memory power section".

The last 13 errors that occurred and the respective count of the operating hours counter (see P-0-0191) are stored in this parameter.

The error "F8060 Overcurrent in power section", for example, is an error which could occur in the power section. This error would be displayed both in parameter P-0-0193 and in parameter P-0-0194.

## 10.3 Diagnostic System

### 10.3.1 Coded Diagnostic Messages of the Drive

#### Brief Description

The drive provides a diagnostic system including different options that are basically divided into two groups:

- Recognizing and displaying the current drive status by means of drive-internal, priority-dependent generation of diagnostic messages
- Collective messages for diverse status messages

Additionally, there are parameters for all important operating data the values of which can be transmitted both via master communication (e.g. SERCOS) and a parameterization interface (RS-232/485 in the ASCII protocol or SIS protocol; see "Serial Communication").

**Pertinent Parameters**

- S-0-0030, Manufacturer version
- S-0-0095, Diagnostic message
- S-0-0140, Controller type
- S-0-0142, Application type
- S-0-0375, Diagnostic numbers list
- S-0-0390, Diagnostic message number
- P-0-0007, Display text of diagnostic message
- P-0-0009, Error number
- P-0-0478, Logbook event
- P-0-0479, Logbook time stamp
- P-0-3219, Extended safety technology diagnosis



For integrated safety technology, an extended diagnosis option is provided in the form of a safety technology error code. When certain safety technology errors occur, this error code can be read in parameter "P-0-3219, Extended safety technology diagnosis" which allows quick error diagnosis.

#### Drive-Internal Generation of Diagnostic Messages

Operating states, activities and reactions of the drive controller are detected by drive-internal generation of diagnostic messages and appear in coded form on the display of the control panel. In addition, these diagnostic messages can be transmitted to the master (control) and displayed and evaluated in a service and commissioning software (e.g. "IndraWorks Ds/D/MLD")

We distinguish the following categories of diagnostic messages (kinds of diagnostic messages):

- Errors
- Warnings
- Commands/command errors
- Status displays/operating states

Generally, the current diagnostic message with the highest priority is displayed or stored at the following locations in the drive:

- **Display of the control panel and parameter "P-0-0007, Display text of diagnostic message"**  
→ The diagnostic message number or, if applicable, text appears on the 8-digit display of the standard control panel. The current display is stored in parameter P-0-0007.
- **Parameter "S-0-0095, Diagnostic message"**  
→ This parameter, in the form of plain text, contains the operating status of the drive at present relevant. Preceding the text is the respective content of parameter S-0-0390.
- **Parameter "S-0-0390, Diagnostic message number"**  
→ The diagnostic message number shown on the display is stored in this parameter.

When a diagnostic message of the "error" category occurs, the corresponding diagnostic message number is stored in parameter "P-0-0009, Error number". When there isn't any error present, the value of parameter P-0-0009 equals zero.

In parameter "S-0-0375, Diagnostic numbers list", the last 50 diagnostic message numbers of parameter S-0-0390 are recorded in chronological order. When reading this list, the number of the diagnostic message that last occurred is displayed as parameter element 1.

**Priorities of Display**

The following priorities apply for displaying the current diagnostic message:

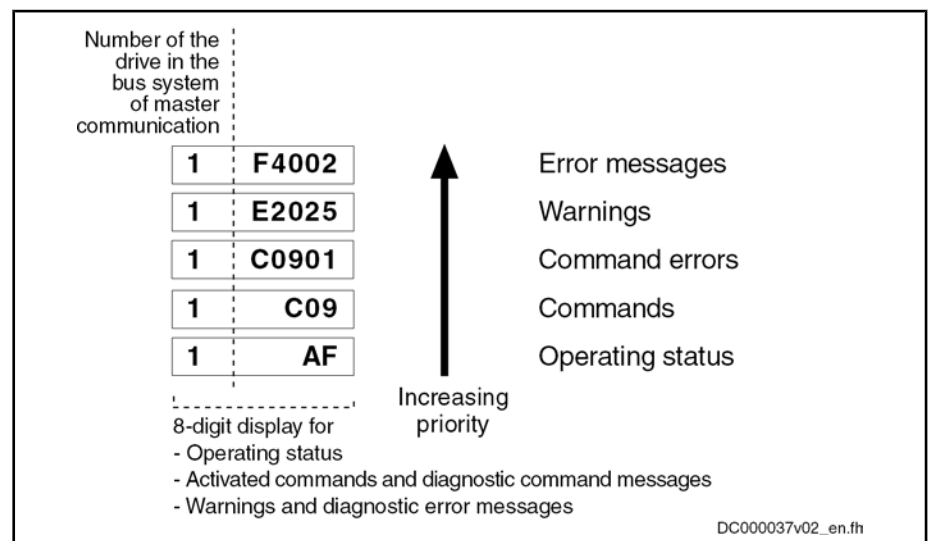


Fig.10-11: Priorities of Displays (With Example Displays)

An overview of all diagnostic messages and their meanings is included in the documentation "Troubleshooting Guide (description of diagnostic messages)".

## Handling, Diagnostic and Service Functions

## Structure of a Diagnostic Message

## General Information

Every diagnostic message consists of

- Diagnostic message number  
- and -
- diagnostic text.

The diagnostic message for the non-fatal error "F2028 Excessive deviation", for example, has the following structure:

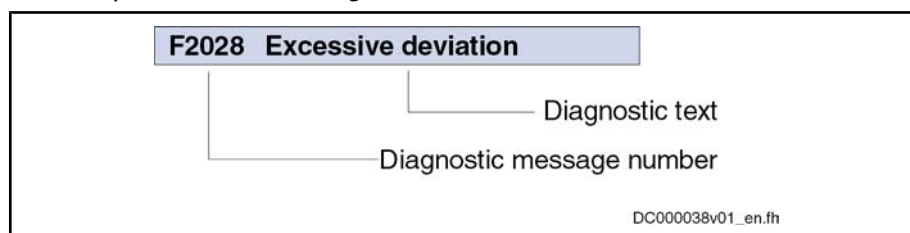


Fig. 10-12: Structure of a Diagnostic Message

"F2028" flashes on the display of the control panel. The display "F2028" is output via parameter "P-0-0007, Display text of diagnostic message", too. The diagnostic message number is contained in parameter "S-0-0390, Diagnostic message number" in hexadecimal form (for this example: 0x00F2028). The diagnostic message number and the diagnostic text are contained as string "F2028 Excessive deviation" in parameter "S-0-0095, Diagnostic message". "2028" (dec) is written to parameter "P-0-0009, Error number", because it is an error diagnosis.

## Diagnostic Message on the Control Panel Display

The diagnostic message number appears on the 8-digit display of the standard control panel. This allows recognizing the current operating status of the drive quickly and without using a communication interface.

As a matter of principle, the following applies:

- Status displays (P0, Ab, AF ...) are displayed in right-aligned form
- Warnings, command errors and other error messages are flashing

Kind of diagnostic message	Diagnostic message number	Display
Errors	F2xxx	F2xxx
Command	C0200	C02
Command errors	C02xx	C02xx
Warning	E2xxx	E2xxx
Communication phase e.g. communication phase 1	A0001	P1
Drive ready for operation	A0012	Ab
Operation mode e.g. velocity control	A0101	AF

Fig. 10-13: Overview of Diagnostic Messages Displayed



The current operation mode is not shown on the display. When the drive follows the preset operation mode and no command was activated, the display reads "AF".

### Diagnostic Message in Plain Text

The diagnostic message in plain text contains the diagnostic message number followed by the diagnostic message text. It can be read via parameter "S-0-0095, Diagnostic message" and directly displayed on an operator interface as a language-dependent description of the drive status.

The diagnostic message in plain text is switched to the selected language via parameter "S-0-0265, Language selection".

### Diagnostic Message Number

The diagnostic message number contains only the diagnostic number without the diagnostic text. It can be read via parameter "S-0-0390, Diagnostic message number" and is a language-independent possibility of determining and displaying the drive status on an operator interface.

### Display Text of Diagnostic Message

The display text of a diagnostic message is the text appearing on the display of the control panel. It can be read via parameter "P-0-0007, Display text of diagnostic message" which allows an operator interface to determine the drive status and display it in a language-independent way.

### Error Number

The error number contains only the error number without the diagnostic message text. It can be read via parameter "P-0-0009, Error number" and is a language-independent possibility of determining and displaying an error condition on an operator interface. This parameter only contains a value unequal zero when an error is present in the drive.

The error number is generated from the lowest 4 digits of the diagnostic message number. For example, the error "F2028 Excessive deviation" with the diagnostic message number "(0x)F2028" would produce the error number "2028".

### List of Diagnostic Numbers

The last 50 diagnostic message numbers displayed are stored in chronological order in parameter "S-0-0375, Diagnostic numbers list". Every change in the content of "S-0-0390, Diagnostic message number" means that the old content is applied to S-0-0375. When reading the parameter S-0-0375 the last transferred diagnostic message number appears in the first element of the parameter, the diagnostic message number transferred before from S-0-0390 in the second element, etc.

## Language Selection

Via parameter "S-0-0265, Language selection", it is possible to define or switch the language of diagnostic message texts.



See also Parameter Description "S-0-0265, Language selection"

## 10.3.2 Status Classes, Status Displays, Control Parameters

### General Information

In the drive there are many parameters with important status information (bit lists). Some of the bits contained in these lists can be used for configuring real-

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time status bits and additionally can be assigned to digital outputs or to the configurable signal status word.

See "Digital Inputs/Outputs"

See "Configurable Signal Status Word"

## Status Classes

## Brief Description

The drive differentiates between 3 states (error, warning and message) for which there is status information. To make the status information available, there are so-called class diagnostics parameters (S-0-0011, S-0-0012, S-0-0013) which contain the respective status bits.

In addition to these class diagnostics parameters, there are change bits contained in the status word of the field bus (e.g. S-0-0135 in the case of SERCOS) which display changes in one of the above-mentioned class diagnostics parameters (collective information).

- Features**
- Class diagnostics parameter for **errors** (cf. S-0-0011)
  - Class diagnostics parameter for **warnings** (cf. S-0-0012)
  - Class diagnostics parameter for **messages** (cf. S-0-0013)
  - **Change bits in status word** of master communication (e.g. S-0-0135 in the case of SERCOS)
  - Change bits of class 2 and 3 diagnostics (S-0-0097 and S-0-0098) **can be masked** in status word of master communication (e.g. S-0-0135 in the case of SERCOS) to suppress individual bits or status messages

- Pertinent Parameters**
- S-0-0011, Class 1 diagnostics
  - S-0-0012, Class 2 diagnostics
  - S-0-0013, Class 3 diagnostics
  - S-0-0097, Mask class 2 diagnostics
  - S-0-0098, Mask class 3 diagnostics
  - S-0-0135, Drive status word

## Functional Description

- Status Class Parameters**
- **S-0-0011, Class 1 diagnostics** (status parameter for drive errors)
    - In case a drive error occurs, the bit assigned to the error is set in parameter S-0-0011. A separate bit is assigned in S-0-0011 to errors defined according to SERCOS.

Manufacturer-specific errors cause bit 15 to be set in parameter S-0-0011 (see also Parameter Description "S-0-0011, Class 1 diagnostics").

  - In case a drive error occurs, bit 13 (drive interlock; error in class 1 diagnostics) is simultaneously set in the status word of the field bus (S-0-0135 in the case of SERCOS).



All bits in class 1 diagnostics are cleared by executing the command C0500 (reset class 1 diagnostics).

See also Parameter Description "S-0-0099, C0500 Reset class 1 diagnostics"

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- **S-0-0012, Class 2 diagnostics** (status parameter for drive warnings)

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- In case a drive warning occurs, the bit assigned to the warning is set in parameter S-0-0012. A separate bit is assigned in S-0-0012 to warnings defined according to SERCOS.

Manufacturer-specific errors cause bit 15 to be set in parameter S-0-0011 (see also Parameter Description "S-0-0012, Class 2 diagnostics").

- In case a drive warning occurs, bit 12 (change bit class 2 diagnostics) is simultaneously set in the status word of the field bus (S-0-0135 in the case of SERCOS), when the content of S-0-0012 changes (i.e. at least one bit toggles).
- The bits in parameter S-0-0012 are automatically cleared when the warning disappears. The change bit in the status word of the master communication (S-0-0135 in the case of SERCOS) remains set, however, until parameter S-0-0012 has been read once.



Via parameter "S-0-0097, Mask class 2 diagnostics", warnings can be masked in terms of their effect on the change bit.

- **S-0-0013, Class 3 diagnostics** (status parameter for drive messages)
  - Messages of the drive are listed in parameter S-0-0013. A separate bit is assigned in S-0-0013 to messages defined according to SERCOS (see also Parameter Description "S-0-0013, Class 3 diagnostics").
  - In the case of a drive message, bit 11 (change bit class 3 diagnostics) is simultaneously set in the status word of the field bus (S-0-0135 in the case of SERCOS).
  - The bits in parameter S-0-0013 are automatically cleared when the message disappears. The change bit in the status word of the master communication (S-0-0135 in the case of SERCOS) remains set, however, until parameter S-0-0013 has at least been read once.



Each of these messages is stored in a separate parameter (S-0-0330 to S-0-0342).

**Change Bits in Drive Status Word**

If the status of a bit in "S-0-0012, Class 2 diagnostics" or "S-0-0013, Class 3 diagnostics" changes, the change bit for class 2 or 3 diagnostics is set in the field bus status word (e.g. S-0-0135 in the case of SERCOS). A change bit in the status word (bit 11 or 12) is always set due to a change of the parameter content of S-0-0012 or S-0-0013. This enables the master to recognize very quickly whether a change occurred in S-0-0012 or S-0-0013.

A read access to one of the two parameters clears the respective change bit again.

**Masking the Change Bit**

By means of the parameters "S-0-0097, Mask class 2 diagnostics" and "S-0-0098, Mask class 3 diagnostics", it is possible to mask certain bits in terms of their effect on the change bit of the status word (bit 12 or bit 11).

The figure below illustrates the principle of masking by means of an example:

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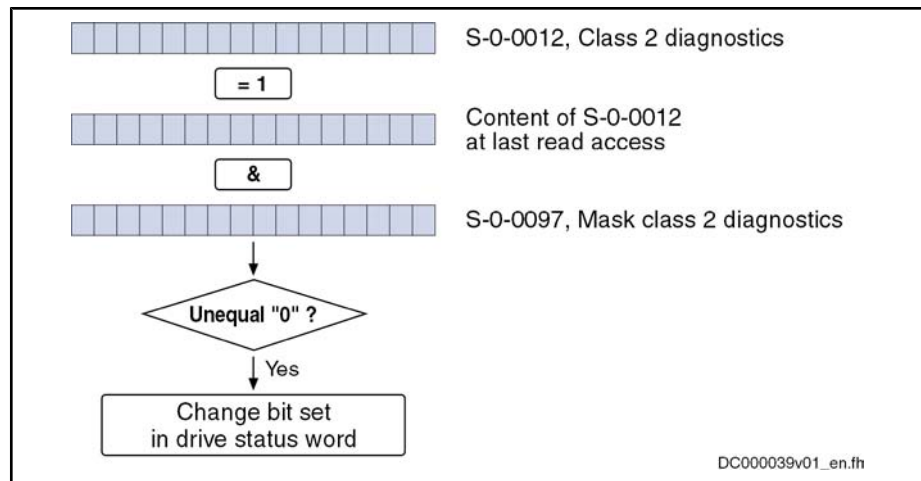


Fig.10-14: Generating the Change Bit of Class 2 Diagnostics

### Notes on Commissioning

The figure below illustrates the handling of the change bits in the status word and of the status class parameters:

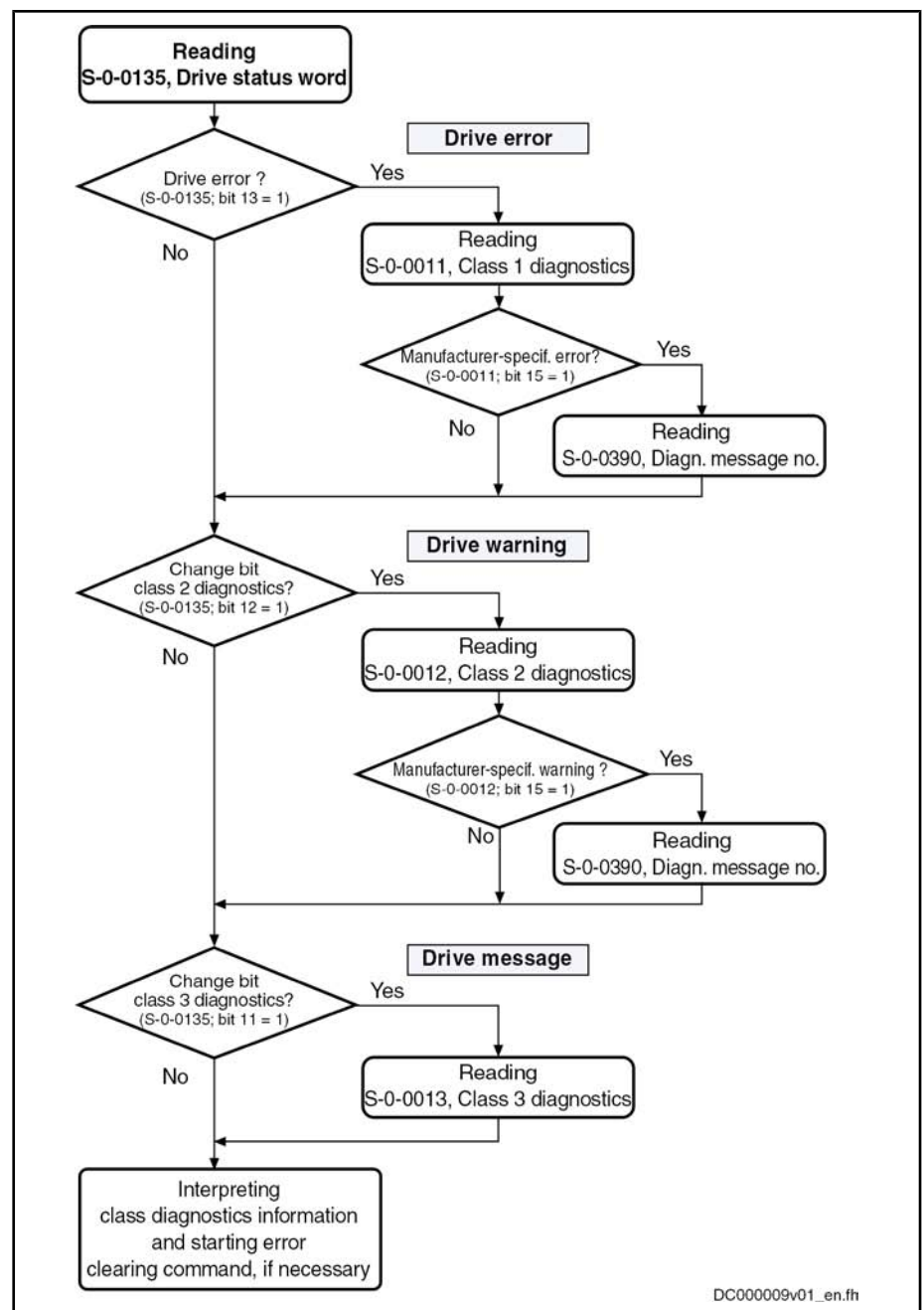


Fig. 10-15: Handling the Change Bits and Status Class Parameters

## Fixed Status Displays

### Function-Related Status Parameters

In the drive there are parameters the content of which has a direct relation to the status of the sequence of different drive functions. These parameters are used to display the current status information of the assigned function.

The following parameters are available for function-related status display:

- **S-0-0014, Interface status**

This parameter displays the status of the communication phase transition and the cyclic communication.

- **S-0-0135, Drive status word**

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This is the status word of the master communication (SERCOS) and contains all essential pieces of status information for the master.

- **S-0-0403, Position feedback value status**

This parameter contains status bits for the position data reference of the individual measuring systems.

- **S-0-0419, Positioning command acknowledge**

This status information is used for acknowledgment in the "drive-controlled positioning" mode.

- **P-0-0046, Status word of current controller**

This parameter contains status bits of the internal motor control (e.g. over-voltage in DC bus).

- **P-0-0115, Device control: status word**

This parameter contains status bits of device control (see also "Device Control and State Machines").

- **P-0-0222, Travel range limit switch inputs**

This parameter displays the status of the travel range limit switch inputs (see also "Limitations: Travel Range Limit Switches").

- **P-0-0223, E-Stop input**

This parameter displays the status of the E-Stop input (see also "E-Stop Function").

- **P-0-0455, Acceleration feedforward actual value**

This parameter contains status bits to display the activation of torque/current limitation (see also "Limitations: Current and Torque/Force Limitation").

- **P-0-0539, Holding brake status word**

This parameter contains status bits for the status of the motor holding brake (see also "Motor Holding Brake").

- **P-0-0555, Status word of axis controller**

This parameter displays messages with regard to velocity and limits that have been reached.

- **P-0-4029, Diagnostic report SCSB module**

Parameter for reading master communication settings and states (with SERCOS interface).

- **P-0-4086, Master communication status**

This parameter displays control information of the master communication for handling phase switch, drive enable etc., defined during initialization.

### Status Parameters for Real-Time Status Bits

The following list contains status parameters that only contain one bit and can therefore be used for configuring real-time status bits (see "SERCOS Interface"):

- S-0-0330, Status "n\_feedback = n\_command"
- S-0-0331, Status "n\_feedback = 0"
- S-0-0332, Status "n\_feedback < nx"
- S-0-0333, Status "T >= Tx"
- S-0-0334, Status "T >= Tlimit"
- S-0-0335, Status "n\_command > n\_limit"

- S-0-0336, Status "In position"
- S-0-0337, Status "P >= Px"
- S-0-0341, Status "In coarse position"
- S-0-0342, Status "Target position attained"
- S-0-0343, Status "Interpolator halted"
- S-0-0409, Probe 1 positive latched
- S-0-0410, Probe 1 negative latched
- S-0-0411, Probe 2 positive latched
- S-0-0412, Probe 2 negative latched

## Control Parameters

Apart from the parameters for status display, there are parameters available in the drive that are used to control the drive functions (see also description of corresponding parameter):

- P-0-0045, Control word of current controller
- P-0-0427, Control parameter of analog output
- P-0-0522, Control word for commutation setting
- P-0-0556, Config word of axis controller
- P-0-0612, Set absolute position control
- P-0-4028, Device control word

## 10.4 Control Panels of the IndraDrive Controllers

### 10.4.1 General Information on the Operation Options

#### Control Panel Variants

IndraDrive controllers are equipped with a "control panel"; its front consists of a display and keys located underneath it. The display shows operating states, command and error diagnoses, as well as present warnings. By means of the keys you can make settings, call information and trigger some commands.



Fig. 10-16: Standard Control Panel

Variant	Description
Standard control panel	Component of the IndraDrive controller
Comfort control panel	Optional

Fig. 10-17: Control Panel Variants

Via the serial interface of the controller, it is additionally possible to connect an independent **VCP operator terminal** that can, for example, be integrated in the front of the control cabinet.

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VCP operator terminals are separate components (terminals) that can be used in addition to the standard or comfort control panel. They are connected to the serial interface of the controller via a separate line. This allows integrating a VCP operator terminal in the front of the control cabinet, for example.

By means of a configuration tool it is additionally possible to configure other application-dependent settings, displays and command functions.

## 10.4.2 Standard Control Panel

### Brief Description

The control panel of an IndraDrive controller has an 8-digit display and keys located underneath it.

The display shows operating states, command and error diagnoses, as well as present warnings, if any.

Using the four keys, the commissioning engineer or service technician can opt to display extended diagnostic messages at the drive controller and to activate simple commands (in addition to master communication using the commissioning tool or NC control unit).

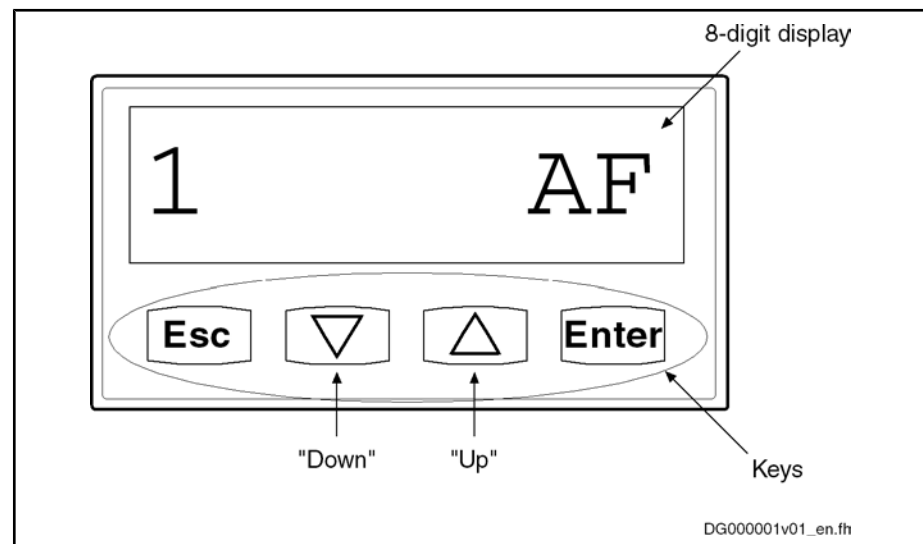


Fig.10-18: Standard Control Panel With Display and Control Elements (Example of Display)

#### Possibilities of Display of Standard Control Panel

The display of the IndraDrive controller automatically shows:

- Status of the master communication
- Operating status
- Commands and diagnostic command messages
- Warnings and diagnostic error messages
- Extended displays such as contents of error memories, diagnostic message memory, operating hours counter of control section, operating hours counter of power section, type designation of firmware active in the device, safety technology code (if safety technology option available)

#### Possible Settings with Standard Control Panel

The following settings can be made with the standard control panel:

- Set the drive address (drive number in the bus system of the master communication)
- Set the length of the fiber optic cable
- Activating the master communication mode "Easy Startup"



**Command Activation Using the Standard Control Panel**

The following commands can be activated via the standard control panel:

- Activating "S-0-0262, C07\_x Load defaults procedure command" (load controller parameters or basic parameters)
- Activating other commands, such as:
  - C0200 Exit parameterization level procedure command
  - C0300 Set absolute position procedure command
  - C0400 Activate parameterization level 1 procedure command
  - C2000 Command Release motor holding brake
  - C2200 Backup working memory procedure command
  - C2300 Load working memory procedure command
  - C2800 Analog input adjustment command
  - C2900 Command Firmware update from MMC

**Functional Description****Standard Displays**

The displays have priorities, because it is impossible to have various displays at the same time!

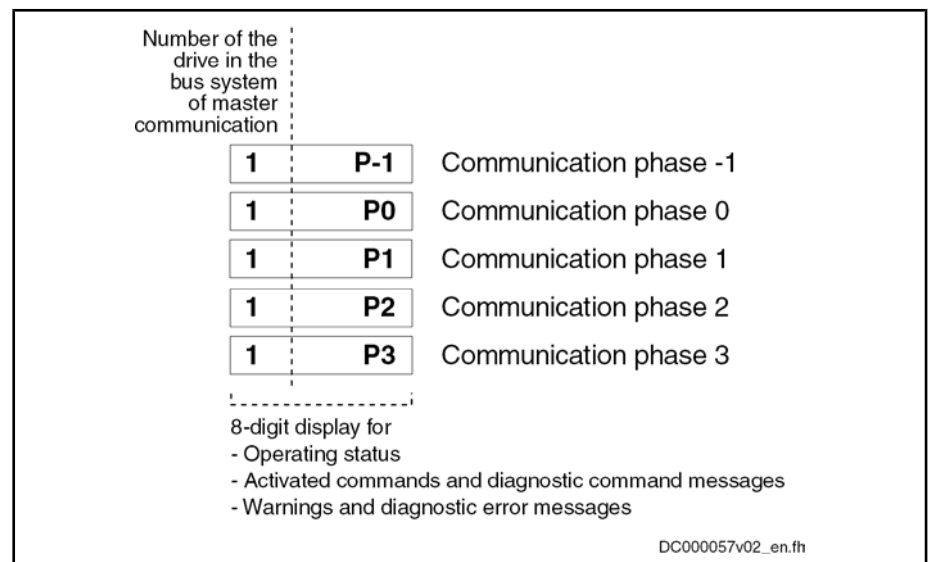


Fig. 10-19: Displays During Phase Progression of the Master Communication

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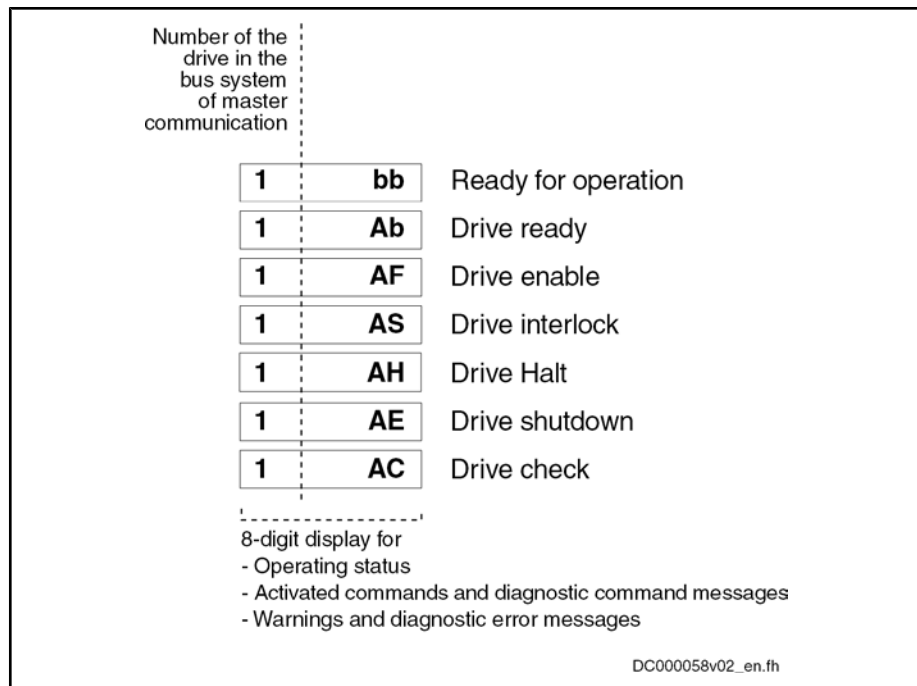


Fig.10-20: Displays During Phase Progression of the Master Communication

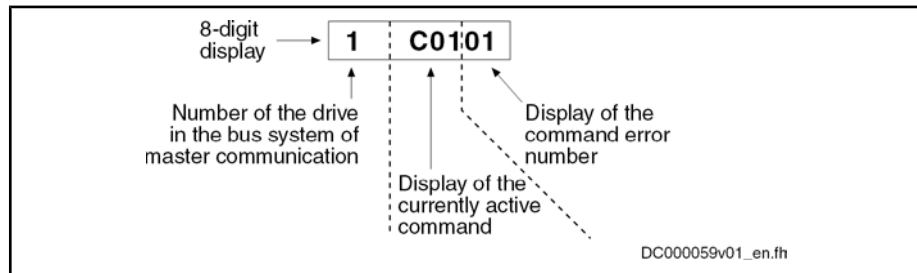


Fig.10-21: Explanation of Command Error Displays

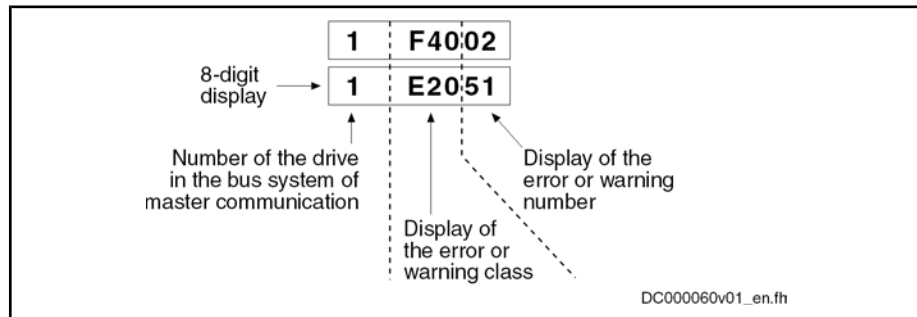


Fig.10-22: Explanation of Error and Warning Displays

Priorities of Display

The current drive status is displayed with highest priority.

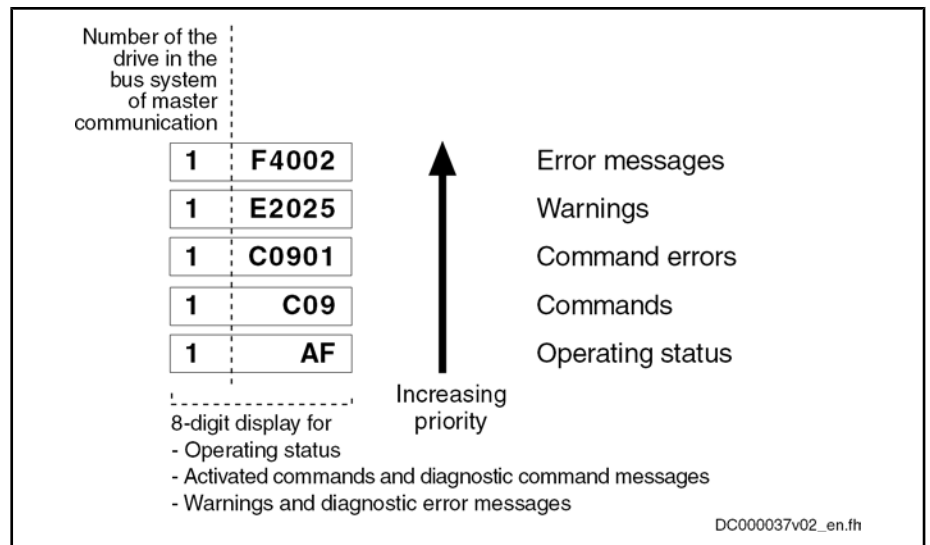


Fig. 10-23: Priorities of Displays (With Example Displays)

In the case of error messages, warnings and command errors, the diagnostic message text is displayed on the standard display in the form of a marquee text in the standard operating panel, in addition to the flashing diagnostic message number (see also Parameter Description "S-0-0095, Diagnostic message").

**Activating Extended Display, Command Menu, Service Menu, and Easy Menu**

The easy menu can always (without unlocking) be accessed by pressing the "Enter" key.

By simultaneously pressing the "Esc" and the "Enter" keys in the standard display (for 8 s when activated for the first time) the extended menu can be accessed.

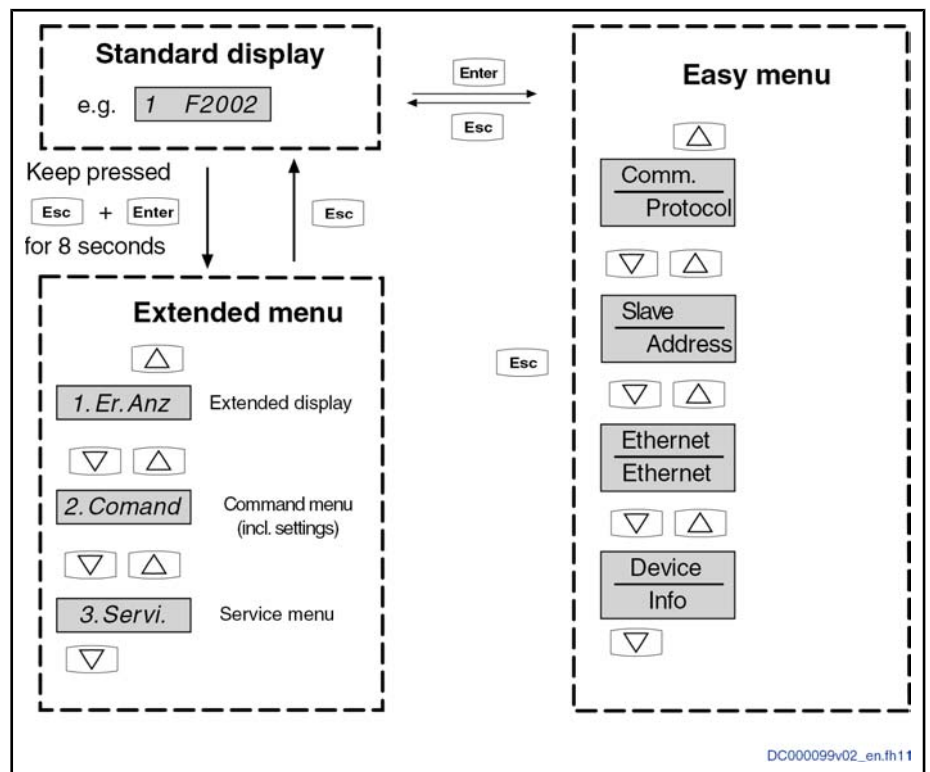


Fig. 10-24: Activating the Extended Display, the Command Menu and the Easy Menu

**Easy Menu**

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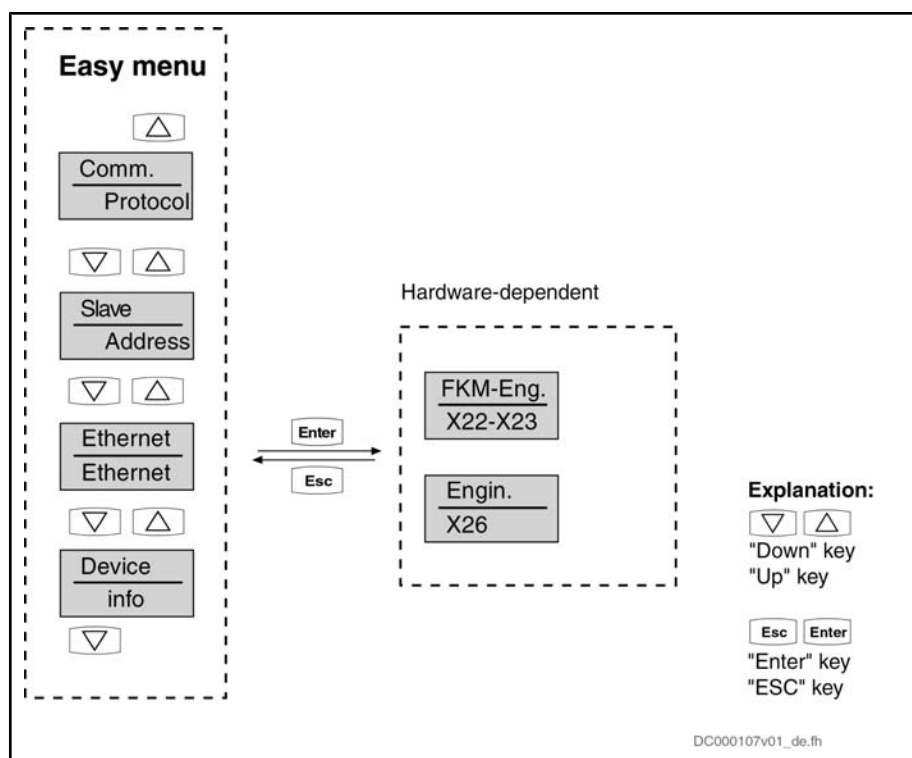


Fig.10-25: Easy Menu

Control panel text:	Comment/note:
"Comm.____" "Protocol"	This submenu shows the current field bus protocol and can be changed, if required.
"Slave____" " _Address"	This submenu shows the current drive address. It can be changed, if required.
"Ethernet" "Ethernet"	In this menu the Ethernet connection can be viewed or set. The menu structure below "Ethernet" may vary, depending on the hardware (see "Easy Menu" on page 937).
"Device__" " ____Info"	This submenu shows the information of the hardware to be used, e.g. firmware string ( S-0-0030). <b>No settings can be made in this submenu.</b>

Handling, Diagnostic and Service Functions

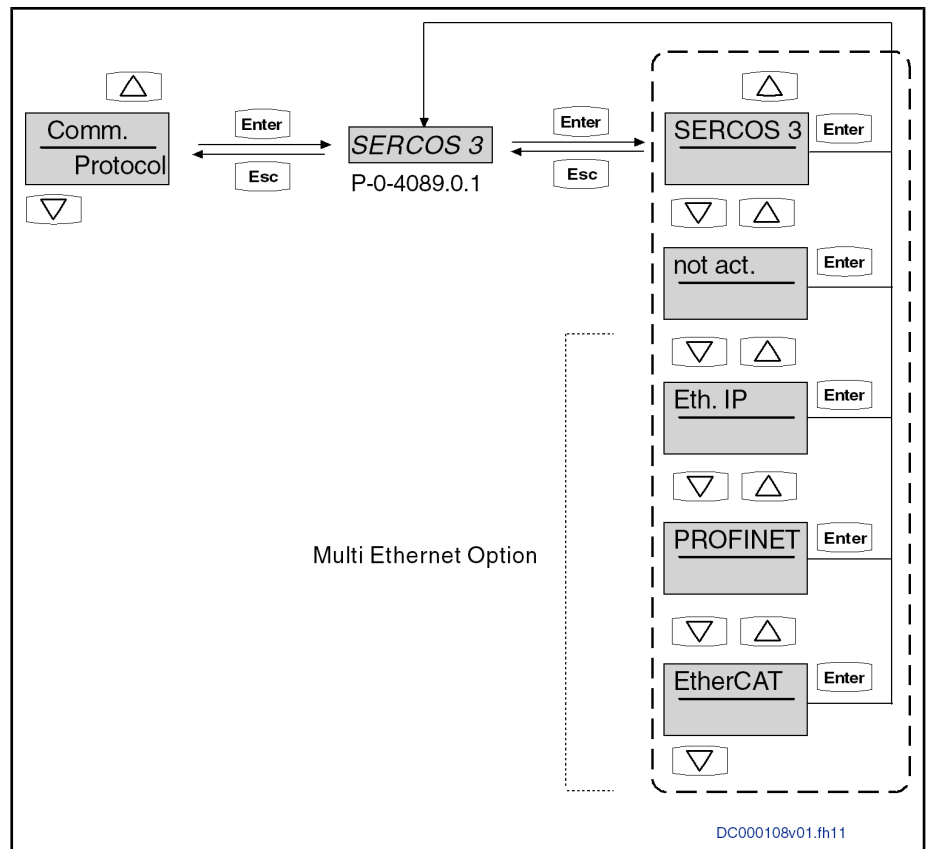


Fig. 10-26: Submenu of "Comm.\_\_\_\_" "Protocol"

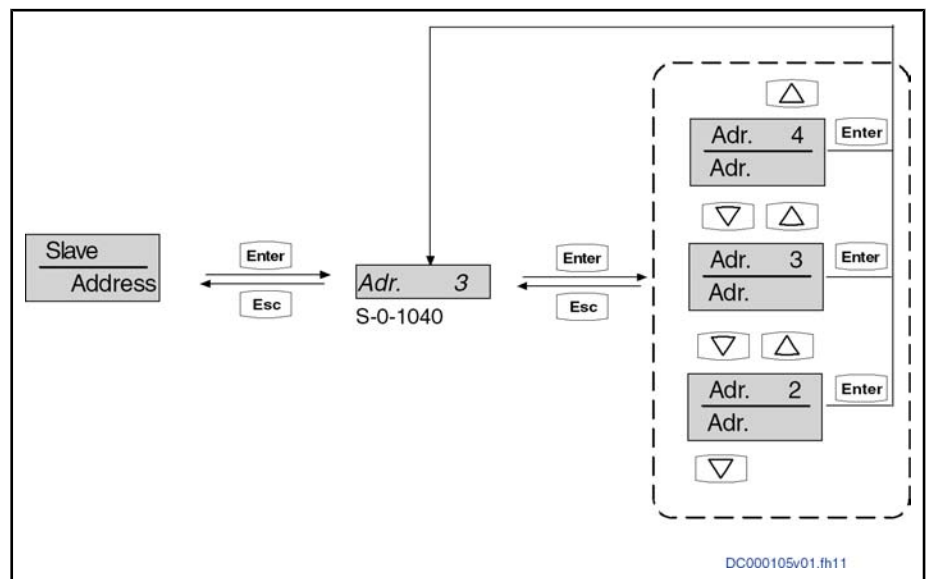


Fig. 10-27: Submenu of "Slave\_\_\_\_" "Address"

Handling, Diagnostic and Service Functions

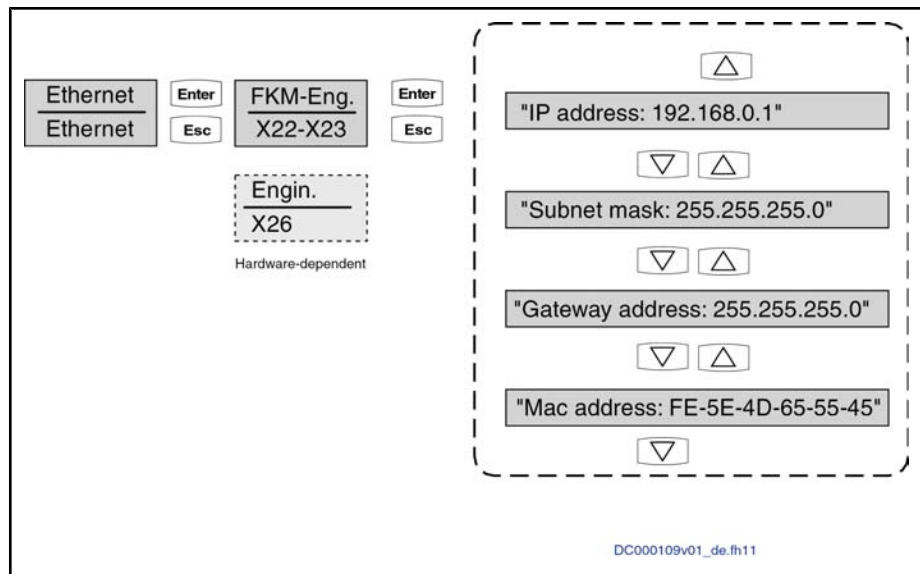


Fig.10-28: Submenu of "Ethernet" "Ethernet"

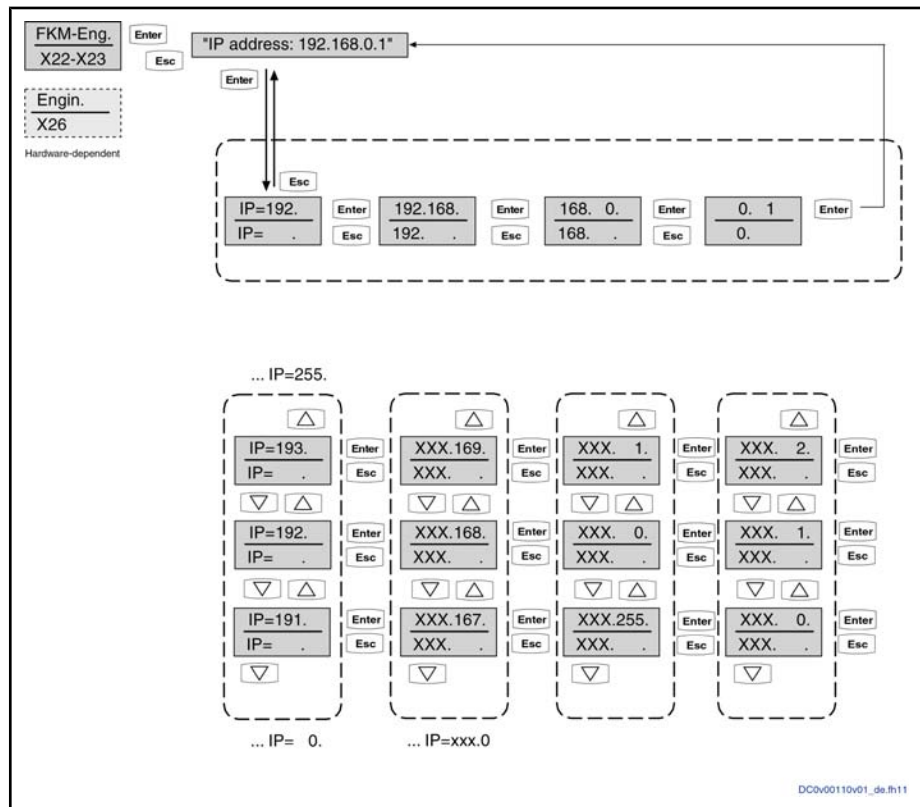


Fig.10-29: Example for Setting the IP Address for "FKM-Eng." "X22-X23"

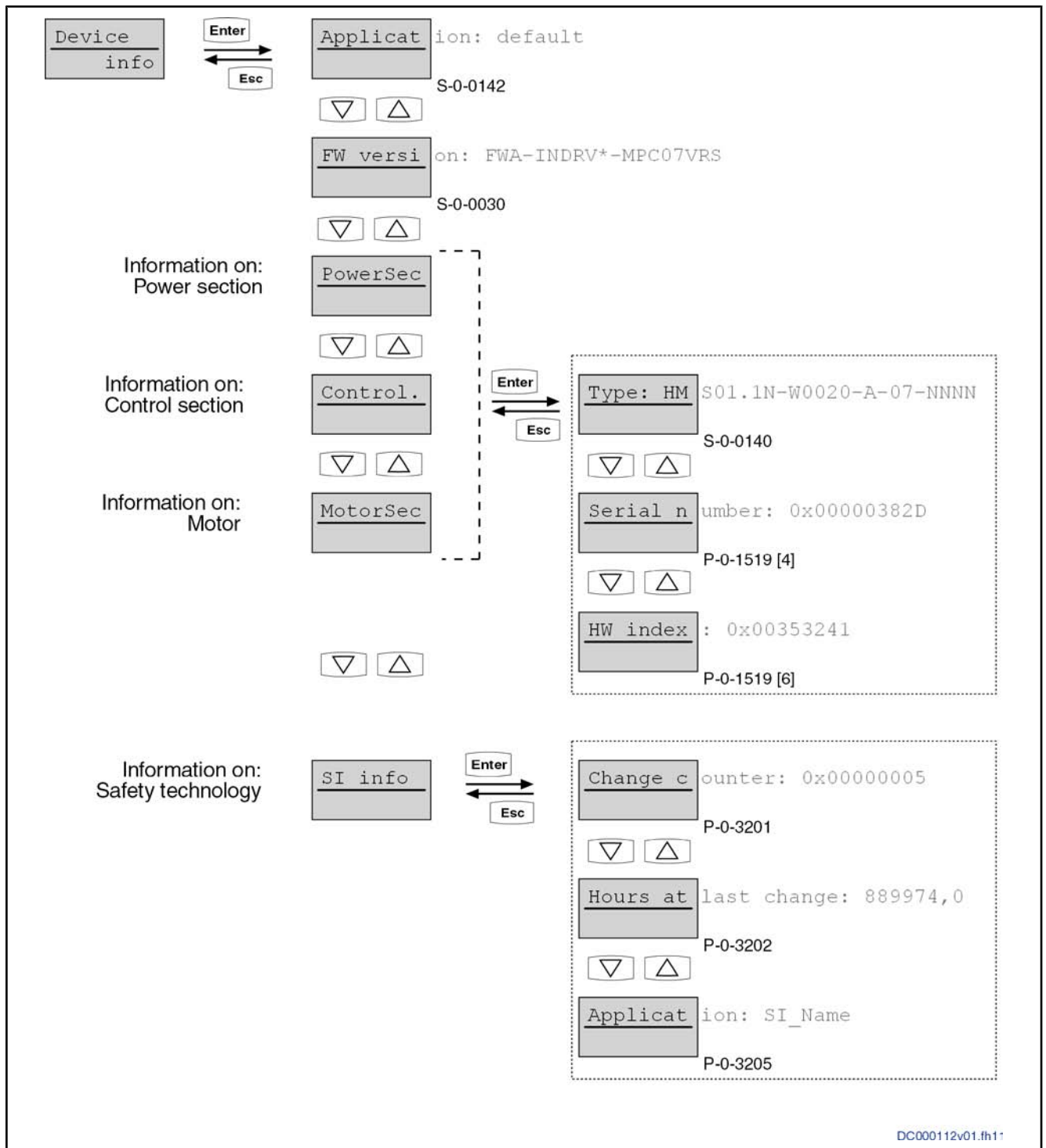


Fig.10-30: Easy Menu, Structure in "Device\_ " " \_\_Info"

Assigning the entries in the menu "Device\_ "" \_\_Info" to the parameters used

Menu	Entry	Parameters used
-	Application	Text in "S-0-0142, Application type"
-	FW version	Text in "S-0-0030, Manufacturer version"

## Handling, Diagnostic and Service Functions

Menu	Entry	Parameters used
PowerSec	Type	Text in "S-0-0140, Controller type"
	Serial number	"P-0-1519, Module code of power section", 5th element
	HW index	"P-0-1519, Module code of power section", 7th element
Control.	Type	Text in "P-0-1520, Control section type"
	Serial number	"P-0-1518, Module code of control section", 5th element
	HW index	"P-0-1518, Module code of control section", 7th element
MotorSec	Type	Text in "S-0-0141, Motor type"
	Serial number	"P-0-3000, Module code of motor, encoder memory", 5th element
	HW index	"P-0-3000, Module code of motor, encoder memory", 7th element
SI info	Change counter	"P-0-3201, Change counter of safety technology memory"
	Hours at last change	"P-0-3202, Operating hours at last change of memory"
	Application	"P-0-3205, Safety technology device identifier"

**Extended Display**

By means of the extended displays, it is possible to additionally call up the contents of certain parameters:

- Error memory
- Diagnostic message memory
- Operating hours counter control section
- Operating hours counter power section
- Type designation of the firmware active in the device
- Safety technology code, change counter of safety technology and operating hours counter since last change (if safety technology option available)
- Diagnostic field bus message (P-0-4073)





## Handling, Diagnostic and Service Functions

For more details on diagnostic messages, error messages and operating hours counters, see the respective sections of the present documentation.

### **Command Menu**

Starting from the extended display, you can activate the command menu by pressing the "Up" key. In this menu, you can make several settings:

- Set the drive address (drive number in the bus system of the master communication)
- Additional communication settings (IP address, gateway addresses and subnet mask)
- Activating the easy master communication mode "easy startup"
- Activating "S-0-0262, C07\_x Load defaults procedure command" (load controller parameters or basic parameters)
- Switch the communication phases between operating mode (OM) and parameter mode (PM)

Handling, Diagnostic and Service Functions

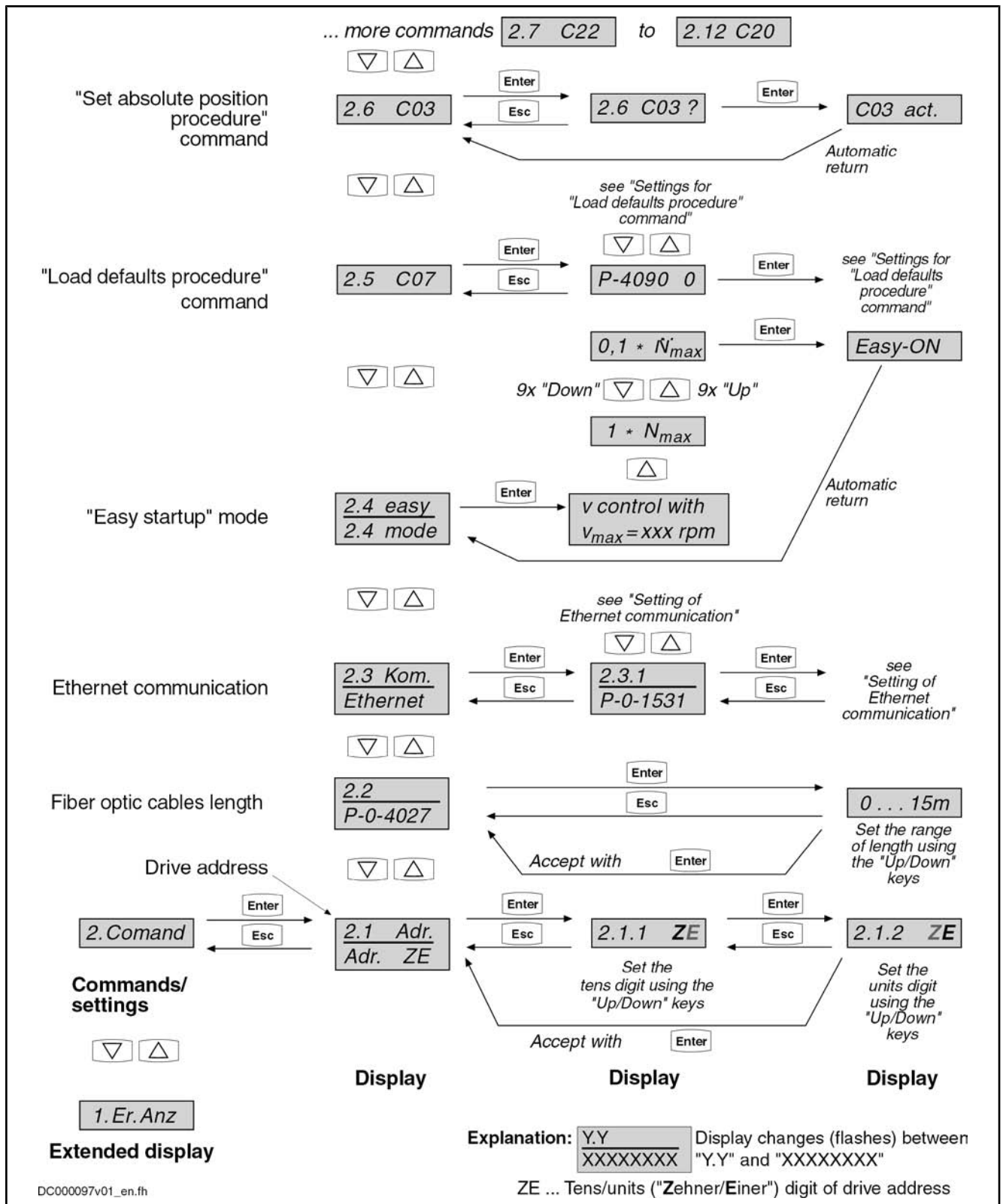


Fig. 10-32: Activating Commands/Settings That can be Accessed Via the Control Panel (Command 2.1 to 2.6)

Handling, Diagnostic and Service Functions

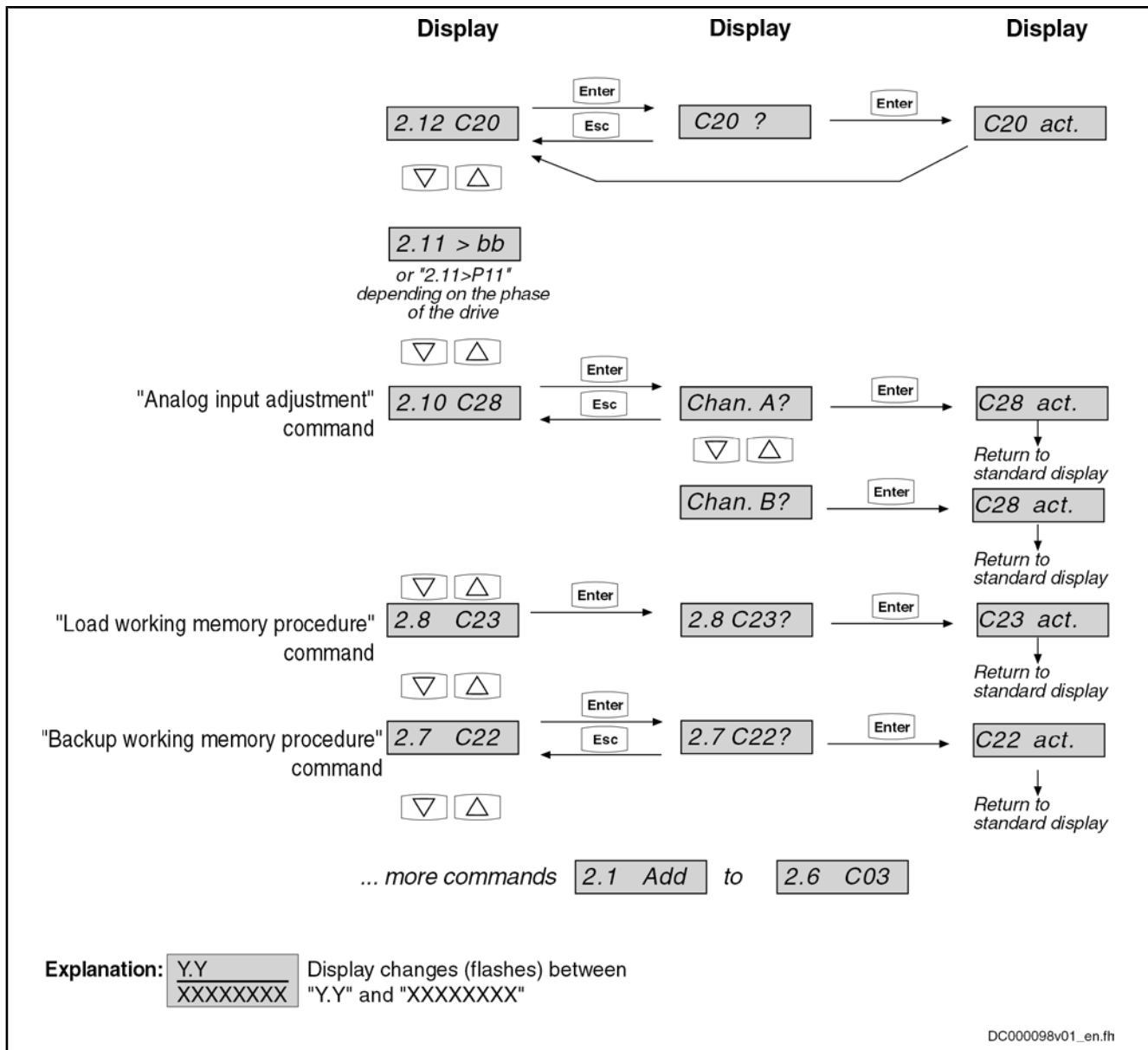


Fig. 10-33: Activating Commands/Settings That can be Accessed Via the Control Panel (Command 2.7 to 2.12)

Settings for the "Load Defaults Procedure" Command

The parameter "S-0-0262, C07\_x Load defaults procedure command" can be activated via the standard control panel, too. Depending on the configuration in parameter "P-0-4090, Configuration for loading default values", different basic parameter sets are loaded internally. The following configurations in parameter P-0-4090 are possible via the standard control panel, the last two digits of the hexadecimal parameter value being displayed on the standard display:

- Loading motor-specific control loop parameter values → 0x0000
- Loading basic parameter values, without exception → 0x0001
- Loading basic parameter values, except for master communication parameters → 0x0011



After the command C07\_x has been executed, the parameter P-0-4090 is automatically reset to its default value (0x0000)!

Handling, Diagnostic and Service Functions

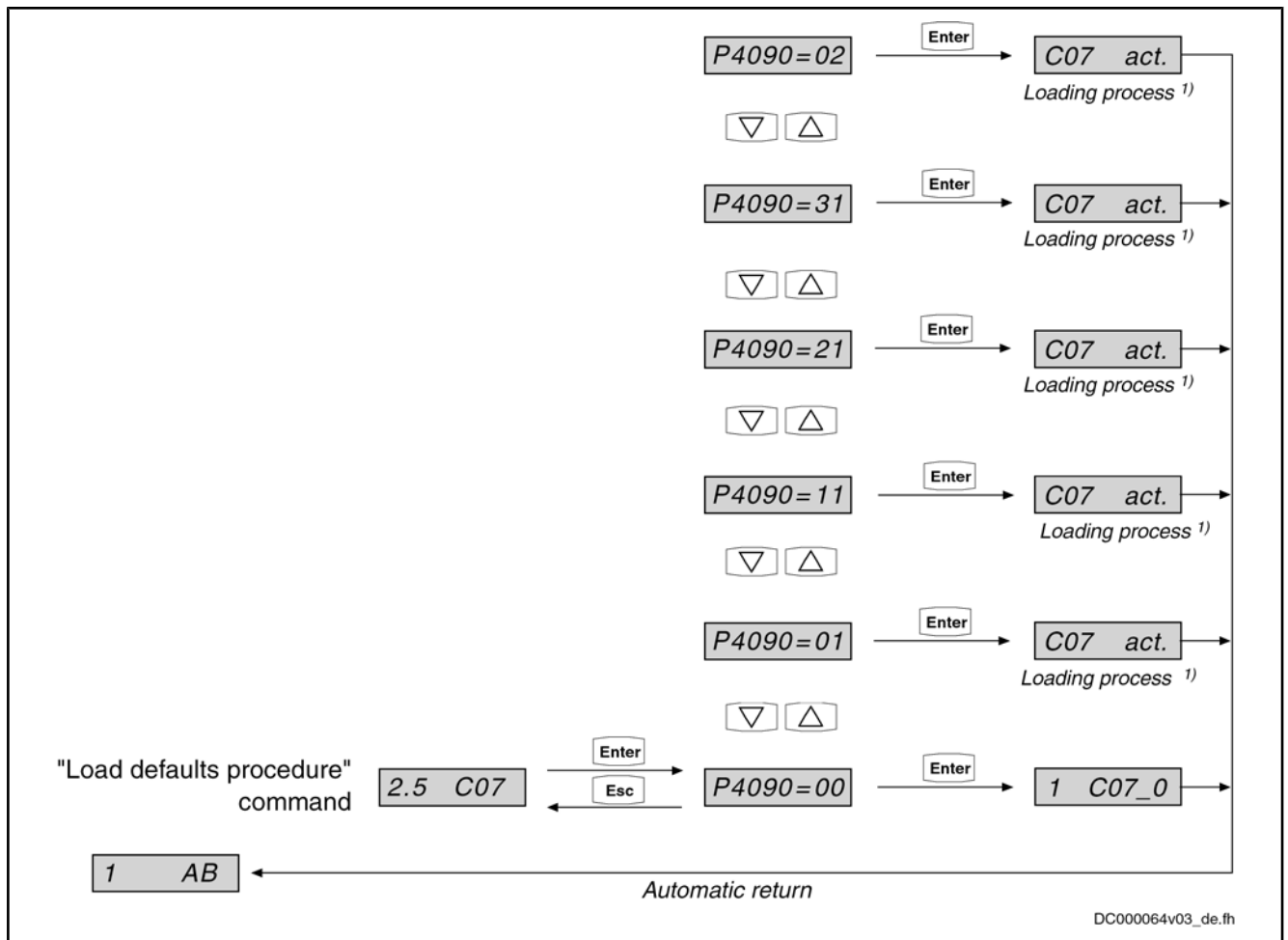


Fig. 10-34: Setting the Parameter P-0-4090 for "Load Defaults Procedure" via the Standard Control Panel

**Switching the Communication Phases**

Switching the communication phases between operating mode (OM) and parameter mode (PM) via the control panel is possible with all master communications, except for SERCOS interface. With SERCOS interface, phase switch controlled via the control panel can only be carried out with active "easy start-up" mode!



In order to execute "C07\_1 Load defaults procedure com. (load basic parameters)", the parameter mode (PM) has to be activated.

Handling, Diagnostic and Service Functions

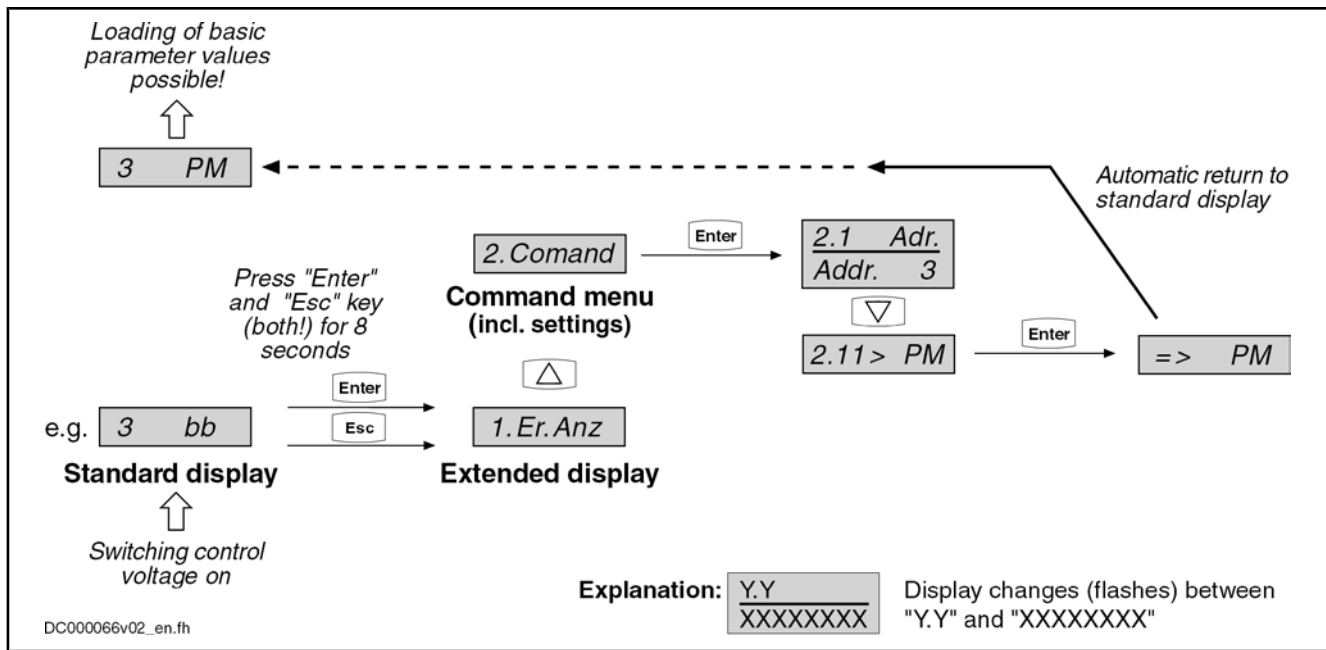


Fig.10-35: Activating the Parameter Mode Via the Control Panel

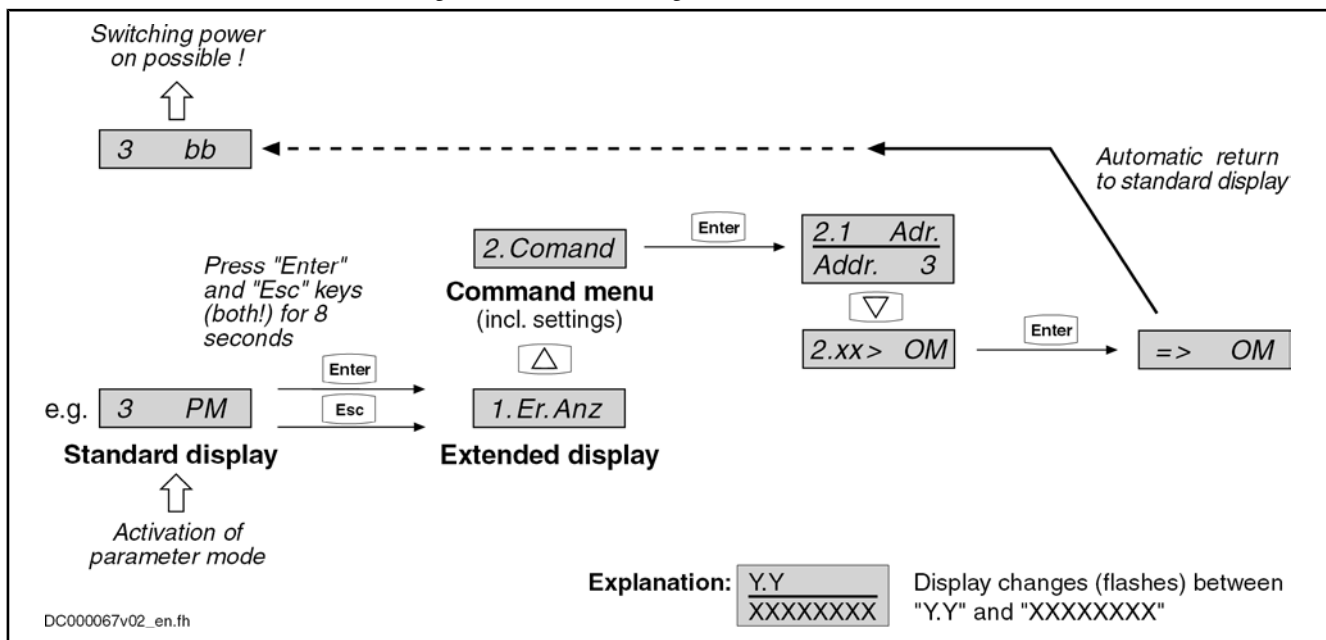


Fig.10-36: Switching Back From Parameter Mode to Operating Mode Via the Control Panel

**Defining the MMC Storage Mode**

The parameter "P-0-4070, Parameter storage configuration" defines how the controller handles the (optional) MMC memory card. This setting can be made directly via the command menu of the control panel (2.10). The following storage modes are possible for operating the MMC:

- MMC as programming module
- MMC as update medium
- MMC as backup medium

**MMC as Programming Module**

If the MMC has been defined as "programming module", all parameters are stored on the MMC. With active controller, the MMC must be permanently

**MMC as Update Medium**

plugged in the control section. If the controller is switched on without MMC or the MMC is removed from the active controller, the controller signals an error.

When the MMC has been defined as "update medium", the control section checks during the booting process whether an MMC was plugged in or not. Via the display, you will be queried whether the parameters are to be loaded from the MMC. If there is a newer firmware on the MMC, you will also be queried whether this firmware is to be loaded. The parameters are not stored on the MMC, but in the onboard flash memory.

**MMC as Backup Medium**

When the MMC has been defined as "backup medium", it is used as a demand-dependent storage location for parameter settings. The parameter values are stored via a command, via FTP server or file services (MLD).

When the MMC operation has been defined as "update medium" or as "backup medium", it is **not** necessary to have the MMC permanently plugged in the control section. The MMC can be plugged in or removed with the drive active. Loading and storing parameter sets, however, is only possible with the MMC plugged in!



The possibilities of use for the MMC in the IndraDrive controller are described in detail in the section "MultiMediaCard (MMC)".

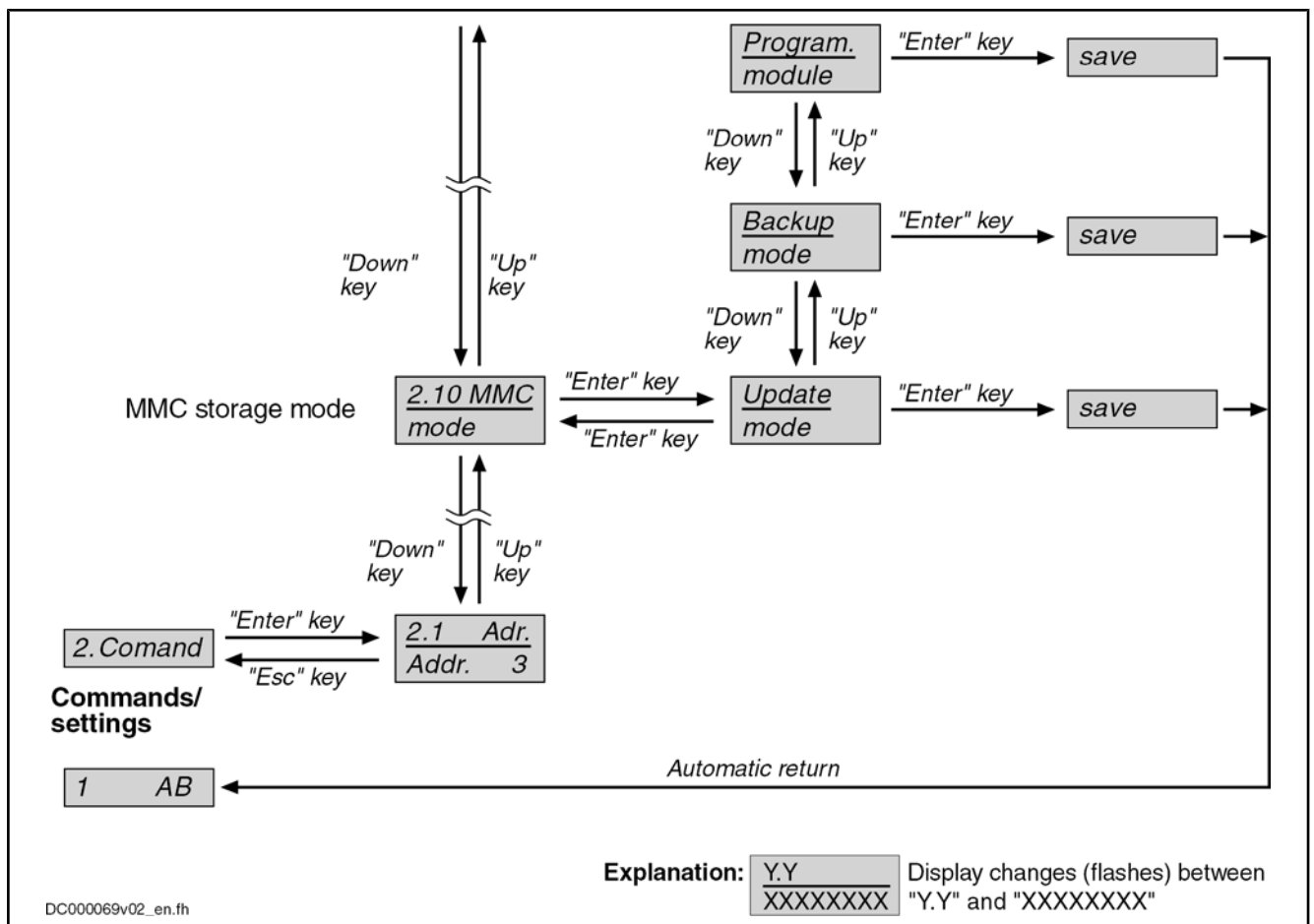


Fig. 10-37: Setting the MMC Storage Mode With the Control Panel

**Service Menu**

Starting from the command menu, you can activate the service menu by pressing the "Up" key. It supports the following actions:

## Handling, Diagnostic and Service Functions

- Firmware update with previous saving of the parameter values on the internal memory (flash), if the optional memory (MMC) is the active memory (MMC as "programming module"). After the update, the parameter values can be loaded to the MMC again from the internal memory (flash).  
**Note:** If the internal memory (flash) is the active storage medium ("hot plug" of the MMC), the parameter values are already available in the device and do not need to be saved before the MMC-based firmware update. In this case, pressing the "Enter" key with the display "Save data" is without effect!
- Replacement of device with saving of parameter values on MMC, if the internal memory (flash) is the active memory. After the device has been replaced, firmware and values of the drive parameters, as well as PLC retain data, can be loaded from this MMC to the replacement controller.  
**Note:** If the control section has been equipped with the optional module "MDx", the retain data of the PLC are saved on the MMC in addition to the values of the drive parameters, when "Save data" is executed! When the MMC is the active memory, the drive parameters are not saved, because they have already been stored on the MMC, but the PLC data are stored on the MMC.
- Copy parameters:
  - Storing the parameter values and, if necessary, the PLC retain data from the device-internal, non-volatile memories (onboard flash and, if available, memory of optional module "MDx") on the MMC
  - Loading the parameter values stored on the MMC to the non-volatile memories of the controller



Handling, Diagnostic and Service Functions

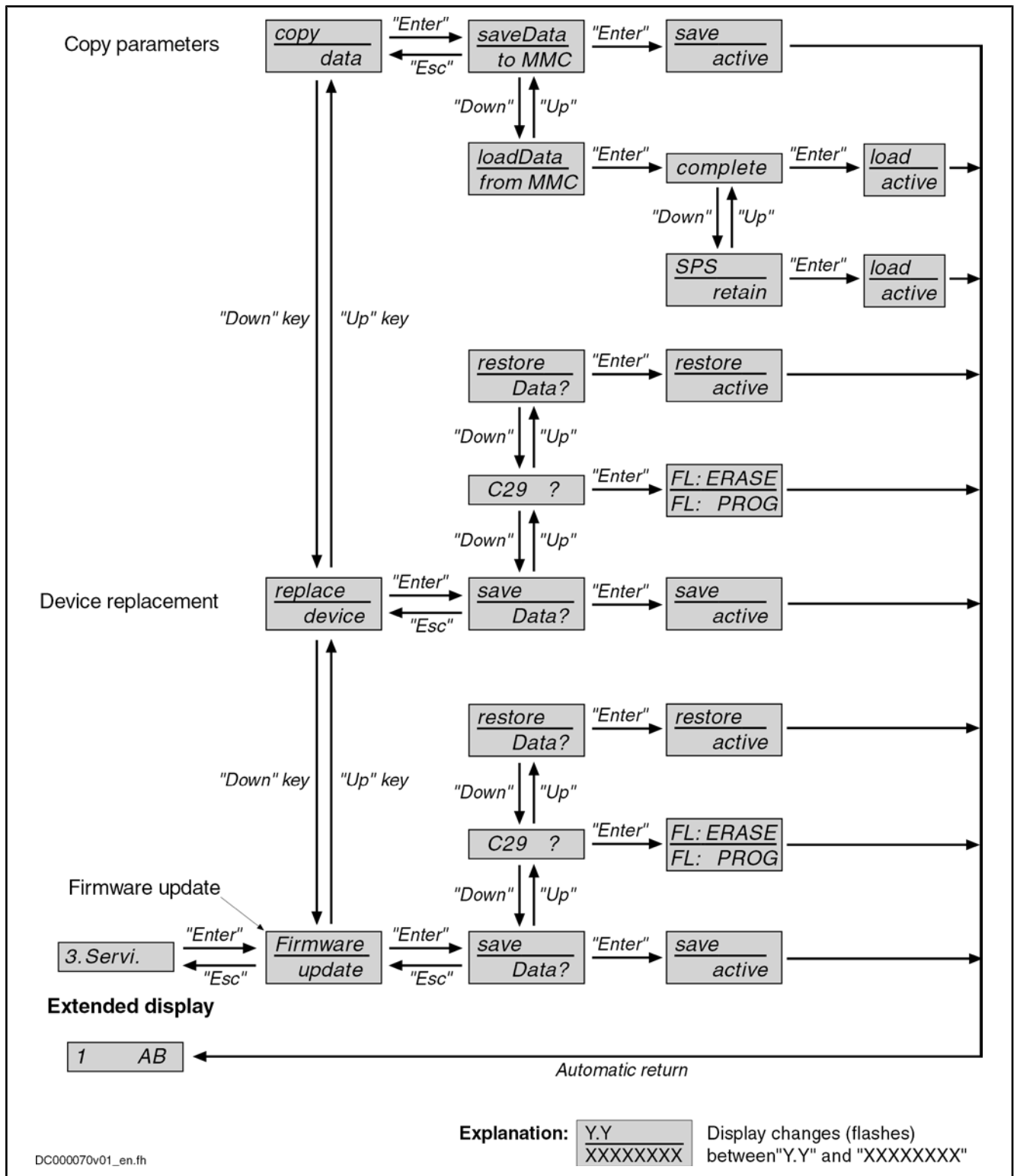


Fig. 10-38: Activating the Functions of the Service Menu

Handling, Diagnostic and Service Functions

## Notes on Commissioning



CAUTION

### Property damage caused by command-dependent activation of motors and moving elements!

⇒ Bring axis resp. moving parts to safe initial position; limit travel range and drive power!



By pressing the "Esc" key again, the standard display will reappear.



The input via the keys is polled in an 8 ms cycle, the display is updated in an 8 ms cycle, too!

## 10.5 MultiMediaCard (MMC)

### 10.5.1 Brief Description

The MultiMediaCard (MMC) is a storage medium that can be inserted in the slot provided for this purpose at the front of the controller. The MMC can store drive firmware, drive parameters and other files (such as PLC programs or user-side files, e.g. with document properties). The MMC can be used optionally.

As **stationarily** (permanently) plugged storage medium, the MMC can be used as:

- "Programming module", as active, non-volatile memory containing the current axis-specific parameter values and the firmware active in the drive.

As a **temporarily** plugged storage medium (backup or init/update medium), the MMC can be used for:

- Replacing firmware via command
- Transmitting drive parameter sets and firmware to other drives for serial commissioning via command
- Saving the parameter values after initial commissioning
- Reestablishing the initial parameter status of the drive (loading the saved parameter values)

**Note: Not for drives with absolute value encoder and modulo format!**

See "Initial Commissioning/Serial Commissioning"

- Storing/reestablishing of parameters centrally from control master (MLD)

**Note: Not for drives with absolute value encoder and modulo format!**

See "Initial Commissioning/Serial Commissioning"

Without firmware or parameter loss the controller can be changed from MMC device status "device without MMC or temporary backup MMC" to the status "device with stationarily plugged MMC (programming module mode)" and vice versa.



The MMC commands can be started via the control panel. This is especially advantageous when replacing devices!



It is only allowed to use MMCs by Bosch Rexroth (type designation PFM02.1-\*\*\*\*-FW)! For storage media of other manufacturers we cannot assume any guarantee for faultless operation.

#### Pertinent Parameters

- P-0-4065, Active non-volatile memory

- P-0-4066, MMC identification number (CID)
- P-0-4070, Parameter storage configuration
- P-0-4072, C2900 Command Firmware update from MMC
- P-0-4091, C2500 Copy IDN from optional memory to internal memory
- P-0-4092, C2600 Copy IDN from internal memory to optional memory

**Pertinent Diagnostic Messages**

Copying parameters from MMC to flash:

- C2500 Copy IDN from optional memory to internal memory
- C2502 Error when accessing the MMC
- C2504 Error when writing data to internal memory

Copying Parameters from flash to MMC:

- C2600 Copy IDN from internal memory to optional memory
- C2602 Error when accessing the MMC
- C2604 Error when reading the internal memory

Replacing firmware via MMC:

- C2900 Command Firmware update from MMC
- C2903 Error when accessing the MMC
- C2904 Error when accessing the flash
- C2905 Programmed firmware defective

Storage medium missing:

- F2006 MMC was removed
- F2120 MMC: Defective or missing, replace

## 10.5.2 MMC Folder Structure

The MMC is a non-volatile storage medium that can be read and written both by the controller and via a PC with the appropriate adapter.



Should it be necessary to reformat an MMC of type PFM02.1-\*\*\*\*-FW, make sure that FAT, FAT12 or FAT16 formatting is used! FAT32 formatting is not supported and therefore cannot be used!

---

When being used in IndraDrive devices, the MMC has to have the following folder structure:

## Handling, Diagnostic and Service Functions

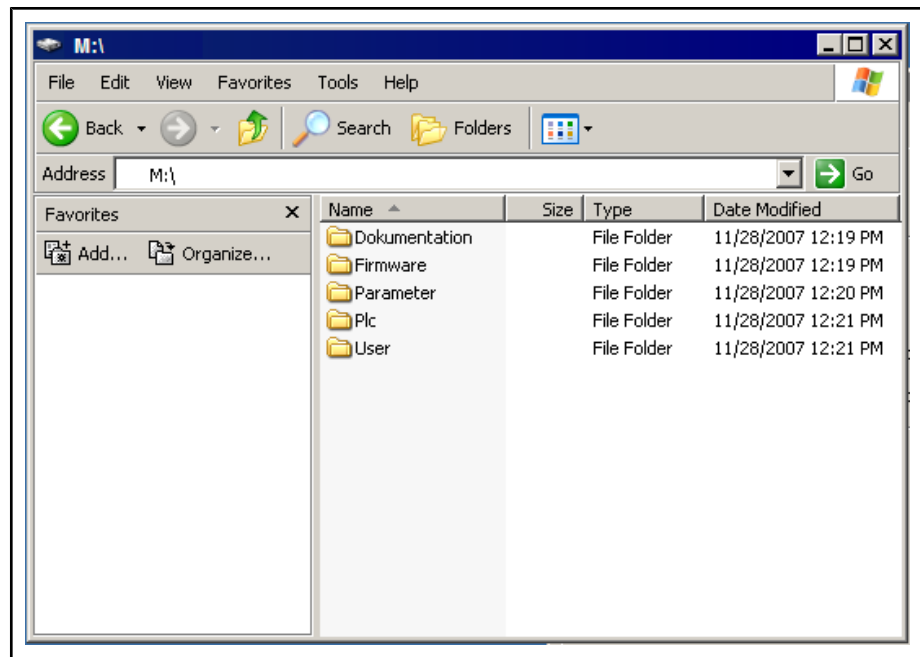


Fig.10-39: Required Folder Structure of the MMC

The folders on the MMC are provided for the following contents:

#### "Firmware" Folder

The file with the drive firmware has to be filed in this folder. The file extension has to be ".ibf".

The following firmware variants are possible:

- FWA-INDRV\*-MPC-... (Advanced single-axis)
- FWA-INDRV\*-MPH-... (Advanced single-axis)
- FWA-INDRV\*-MPB-... (Basic single-axis)
- FWA-INDRV\*-MPD-... (Basic double-axis)

At delivery the MMC has the required folder structure, the "firmware" folder contains the latest release of the drive firmware.



When replacing the firmware via MMC, make sure that the "firmware" folder **only contains one file with the extension ".ibf"**. This folder may contain other files but not with the extension ".ibf"!

#### "Parameter" Folder

In this folder contains the files with the axis-specific parameter values and the parameter values relevant for replacing the devices:

- A file with the extension "...#1.pbk" (size 320kB)  
→ Parameter values to be saved according to "S-0-0192, IDN-list of all backup operation data"
- A file with the extension "...#1.rbf" (size 16kB)  
→ "Retain" data for replacement of device according to "P-0-0195, IDN list of retain data (replacement of devices)"

Storage takes place automatically when the MMC is used as "programming module" (stationarily plugged). Storage takes place by a command, if the MMC has only been plugged temporarily.



In the case of the firmware variant "Basic double axis" (FWA-INDRV\*-MPD-...), the mentioned files are stored for each of the two axes. The extensions for the files of the second axis are "...#2.pbf" and "...#2.rbf"

If the files are transmitted to the MMC from PC storage media, make sure that the file sizes correspond to the mentioned requirements!

At delivery of the MMC the basic parameters for the firmware contained on the MMC are included in the folder "parameters".

<b>"Documentation" Folder</b>	At delivery of the MMC, this folder does not contain any files. The customer can store any data in this folder that are useful for handling the firmware or the axis.
<b>"Plc" Folder</b>	The source code and symbol files of the drive PLC ("IndraMotion MLD") are stored in this folder. Storage is triggered via the programming system. At delivery of the MMC the folder "Plc" is empty.
<b>"User" Folder</b>	At delivery of the MMC, this folder does not contain any files. The customer can store files in this folder. In the future, the folder will be used for extensions of the file handling in the drive PLC ("IndraMotion MLD").

### 10.5.3 Controller With or Without MMC

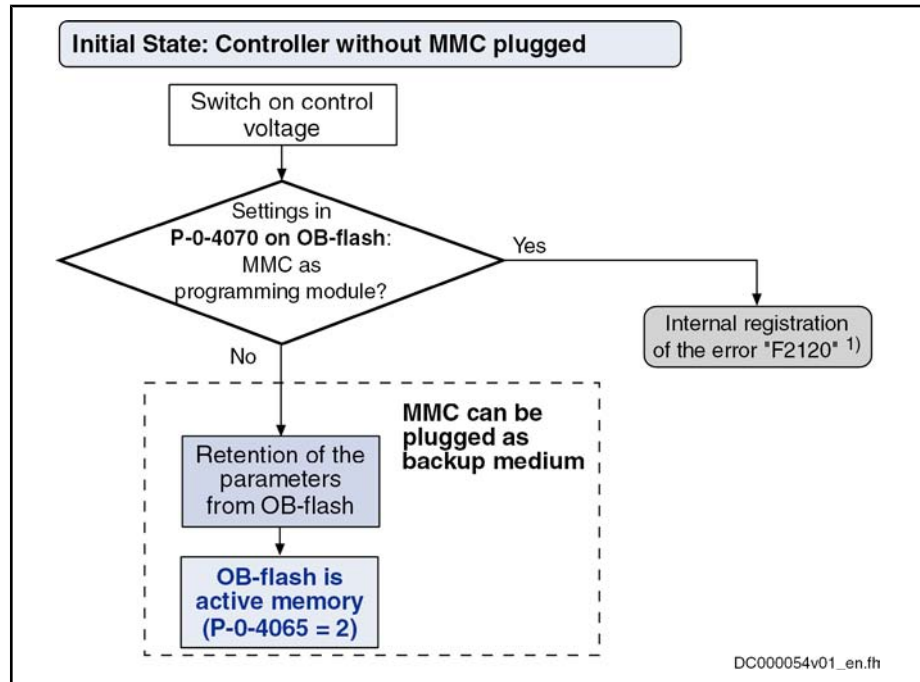
#### General Information

Depending on the setting in "P-0-4070, Parameter storage configuration" it may be necessary to make decisions at switch-on with regard to parameter update and firmware exchange. If an error status is detected, progression to the operating mode ("OM") will be prevented.

Changes in parameter P-0-4070 only become effective after rebooting the axis. The device status as regards the MMC is displayed in parameter "P-0-4065, Active non-volatile memory".

Handling, Diagnostic and Service Functions

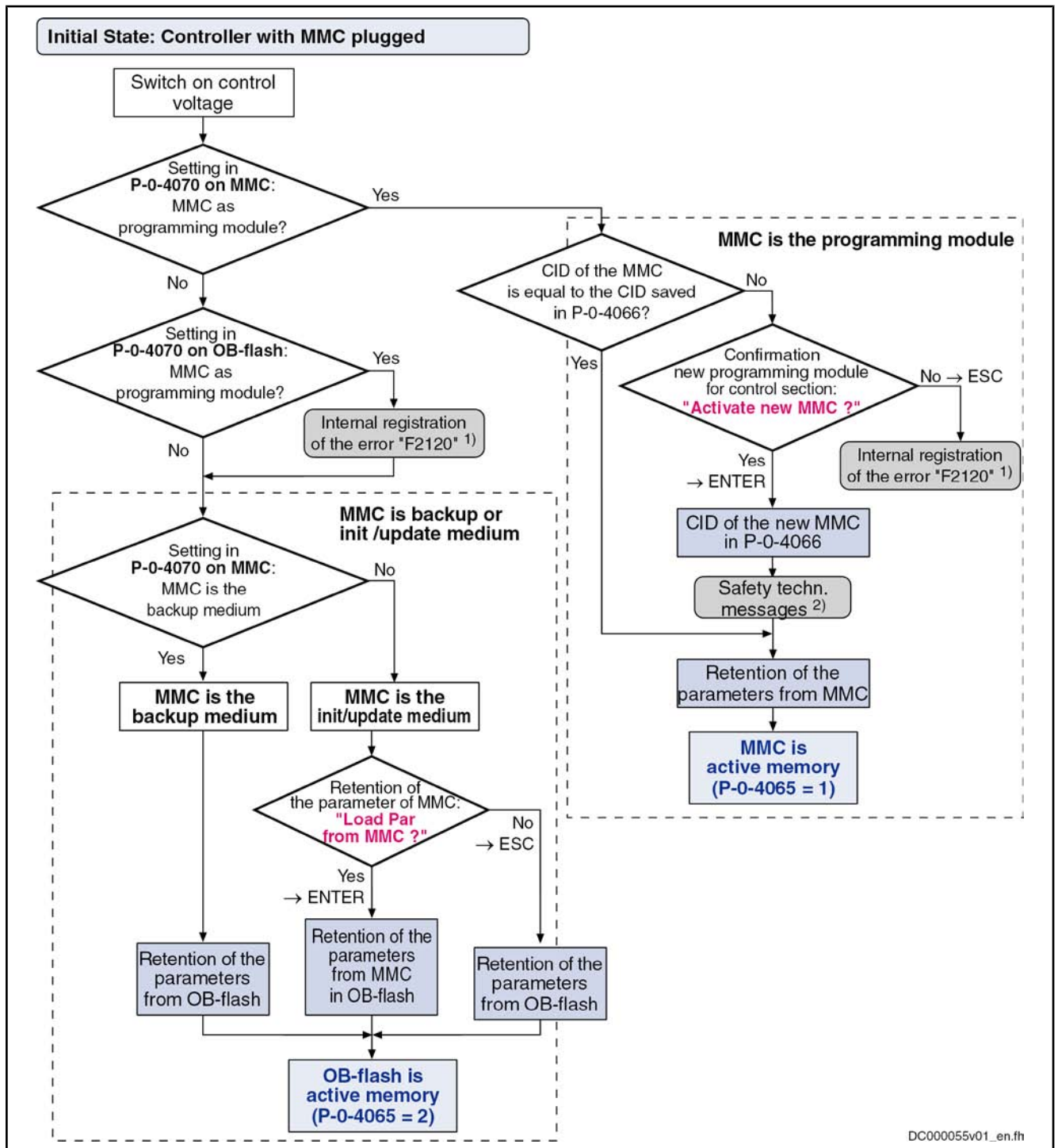
### Switching on Controller Without MMC Plugged



- MMC                    MultiMediaCard (type PFM02.1-...)
- OB-flash            non-volatile memory in the controller (OnBoard)
- P-0-4065            Non-volatile memory active
- P-0-4070            Parameter storage configuration
- 1)                    At the end of the boot process the error message "F2120 MMC: Defective or missing, replace" is displayed.

Fig. 10-40: Switching on Controller Without MMC Plugged

### Switching on Controller With MMC Plugged



DC000055v01\_en.fh

- MMC MultiMediaCard (type PFM02.1-...)
- OB-flash non-volatile memory in the controller (OnBoard)
- CID MMC-IDN
- P-0-4065 Non-volatile memory active
- P-0-4066 MMC identification number (CID)
- P-0-4070 Parameter storage configuration
- 1) At the end of the boot process the error message "F2120 MMC: Defective or missing, replace" is displayed.

## Handling, Diagnostic and Service Functions

- 2) Only with safety technology option available, further messages will appear (see documentation "Integrated Safety Technology").

*Fig. 10-41: Switching on Controller With MMC Plugged*

If the stationarily plugged MMC (as programming module) is removed from a device during operation, the error message "F2006 MMC was removed" is displayed and the drive reacts with the error reaction that was set. This error message can be deleted, if the same (identical!) MMC has been plugged again. When a different MMC is used, the error message F2006 will appear again!

## 10.5.4 Using the MMC in the Drive Controller

### Replacing Firmware With MMC

The MMC allows transmitting drive firmware to the drive controller in a quick and uncomplicated way. We basically distinguish stationarily and temporarily plugged MMCs.



It is impossible to transmit, the other way round, firmware from the controller to the MMC!

The MMC with the latest release of the drive firmware can be ordered with the type designation

- **PFM02.1-\*\*\*\*-FW** with one of the firmware-dependent sub-items:
  - FWA-INDRV\*-MPH-\*\*VRS-D5 (Advanced single-axis)
  - FWA-INDRV\*-MPD-\*\*VRS-D5 (Basic double-axis)
  - FWA-INDRV\*-MPB-\*\*VRS-D5 (Basic single-axis)



An MMC with current release of the required firmware can be ordered from our sales and service facilities.

Carrying out a firmware replacement with MMC depends on different factors. The variants of firmware replacement with MMC, the conditions and the sequence of firmware replacement are described in the section below.

See "Firmware Replacement"

### MMC When Replacing Devices

See "Notes on How to Replace the Devices"

### Saving Parameter Values on MMC

Put MMC into controller after boot phase ("hot plug"). In communication phase 2, the following action is to be carried out via control panel or appropriate master communication:

- **Via control panel**
  - Activating the command "saveData" in the service menu of the control panel
- **Via master communication**
  - Activate the command parameter "P-0-4092, C2600 Copy IDN from internal memory to optional memory"

By starting this command, the application-specific parameter values (according to list parameters S-0-0192 and P-0-0195) are stored on the MMC.

#### Diagnostic Messages

Respective diagnostic command message:

- C2600 Copy IDN from internal memory to optional memory

The following diagnostic error messages can be signaled:



- C2602 Error when accessing the MMC
- C2604 Error when reading the internal memory



As a matter of principle it is recommended to additionally save the application-specific parameter values via the "IndraWorks Ds/D/MLD" commissioning tool or the control master on an external storage medium!

## Loading Parameter Values From MMC

Put MMC containing the axis-specific parameter values into controller after "boot" phase ("hot plug"). In communication phase P2, the following action is to be carried out via control panel or appropriate master communication:

- **Via control panel**  
→ Activating the command "loadData" in the service menu of the control panel
- **Via master communication**  
→ Activate the command parameter "P-0-4091, C2500 Copy IDN from optional memory to internal memory"

By starting this command, the application-specific parameter values (according to list parameter S-0-0192) can be

- transmitted to other axes of the same type during serial commissioning
- or -
- loaded to the same controller again to reestablish the initial status.



In the case of drives with absolute value encoder and modulo format, the position data reference has to be established again after having loaded the parameter values saved after initial commissioning, even if the actual position values are signaled to be valid via the parameter "S-0-0403, Position feedback value status"!

### Diagnostic Messages

Respective diagnostic command message:

- C2500 Copy IDN from optional memory to internal memory

The following diagnostic error messages can be signaled:

- C2502 Error when accessing the MMC
- C2504 Error when writing data to internal memory

If the stationary MMC is removed from a controller in operation or a different MMC is plugged in again, the following message appears:

- F2006 MMC was removed.

## Change in Device Status Regarding MMC (Stationary/Temporary)

### Device With Stationarily Plugged MMC → Device Without MMC

Sequence for status change "device with stationarily plugged MMC" (programming module mode) to "device without MMC" (backup or init/update medium):

1. Store axis-specific parameter values stored on the previously active MMC via command "C2500 Copy IDN from optional memory to internal memory" in non-volatile memory of controller.
2. Switch from "P-0-4070, Parameter storage configuration" to option "MMC as init/update medium"
3. Switch control voltage of drive off and remove previously active MMC from controller.

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4. Switch drive on again without MMC plugged.

Boot process is completed and drive then waits for other commands or is put into readiness for operation via the control master.



If "P-0-4070, Parameter storage configuration" has not been changed, the error message "F2120 MMC: Defective or missing, replace" will appear after booting.

In order to clear the error message the setting in parameter P-0-4070 must be corrected and then switched on and off again.

#### Device Without MMC → Device With Stationarily Plugged MMC

Sequence for status change "device without MMC" (backup or init/update medium) to "device with stationarily plugged MMC" (programming module mode):

1. Make sure correct firmware has been stored on MMC that in the future is to remain stationarily in device.  
**Note:** With PC, check whether the folder "firmware" on the MMC contains the file with the desired firmware!
2. After end of boot phase plug MMC, in the future remaining in device, in controller, then via command transmit axis-specific parameter values stored in controller to MMC via command "C2600 Copy IDN from internal memory to optional memory".
3. Switch "P-0-4070, Parameter storage configuration" to "programming module mode" option.
4. Switch control voltage of drive off, leave new MMC in controller and switch drive on again.
5. When controller is "booted", the message "Firmware update?" appears on display, if the firmware stored on MMC differs from the firmware stored in device. Acknowledge this message by pressing "Enter" key (control pane)!
6. New firmware now is possibly loaded to controller (firmware update); display shows corresponding download messages.
7. In the course of the boot process, display shows message "Activate new MMC?". Acknowledge this message by pressing the "Enter" key (control panel). With safety technology option available, further messages will appear (see documentation "Integrated Safety Technology"). Acknowledge these messages by pressing the "Enter" key (control panel). New MMC now is active MMC of this drive. This means that with each repeated switch-on procedure the parameters are automatically loaded from the MMC and retained on the MMC during operation.



By confirming the message "Activate new MMC?" with the "Esc" key, the parameters are loaded from the OB-Flash and the error message "F2120 MMC: Defective or missing, replace" is displayed.



If the parameters stored on the MMC are to be stored in the device-internal non-volatile memory, too, carry out the command "C2500 Copy IDN from optional memory to internal memory"!

Boot process is completed and drive then waits for other commands or is put into readiness for operation via the control master.

## 10.6 Firmware Replacement

### 10.6.1 General Notes on How to Replace the Firmware

#### Basic Principles

##### Explanation of Terms

For firmware replacement, we distinguish the following cases:

- **Release update**

An old firmware release (e.g. MPH07V02) contained in the device is replaced by a new firmware release (e.g. MPH07V04).

- **Version upgrade**

The old firmware version (e.g. MPH06V08) in the device is replaced by a new firmware version (e.g. MPH07V02).



The paragraphs below describe the recommended options of firmware replacement by higher releases ("update") or versions ("upgrade"). The same conditions and sequences of actions apply to firmware replacement by older releases or older firmware versions.

---

Firmware for IndraDrive is replaced using the following hardware and software:

- **MultiMediaCard (MMC)**
- **PC with software "IndraWorks Ds/D/MLD"**



The commissioning software "IndraWorks Ds/D/MLD" can be ordered from one of our sales and service facilities. The scope of supply of "IndraWorks Ds/D/MLD" contains a documentation which describes the operation of the program.

---

#### Preparations and Conditions for Firmware Replacement

##### Preparing the Firmware Replacement

You have to make the following preparations for firmware replacement:

1. Drive controller must be on (24 V supply).
2. Be absolutely sure to save parameter values before any firmware version upgrade (for release update this is recommended), as otherwise complete (re-)commissioning is required.

See Functional Description of firmware "Loading, Storing and Saving Parameters"

3. Drive controller **mustn't** be in operating mode (communication phase 4) (cf. P-0-0115).

##### General Notes on How to Carry Out Firmware Replacement

You have to observe the following points when carrying out the firmware replacement:

- Do not switch off the 24 V control voltage while replacing the firmware.
- Firmware replacement always must be carried out completely, i.e. the firmware on the optional safety technology module must be replaced, too.
- For firmware replacement, we distinguish between **release update** and **version upgrade**.



When the firmware is replaced in conjunction with the option "Safe Torque Off" (L2), this does not require any specific measures, i.e. the additional measures described below only apply to the use of option "S2"!

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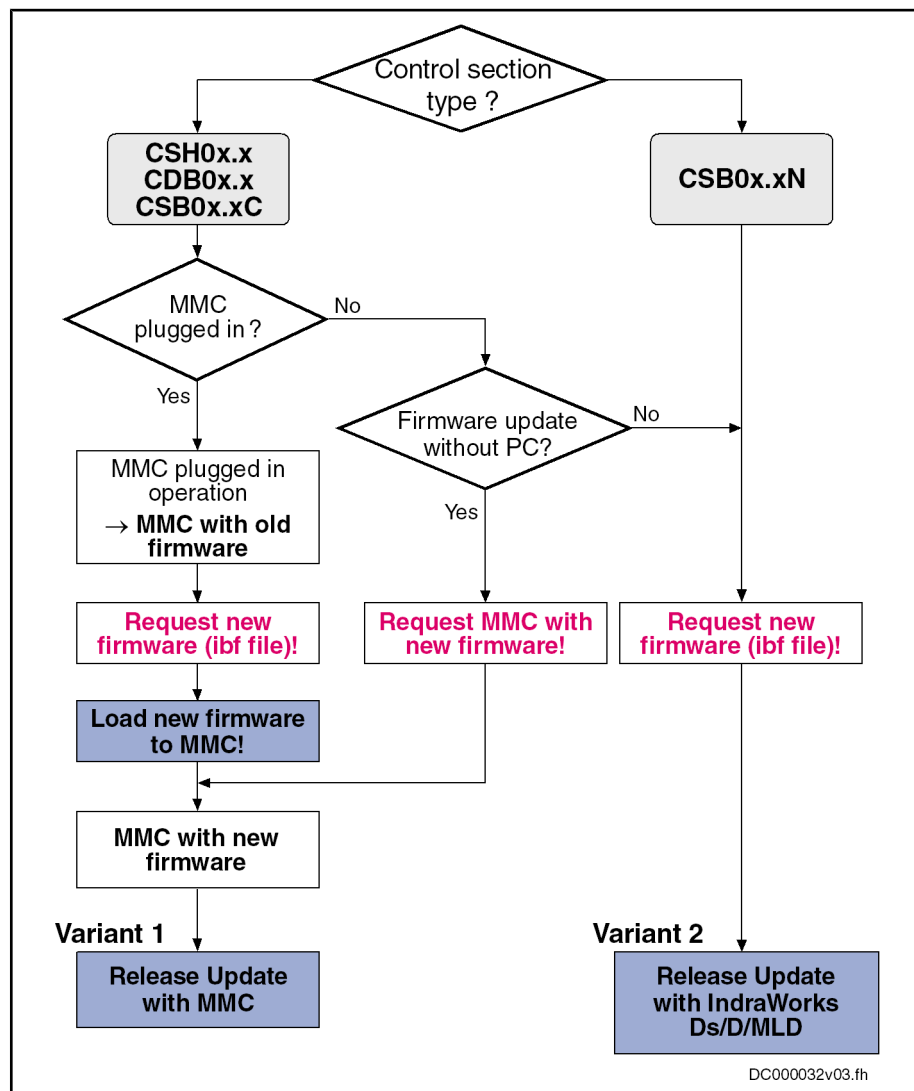
Handling, Diagnostic and Service Functions

## 10.6.2 Firmware Release Update

### General Information

When firmware in a drive controller is replaced by firmware of a **new release**, this is called firmware release update (e.g. FWA-INDRV\*-MPH-07V02-D5 replaced by FWA-INDRV\*-MPH-07V04-D5).

The described sequences of the firmware release update depend on the configuration of the control section and the hardware (MMC or PC) used for update. The basically recommended sequence of the firmware release update is illustrated in the scheme below:



- CSH0x.x      ADVANCED single-axis control section
- CDB0x.x      BASIC double-axis control section
- CSB0x.xC      BASIC single-axis control section (configurable)
- CSB0x.xN      BASIC single-axis control section (not configurable)
- Active memory      "Programming module" operation of MMC (see P-0-4065)

Fig. 10-42: Schematic Sequence of Firmware Release Update



The actions to be taken which are marked with dark background in this figure are described in the paragraphs below.

## Loading New Firmware to MMC

**Requirements** The following requirements must have been fulfilled for loading firmware to the MMC of the drive:

- New firmware available (ibf file)
- PC with MMC reader
- MMC with old firmware in drive

**Loading Firmware to MMC** The following steps are required for loading the firmware to the MMC:

1. Switch drive off and remove MMC.
2. Plug MMC into MMC reader and open folder "Firmware" on MMC.
3. Delete old firmware (e.g., FWA-INDRV\_-MPH-07V02-D5.ibf).
4. Copy new firmware (e.g., FWA-INDRV\_-MPH-07V04-D5.ibf) to folder "Firmware".



Only one firmware file may be stored in the folder "Firmware" on the MMC. With several firmware files, the message "MMC not correct" appears on the display of the drive after the booting process.

5. Remove MMC from MMC reader after writing process has been completed.

## Variant 1: Release Update With MMC

**Selection Criterion** Carrying out the firmware release update with MMC makes sense when the controller has **not** been equipped with a BASIC single-axis control section of the CSB0x.xN type.

**Firmware Update With MMC** The optional MultiMediaCard (MMC) allows transmitting drive firmware to the drive controller in a quick and uncomplicated way.



As the MMC is a storage medium that can be written in a simple way (e.g., via PC), it is recommended that you check the MMC content before downloading the firmware. You have to make sure that the MMC really contains the appropriate firmware type.

An MMC with the current release of the required firmware can be ordered from one of our sales and service facilities.

Carrying out the firmware release update with MMC requires the following steps:

### 1. Load firmware

- ⇒ Switch drive off!
- ⇒ Plug MMC with new firmware into corresponding slot at controller.
- ⇒ Restart drive with MMC plugged!

After drive has been booted, the following message appears:

- "Firmware update?"

⇒ Acknowledge this message by pressing "Enter" key of control panel. By doing this, firmware is loaded from plugged MMC to controller.

One of the following messages will be displayed, depending on the operating status of the drive:

- "Load Param from MMC" or "Load new param?"
- "Activate new MMC?"
- "F2120 MMC: Defective or missing, replace"

## Handling, Diagnostic and Service Functions

⇒ Switch off drive, remove MMC (if drive was operated without MMC plugged) and restart drive!

## 2. Put machine into ready-for-operation status

⇒ Put machine into ready-for-operation status again according to machine manufacturer's instructions.

⇒ Check functions of drive.

## 3. Check safety technology parameters (only when safety technology has been activated in the drive)

In the case of a release update, the safety technology parameters are retained. With safety technology activated, the following steps are additionally required:

⇒ Check whether the correct safety technology parameter settings for drive are still available!

To do this, check the following points:

- Data in parameter "P-0-3205, Safety technology device identifier"
- Status of safety technology via parameter "P-0-3207, Safety technology password level" (in the case of active and locked safety technology, level is 2)
- Change counter of safety technology memory (parameter "P-0-3201, Change counter of safety technology memory")
- Operating hours at last change of memory (parameter "P-0-3202, Operating hours at last change of memory")



**CAUTION**

**If the integrated safety technology is used and a firmware release update is carried out for firmware versions older than MPx02V20, it is necessary to repeat the safety technology acceptance test.**

After firmware release update, the safety technology acceptance test must be carried out again!

## Variant 2: Release Update With "IndraWorks Ds/D/MLD"

### Selection Criterion

The following requirements should have been fulfilled in order that carrying out the firmware release update with "IndraWorks Ds/D/MLD" makes sense:

- Controller is operated without MMC.
- or -
- Controller has been equipped with BASIC single-axis control section of type CSB0x.xN.

### Firmware Update With "IndraWorks Ds/D/MLD"

Carrying out the firmware release update with "IndraWorks Ds/D/MLD" requires the following steps:

#### 1. Load firmware

⇒ Start "IndraWorks".

⇒ Load project for corresponding axis or create new project; to do this, address axis via a serial connection.

⇒ Switch project "online".

⇒ Select/highlight controller and call "Firmware Management" in context menu.

A new window opens and firmware currently available in drive is displayed on its right side. On left side of window, firmware available in current firmware directory is displayed.

⇒ Highlight new firmware (\*.ibf file) and start firmware download via "Download" button.

Firmware download runs automatically and all required firmware components are loaded to drive.



IndraWorks automatically goes to the offline mode. You will be asked whether a backup of the parameters is to be made. Refuse this with "No".

⇒ After firmware download has been completed, close "Firmware Management" window.

## 2. Put machine into ready-for-operation status

⇒ Put machine into ready-for-operation status again according to machine manufacturer's instructions.

⇒ Check functions of drive.

## 3. Check safety technology parameters (only when safety technology has been activated in the drive)

In the case of a firmware release update, the safety technology parameters are retained. With safety technology activated, the following steps are additionally required:

⇒ Check whether the correct safety technology parameter settings for drive are still available!

To do this, check the following points:

- Data in parameter "P-0-3205, Safety technology device identifier"
- Status of safety technology via parameter "P-0-3207, Safety technology password level" (in the case of active and locked safety technology, level is 2)
- Change counter of safety technology memory (parameter "P-0-3201, Change counter of safety technology memory")
- Operating hours at last change of memory (parameter "P-0-3202, Operating hours at last change of memory")

## 10.6.3 Firmware Version Upgrade

### General Information

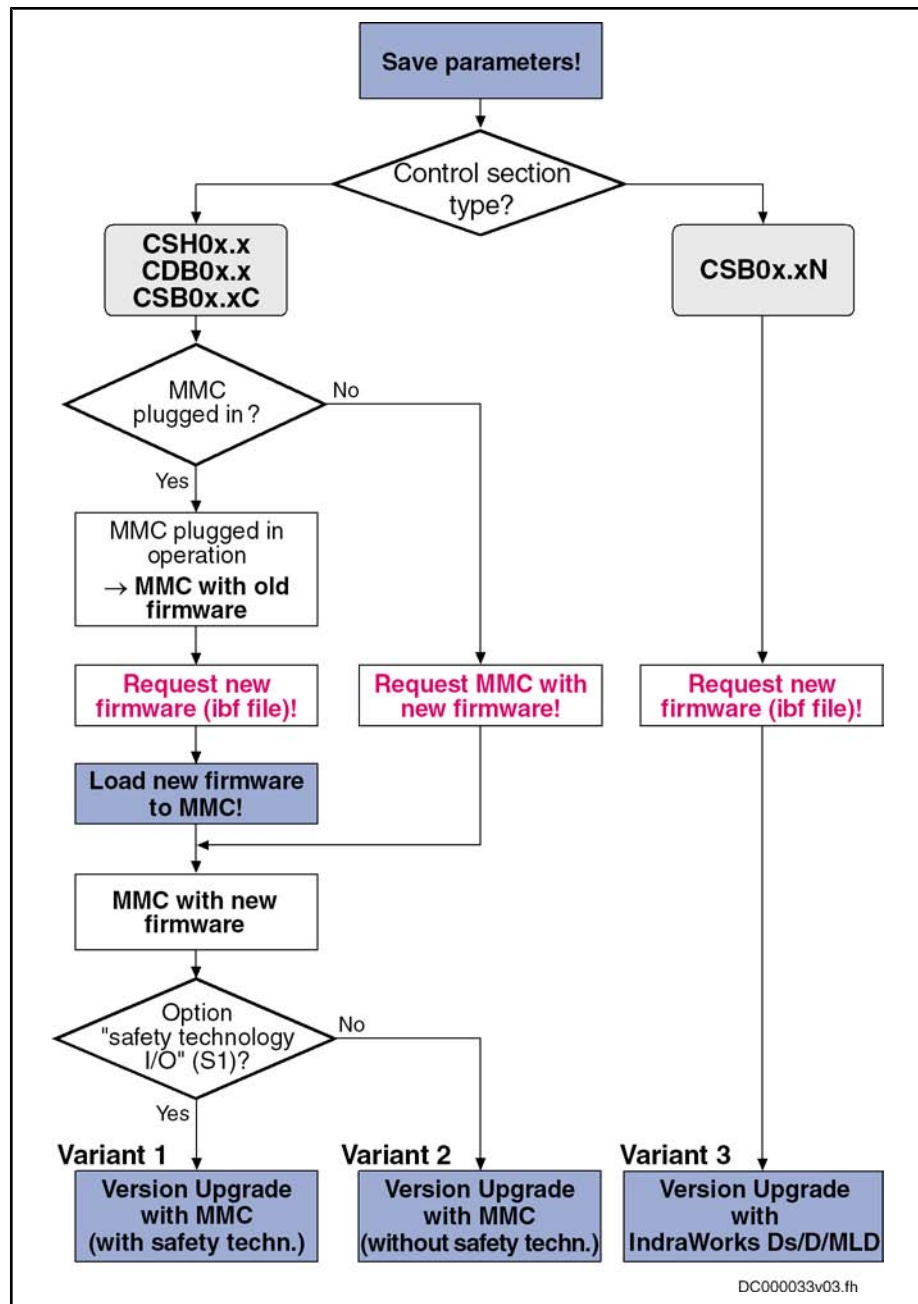
When firmware in a drive controller is replaced by firmware of a **more recent version**, this is called firmware version upgrade (e.g., FWA-INDRV\*-MPH-06V10-D5 replaced by FWA-INDRV\*-MPH-07V02-D5).



**Before** carrying out the firmware version upgrade, you must save all parameters (e.g., with "IndraWorks"). **After** firmware replacement, the parameters must be restored, because the command "C07\_1 Load defaults procedure command" is carried out automatically. After the desired parameter file was loaded, the drive controller is ready for operation again.

The described sequences of the firmware version upgrade depend on the configuration of the control section and the firmware used. The basically recommended sequence of the firmware version upgrade is illustrated in the scheme below:

Handling, Diagnostic and Service Functions



CSH0x.x      ADVANCED single-axis control section  
 CDB0x.x      BASIC double-axis control section  
 CSB0x.xC     BASIC single-axis control section (configurable)  
 CSB0x.xN     BASIC single-axis control section (not configurable)  
 Active memo- "Programming module" operation of MMC (see P-0-4065)  
 ry

Fig. 10-43: Schematic Sequence of Firmware Version Upgrade



The actions to be taken which are marked with dark background in this figure are described in the paragraphs below.

### Save Parameter Values

Before firmware upgrade, all application-specific parameter values must be saved on a data carrier. The parameter backup can be carried out by means of:



- **Commissioning software "IndraWorks Ds/D/MLD"**  
→ Saving parameter values on external data carrier
- or -
- **Control master**  
→ Saving parameter values on master-side data carrier



Saving the parameters on the MMC available in the drive is without effect, as this backup will be deleted during the firmware upgrade!

## Loading New Firmware to MMC

**Requirements** The following requirements must have been fulfilled for loading firmware to the MMC of the drive:

- New firmware available (ibf file)
- PC with MMC reader
- MMC with old firmware in drive

**Loading Firmware to MMC** The following steps are required for loading the firmware to the MMC:

1. Switch drive off and remove MMC.
2. Plug MMC into MMC reader and open folder "Firmware" on MMC.
3. Delete old firmware (e.g., FWA-INDRV\*-MPH-06V10-D5.ibf).
4. Copy new firmware (e.g., FWA-INDRV\*-MPH-07V02-D5.ibf) to folder "Firmware".

**Note:** Only one firmware file may be stored in the folder "Firmware" on the MMC. With several firmware files, the message "MMC not correct" appears on the display of the drive after the booting process.

5. Remove MMC from MMC reader after writing process has been completed.

## Variant 1: Version Upgrade With MMC (With Safety Technology)

**Selection Criterion** The following requirements should have been fulfilled in order that carrying out the firmware version upgrade with MMC makes sense (with safety technology):

- Controller has **not** been equipped with BASIC single-axis control section.
- Optional slot for safety technology has been equipped with the optional module "Safe Motion" (S2).
- Current parameter setting of axis was saved.

**Firmware Upgrade With MMC (With Safety Technology)** Carrying out the firmware version upgrade with MMC requires the following steps (with safety technology):

### 1. Load firmware

⇒ Switch drive off!

⇒ Plug MMC with new firmware into corresponding slot at controller.

⇒ Restart drive with MMC plugged!

After drive has been booted, the following message appears:

- "Firmware update?"

⇒ Acknowledge this message by pressing "Enter" key of control panel. By doing this, firmware is loaded from plugged MMC to controller.

One of the following messages will be displayed, depending on the operating status of the drive:

- "Load Param from MMC" or "Load new param?"

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- "Activate new MMC?"
  - "F2120 MMC: Defective or missing, replace"
- ⇒ Switch off drive, remove MMC (if drive was operated without MMC plugged) and restart drive!
2. **Put drive into ready-for-operation status**
- ⇒ After the drive has been restarted, the error message "F8201" is generated (F8201 Safety command for basic initialization incorrect).
- ⇒ Clear all present error messages and start execution of "C07\_2 Load defaults procedure command (load defaults procedure for safety technology)"!
- ⇒ As the number of parameters to be buffered has changed, "C07\_1 Load defaults parameter command (loading basic parameters)" must be activated subsequently. All buffered parameters are thereby set to their default values.
3. **Load parameter values**
- ⇒ Load parameter file which was saved.
- ⇒ Switch off drive and start it again so that the parameterization becomes active.
4. **Entire commissioning of integrated safety technology**
- ⇒ Switch drive to operating mode (communication phase 4).
- The error message "F3152 Incorrect backup of safety technology data" appears, as the safety technology parameter set between firmware versions 02, 03, 04 and 05 has changed.
- ⇒ Clear error message.
- ⇒ Activate command "synchronize and store safety technology IDN". (C3000 Synchronize and store safety technology IDN)
- ⇒ Activate safety technology by inputting safety technology password (P-0-3206, Safety technology password).
- ⇒ Carry out new acceptance test.



See sections "Activating the Safety Technology" and "Acceptance Test" in the separate documentation "Integrated Safety Technology According to IEC61508" (DOK-INDRV\*-SI2-\*\*VRS\*\*-AW\*\*-EN-P; part no. R911327664)



**Dangerous movements possible! Danger to life, risk of injury, serious injury or property damage!**

In order to ensure correct functioning and to prevent personal damage, a complete acceptance test must be carried out after a firmware version upgrade for drive controllers with the optional module for safety technology (S2).

- ⇒ Make safety technology parameter backup, compile acceptance test protocol and add it to safety-relevant documentation of machine.
5. **Put machine into ready-for-operation status**
- ⇒ Put machine into ready-for-operation status again according to machine manufacturer's instructions.
- ⇒ Check functions of drive.

## Variant 2: Version Upgrade With MMC (Without Safety Technology)

<b>Selection Criterion</b>	<p>The following requirements should have been fulfilled in order that carrying out the firmware version upgrade with MMC makes sense (without safety technology):</p> <ul style="list-style-type: none"> <li>• Controller has <b>not</b> been equipped with BASIC single-axis control section of type CSB0x.xN.</li> <li>• Optional slot for safety technology has <b>not</b> been equipped with the optional module "Safe Motion" (S2).</li> <li>• Current parameter setting of axis was saved.</li> </ul>
<b>Firmware Upgrade With MMC (Without Safety Technology)</b>	<p>Carrying out the firmware version upgrade with MMC requires the following steps (without safety technology):</p> <ol style="list-style-type: none"> <li>1. <b>Load firmware</b> <ul style="list-style-type: none"> <li>⇒ Switch drive off!</li> <li>⇒ Plug MMC with new firmware into corresponding slot at controller.</li> <li>⇒ Restart drive with MMC plugged!</li> </ul> <p>After drive has been booted, the following message appears:</p> <ul style="list-style-type: none"> <li>• "Firmware update?"</li> </ul> <p>⇒ Acknowledge this message by pressing "Enter" key of control panel. By doing this, firmware is loaded from plugged MMC to controller.</p> <p>One of the following messages will be displayed, depending on the operating status of the drive:</p> <ul style="list-style-type: none"> <li>• "Load Param from MMC" or "Load new param.?"</li> <li>• "Activate new MMC?"</li> <li>• "F2120 MMC: Defective or missing, replace"</li> </ul> <p>⇒ Switch off drive, remove MMC (if drive was operated without MMC plugged) and restart drive!</p> </li> <li>2. <b>Put drive into ready-for-operation status</b> <ul style="list-style-type: none"> <li>⇒ As number of parameters to be buffered has changed, "PL" appears on display (in case errors are present, remove them first). If you now press "Esc" key, all buffered parameters are set to their default values. During this time, message "C07 Load default parameters" appears on display. If errors are present, they first have to be removed and the command C07_1 must then be manually activated!</li> </ul> </li> <li>3. <b>Load parameter values</b> <ul style="list-style-type: none"> <li>⇒ Load parameter file which was saved.</li> <li>⇒ Switch off drive and start it again so that the parameterization becomes active.</li> </ul> </li> <li>4. <b>Put machine into ready-for-operation status</b> <ul style="list-style-type: none"> <li>⇒ Put machine into ready-for-operation status again according to machine manufacturer's instructions.</li> <li>⇒ Check functions of drive.</li> </ul> </li> </ol>

## Variant 3: Version Upgrade With "IndraWorks Ds/D/MLD"

<b>Selection Criterion</b>	<p>The following requirements should have been fulfilled in order that carrying out the firmware version upgrade with "IndraWorks Ds/D/MLD" makes sense:</p> <ul style="list-style-type: none"> <li>• Controller has been equipped with BASIC single-axis control section.</li> <li>• Current parameter setting of axis was saved.</li> </ul>
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## Handling, Diagnostic and Service Functions

**Firmware Upgrade With  
"IndraWorks Ds/D/MLD"**

Carrying out the firmware version upgrade with "IndraWorks Ds/D/MLD" requires the following steps:

**1. Load firmware**

⇒ Call "IndraWorks".

⇒ Load project for corresponding axis or create new project. To do this, address axis via a serial connection.

⇒ Switch project "online".

⇒ Select/highlight controller and call "Firmware Management" in context menu.

A new window opens and firmware currently available in drive is displayed on its right side. On left side of window, firmware available in current firmware directory is displayed.

⇒ Highlight new firmware (\*.ibf file) on left side and start firmware download via "Download" button.

Firmware download runs automatically and all required firmware components are loaded to drive.

⇒ After firmware download has been completed, close "Firmware Management" window.

**2. Put drive into ready-for-operation status**

⇒ Switch project "offline" and then "online" again.

After project has been switched online, a message signals that "IndraWorks" could not establish communication to drive via serial interface, as drive-internal settings for serial communication were reset.

⇒ Reconfigure communication via button "Search for devices".

⇒ As firmware in drive no longer complies with version stored in project, a corresponding message is displayed. To adjust firmware version in project, first select option "Repair" and then options "Delete existing drive from project" and "Add new drive to project".

⇒ As number of parameters to be buffered has changed, "PL" appears on display (in case errors are present, remove them first). If you now press "Esc" key, all buffered parameters are set to their default values. During this time, message "C07 Load default parameters" appears on display.

If errors are present, they first have to be removed and the command C07\_1 must then be manually started!

**3. Load parameter values**

⇒ Load parameter file which was saved.

**4. Put machine into ready-for-operation status**

⇒ Put machine into ready-for-operation status again according to machine manufacturer's instructions.

⇒ Check functions of drive.

## 10.6.4 Possible Problems During Firmware Replacement

**Problematic Situations**

Firmware replacement is carried out incompletely, if one of the following situations occurs during the sequence of firmware replacement:

- 24V supply of control section is switched off
- Connection to drive is interrupted (e.g., defective interface cable)
- Software crashes

The drive controller then possibly is no longer operable, because the firmware contained in the components is no longer compatible.

If there isn't any valid firmware available in the control section in this case, the loader is started. The drive display signals "LOADER". The loader only allows updating the firmware of the control section. Optional modules, such as "Safe Motion" (S2) or "cross communication" (CCD), cannot be programmed in this state. This must be done, after successful firmware replacement in the control section, in a second run according to the descriptions of the firmware replacement variants.

In this situation, replacement of the control section firmware is only supported by "IndraWorks".



Upon successful firmware replacement in the control section, a restart has to be carried out. Then all available components have to be updated, too.

#### Requirements for Loading the Firmware

The following requirements must have been fulfilled for loading firmware to the drive:

- Serial connection to drive available
- Drive display signals "LOADER"

#### Firmware Replacement in Control Section in the Case of Error

The following steps are required for loading the firmware to the control section in the case of error:

1. Call "IndraWorks Ds/D/MLD".
2. In menu, call firmware management under "Tools→ Drive → Firmware Management".
3. Select device and COM interface.  
A new window opens and firmware available in current firmware directory is displayed on its left side.
4. Highlight new firmware (\*.ibf file) on left side and start firmware download via "Download" button.  
Firmware download runs automatically and all required firmware components are loaded to drive.
5. After firmware download has been completed, close "Firmware Management" window.
6. Restart drive!

If the drive has not been equipped with any optional modules, such as "Safe Motion" (S2) or "cross communication" (CCD), continue following the instructions for release update or version upgrade! Otherwise, carry out the release update or version upgrade again to program the optional modules.

## 10.7 Notes on How to Replace the Devices

### 10.7.1 Replacing the Supply Unit

#### General Information

The concept of Rexroth supply units includes safe, quick and uncomplicated replacement of devices. This allows reducing production downtimes, caused by failures of these devices, to a minimum.

Failures in the supply unit are displayed by means of diagnostic messages. According to the diagnostic error message, the measure "replacing the supply unit" can be indicated.

## Handling, Diagnostic and Service Functions



See documentation "Troubleshooting Guide" (description of diagnostic messages)

Immediately after having replaced the device, the drive is operational again, because it is not required to repeat the adjustment of the drive to the machine.

**How to Replace the Supply Unit**

**Procure Replacement Device** Identify device to be replaced by means of type plate; procure supply unit of same type from Bosch Rexroth!



See also documentation of the respective Supply Unit

**Fill Out Fault Report** In the documentation of the respective supply unit, you can find a fault report form to be copied. Please copy this fault report, fill it out carefully and completely and enclose it with the defective device! The fault report filled out completely supports quick handling of repair and helps recognizing application-related failure causes.

**Replace Supply Unit** De-energize drive system; wait for DC bus to discharge; then replace defective supply unit!



**Live conductor bars (higher than 50 V), even if mains voltage switched off!**

**Electric shock when touching!**

⇒ Wait for the DC bus (L+/L-) to discharge; before touching the conductor bar, check whether below 50 V!



For notes on how to dismount and mount the supply unit, see documentation of the respective Supply Unit

**Put Drive System Into Operation Again** Put machine into operation again according to machine manufacturer's instructions!

**10.7.2 Replacing the Controller****Overview**

A controller of the IndraDrive range consists of the components power section and control section (incl. firmware). The control section can be configured with additional components (encoder interface, optional safety technology module,...). In the case of a defect, it is basically possible to replace one of the two components (control section or power section). As control section and power section are firmly connected and one of the two components may only be replaced by Rexroth service engineers or especially trained users, the paragraphs below describe how to replace the complete controller as regards safety technology. The mounting and dismounting of the entire drive controller is described in the Project Planning Manual for the power section.



Only applies to Rexroth service engineers or especially trained users: The replacement of a defective power section does not require any specific handling due to integrated safety technology; i.e. it is not necessary to repeat safety technology commissioning and acceptance test.

When a controller is replaced for which the control section has been configured with the option "Safe Torque Off" (L2), this does not require any specific measure, i.e. the additional measures only apply to the use of the option "Safe Motion" (S2)!



When you replace the controller, you should not carry out the firmware version upgrade, as otherwise it is necessary to repeat the safety technology acceptance test!

When replacing a controller with activated safety technology, observe that **safety technology is not active for controllers in their condition as supplied**:

- The status of "P-0-3207, Safety technology password level" is zero and
- "INDRASAVE" has been entered in "P-0-3206, Safety technology password".



A controller supplied for replacement which already was in operation has to be put in its condition as supplied before it is used (see documentation "Integrated Safety Technology", index entry "Safety technology → Deactivating").

The figure below illustrates the basically required individual steps.

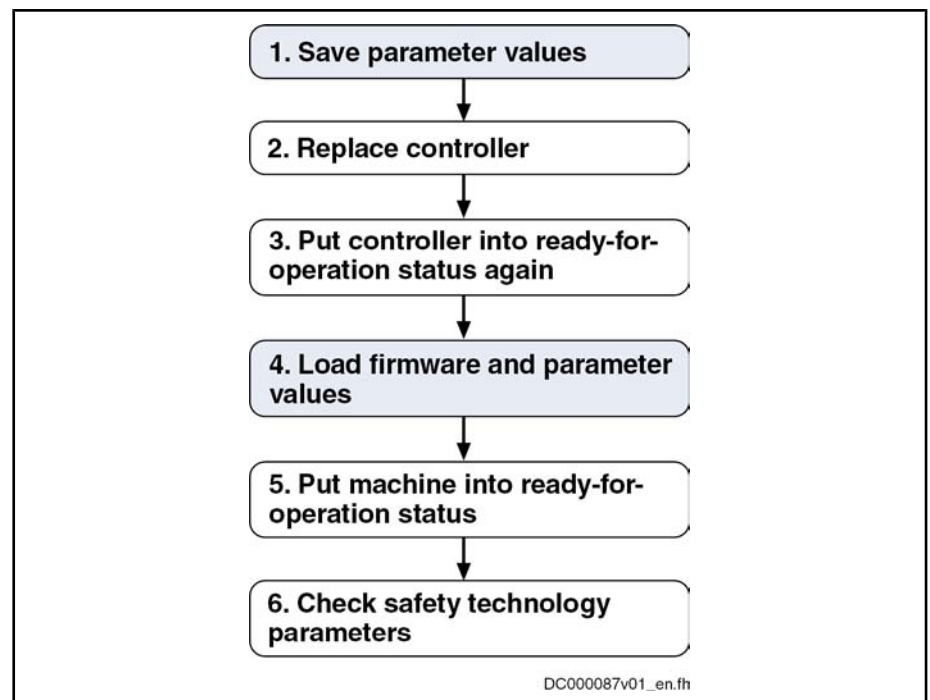


Fig.10-44: General Sequence of Controller Replacement

## Replacing the Controller Without Stationarily Plugged MMC

### 1. Save Parameter Values

Before dismantling the defective device, save the drive parameter values, if possible.

## Handling, Diagnostic and Service Functions

When the controller is to be replaced by means of the MMC, make sure before starting the replacement that the MMC folder "Firmware" contains the firmware required for the drive (e.g., FWA-INDRV\*-MPH-07V02-D5.IBF).



If saving the parameter values before replacing the device should be impossible due to a total breakdown of the device, only the parameter values backed up after initial commissioning can be loaded when the parameter values are loaded later on (see index entry "Load parameter values in case of total breakdown of device")!

---

1. Switch drive off and on again
2. Switch to parameter mode (PM or P2)

The parameter values of the defective device are saved via the control panel of the controller with MMC temporarily plugged ("hot plug").

---



If the MMC does not remain stationarily (permanently) plugged in the device, it may be temporarily plugged **in the switched-on device after the booting phase** and removed again ("hot plug" or "hot unplug").

---

3. Go to service menu

⇒ By simultaneously pressing "Esc" and "Enter" keys for at least 8 seconds, you can call up extended displays; subsequently pressing "Up" key (twice) activates service menu.

Select submenu "device replace" by means of arrow keys and activate it with "Enter" key.

⇒ Active parameter values [according to "S-0-0192, IDN-list of all backup operation data" and "P-0-0195, IDN list of retain data (replacement of devices)"] and PLC retain data are copied from controller-internal memory to an MMC temporarily plugged in controller.

Activate command "save Data?"



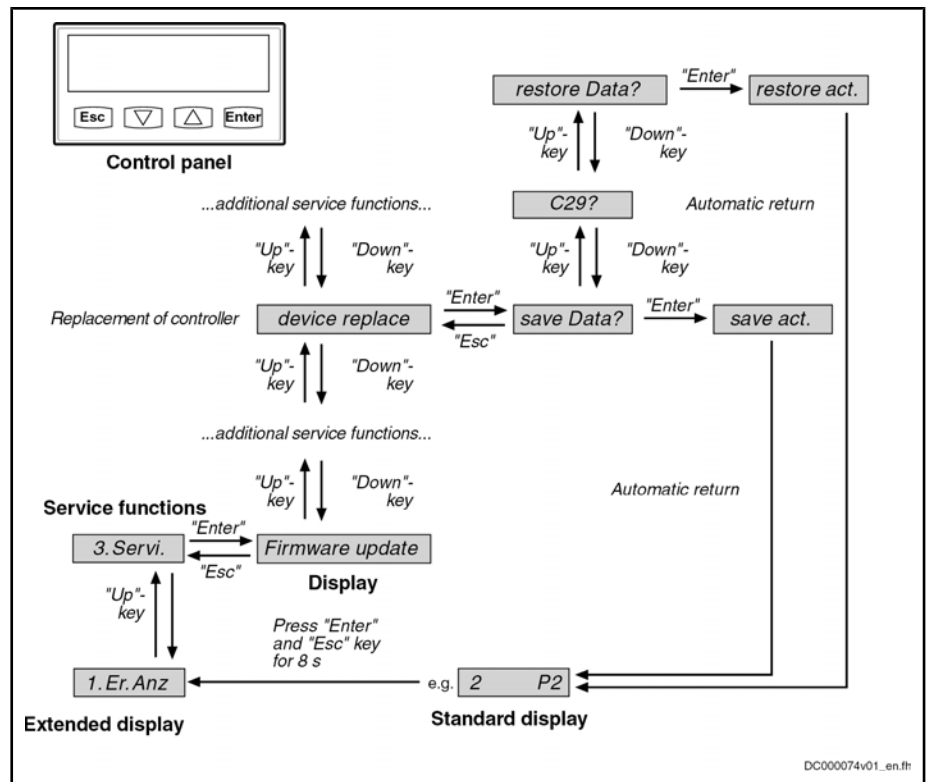


Fig. 10-45: Activating Commands "save Data?" and "restore Data?" When Replacing Controller via Control Panel

## 2. Replace Controller

1. Open main switch
2. Make sure main switch cannot be switched on again
3. Make sure drive controller is completely de-energized



**WARNING**

### Lethal electric shock caused by live parts with more than 50 V!

Before working on live parts: De-energize the installation and secure the power switch against unintentional or unauthorized re-energization.

Wait at least **30 minutes** after switching off the supply voltages to allow dis-charging. To shorten the waiting time until voltage has fallen below 50 V, you can use a discharging device (see chapter "Appendix").

**Check whether voltages have fallen below 50 V before touching live parts!**

4. Remove touch guard and separate connection lines from drive controller
  5. Unscrew screws on top and bottom of housing
  6. Take drive controller out of drive system
  7. Mount new drive controller
  8. Connect new drive controller as specified in machine circuit diagram
  9. Mount touch guard
- 3. Put Controller Into Ready-For-Operation Status Again**
- Put machine into ready-for-operation status again according to machine manufacturer's instructions.
- 4. Load Firmware and Parameter Values via MMC**

## Handling, Diagnostic and Service Functions

When firmware and drive parameters are to be transmitted via MMC to the replacement controller, you have to make sure that the MMC folder "Firmware" contains the firmware required for the drive and the MMC folder "Parameters" contains the parameters saved before the device was replaced.

1. Disconnect replacement controller from control voltage
2. Put MMC into replacement controller
3. Supply device with control voltage again
4. Depending on previous configuration of replacement device, message "Firmware-Update?" can appear during booting phase. Acknowledge this message by pressing "Enter" key of control panel. By doing this, firmware is loaded from plugged MMC to controller.



If the message "Firmware-Update?" is not displayed, the firmware update must be started via the display.

"3. Service" → "Firmware update" → "FWA update"

5. Then one of the messages below can be displayed:

- "Load new param.?"
- "Load Par from MMC?"

⇒ Acknowledge the respective message by pressing "Enter" key of control panel. Drive parameters are now loaded from MMC to volatile memory of device; the message "Load new safety?" then possibly appears.

⇒ Also acknowledge this message by pressing "Enter" key of control panel. Safety technology parameters are now loaded from MMC to memory of optional safety technology module.

6. Switch to parameter mode (PM or P2)

The step below depends on the utilized firmware version:

7. Go to service menu

⇒ By simultaneously pressing "Esc" and "Enter" keys for at least 8 seconds, you can call up extended displays; subsequently pressing "Up" key (twice) activates service menu.

Select submenu "device replace" by means of arrow keys and activate it with "Enter" key.

⇒ Store PLC retain data and parameters from MMC to internal, non-volatile memory of controller via control panel by activating command "restore Data?" (storing according to parameters "S-0-0192, IDN-list of all backup operation data" and "P-0-0195, IDN list of retain data (replacement of devices)"). After parameter loading processes have been completed, drive waits for further actions of control master.



If safety technology is to be activated in the replacement device (in accordance with replaced device), the drive after loading the safety technology parameters has to be switched to operating mode (OM) or communication phase (P4) before it is switched off!

8. Switch controller off

9. Remove MMC from device

10. Switch controller on again

11. Message "Load new param.?" can then be displayed. Acknowledge this message by pressing "Enter" key of control panel. Drive parameters

are now loaded from the non-volatile memory ("flash") to volatile memory (RAM) of device. From now on, device behaves like device without MMC plugged.

#### 5. Put Machine Into Ready-For-Operation Status

1. Put machine into ready-for-operation status again according to machine manufacturer's instructions.
2. Check functions of drive.

#### 6. Check Safety Technology Parameters

Completing the process, you must check with activated safety technology whether the correct safety technology parameters have been loaded for the drive; to do this, check data in "P-0-3205, Safety technology device identifier" (machine type, unit, drive for .. axis/spindle) and compile a protocol with the contents listed below and add it to safety-relevant documentation of the machine:

- Drive controller replaced on (date)
- Change counter of safety technology memory (P-0-3201) is at (value)
- Operating hours at last change of memory (P-0-3202) is at (value)
- (Date), (name), (signature)

## Replacing the Controller With Stationarily Plugged MMC

### 1. Save Parameter Values

When the firmware characteristic IndraMotion MLD (firmware type code: FWA-INDRV\*-MPH-07VRS-D5-1-\*\*\*-ML) is activated and the controller to be replaced is configured in one of the following optional modules, the retain data of the drive PLC must be stored on the MMC before disassembling the defective device.

- Module digital I/O (control section type code: CSH01.\*\*\_\*\*\_\*\*\*\_\*\*\*-MD1-\*\*-S-NN-FW)
- Module digital I/O and SSI encoder interface (control section type code: CSH01.\*\*\_\*\*\_\*\*\*\_\*\*\*-MD2-\*\*-S-NN-FW)



If saving the PLC retain data before replacing the device should be impossible due to a total breakdown of the device, the parameter values and retain data backed up after initial commissioning must be loaded when the parameter values are loaded later on (see index entry "Load parameter values in case of total breakdown of device")!

1. Switch drive off and on again
2. Switch to parameter mode (PM or P2)
3. Switch drive to service menu via display
  - ⇒ By simultaneously pressing "Esc" and "Enter" keys for at least 8 seconds, you can call up extended displays; subsequently pressing "Up" key (twice) activates service menu.
4. Select submenu "device replace" by means of arrow keys and activate it with "Enter" key.
5. Activate command "save Data?"
  - ⇒ The active PLC retain data are copied from the controller-internal memory to the MMC plugged in the controller.

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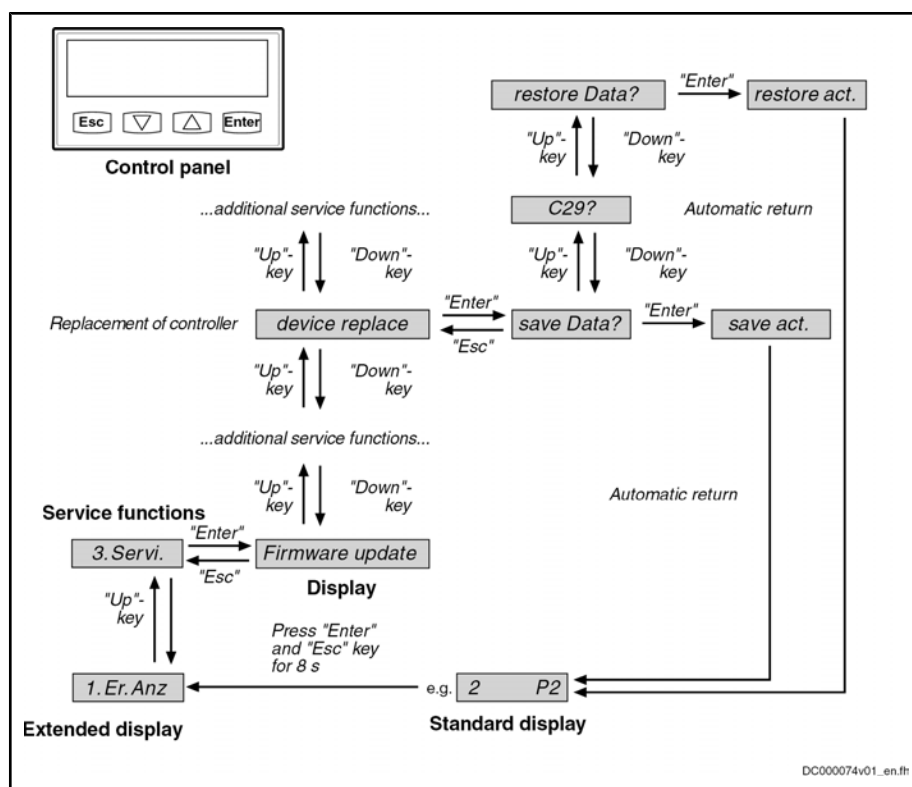


Fig. 10-46: Activating Commands "save Data?" and "restore Data?" When Replacing Controller via Control Panel

6. Disconnect controller from control voltage (this automatically saves parameter values).
7. Remove MMC from controller
2. **Replace Controller**
  1. Open main switch
  2. Make sure main switch cannot be switched on again
  3. Make sure drive controller is completely de-energized



**Lethal electric shock caused by live parts with more than 50 V!**

Before working on live parts: De-energize the installation and secure the power switch against unintentional or unauthorized re-energization.

Wait at least **30 minutes** after switching off the supply voltages to allow dis-charging. To shorten the waiting time until voltage has fallen below 50 V, you can use a discharging device (see chapter "Appendix").

Check whether voltages have fallen below 50 V before touching live parts!

4. Remove touch guard and separate connection lines from drive controller
5. Unscrew screws on top and bottom of housing
6. Take drive controller out of drive system
7. Mount new drive controller
8. Connect new drive controller as specified in machine circuit diagram
9. Mount touch guard
3. **Put Controller Into Ready-For-Operation Status Again**

Put machine into ready-for-operation status again according to machine manufacturer's instructions.

#### 4. Load Firmware and Parameter Values via MMC

When firmware and drive parameters are to be transmitted via MMC to the replacement controller, you have to make sure that the MMC folder "Firmware" contains the firmware required for the drive and the MMC folder "Parameters" contains the parameters saved before the device was replaced.

1. Disconnect replacement controller from control voltage
2. Put MMC into replacement controller
3. Supply device with control voltage again
4. Depending on previous configuration of replacement device, message "Firmware-Update?" can appear during booting phase. Acknowledge this message by pressing "Enter" key of control panel. By doing this, firmware is loaded from plugged MMC to controller.



If the message "Firmware-Update?" is not displayed, the firmware update must be started via the display:

"3. Service" → "Firmware update" → "FWA update"

---

5. Then one of the messages below can be displayed:

- "Load new param.?"
- "activate new MMC?"

⇒ Acknowledge the respective message by pressing "Enter" key of control panel. Drive parameters are now loaded from MMC to volatile memory of device; the message "Load new safety?" then possibly appears.

⇒ Also acknowledge this message by pressing "Enter" key of control panel. Safety technology parameters are now loaded from MMC to memory of optional safety technology module.

After parameter loading process has been completed, drive waits for further actions of control master.



If safety technology is to be activated in the replacement device (in accordance with replaced device), the drive after loading the safety technology parameters has to be switched to operating mode (OM) or communication phase (P4) before it is switched off!

---

#### 5. Put Machine Into Ready-For-Operation Status

1. Put machine into ready-for-operation status again according to machine manufacturer's instructions.
2. Check functions of drive.

#### 6. Check Safety Technology Parameters

Completing the process, you must check with activated safety technology whether the correct safety technology parameters have been loaded for the drive; to do this, check data in "P-0-3205, Safety technology device identifier" (machine type, unit, drive for .. axis/spindle) and compile a protocol with the contents listed below and add it to safety-relevant documentation of the machine:

- Drive controller replaced on (date)
- Change counter of safety technology memory (P-0-3201) is at (value)

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- Operating hours at last change of memory (P-0-3202) is at (value)
- (Date), (name), (signature)

## Replacing the Controller Without MMC



The execution of a **controller replacement without MMC** only makes sense if the controller is equipped with a **BASIC single-axis control section**.

If the controller is equipped with another control section, it cannot be ensured that after the replacement of the device all parameterized device functions are available again when carrying out the process described below. Therefore, for such controllers, **replacement is only recommended with MMC**.

### 1. Save Parameter Values

Before dismounting the defective device, save the drive parameter values, if possible.



If saving the parameter values before replacing the device should be impossible due to a total breakdown of the device, only the parameter values backed up after initial commissioning can be loaded when the parameter values are loaded later on (see index entry "Load parameter values in case of total breakdown of device")!

1. Switch drive off and on again
2. Switch to parameter mode (PM or P2)
3. Saving parameter values of defective device can take place via commissioning tool "IndraWorks Ds/D/MLD" or control master:

- Commissioning tool "IndraWorks Ds/D/MLD":

By selecting the respective menu item, the parameter values according to the list parameters S-0-0192 and P-0-0195 are stored on an external data carrier (hard disk, floppy disk or the like) [serial communication with the controller or via SYSDA/SERCOS interface].

- Control master:

The parameter values according to the list parameters S-0-0192 and P-0-0195 are stored on a master-side data carrier by the control master.

### 2. Replace Controller

1. Open main switch
2. Make sure main switch cannot be switched on again
3. Make sure drive controller is completely de-energized



**WARNING**

### Lethal electric shock caused by live parts with more than 50 V!

Before working on live parts: De-energize the installation and secure the power switch against unintentional or unauthorized re-energization.

Wait at least **30 minutes** after switching off the supply voltages to allow dis-charging. To shorten the waiting time until voltage has fallen below 50 V, you can use a discharging device (see chapter "Appendix").

Check whether voltages have fallen below 50 V before touching live parts!

4. Remove touch guard and separate connection lines from drive controller
  5. Unscrew screws on top and bottom of housing
  6. Take drive controller out of drive system
  7. Mount new drive controller
  8. Connect new drive controller as specified in machine circuit diagram
  9. Mount touch guard
- 3. Put Controller Into Ready-For-Operation Status Again**
- Put machine into ready-for-operation status again according to machine manufacturer's instructions.
- 4. Load Firmware and Parameter Values**
- When firmware and drive parameters are to be transmitted to the replaced controller, the required firmware and a parameter backup of the respective axis must be available.
1. Supply controller with control voltage
  2. Depending on previous configuration of replacement device, one of the following messages can appear during booting phase:
    - "F2120 MMC: Defective or missing, replace"  
⇒ Acknowledge this message by pressing "Esc" key of control panel.
    - "Load new param.?"  
⇒ Acknowledge this message by pressing "Enter" key of control panel.
  3. By selecting respective menu item in "IndraWorks Ds/D/MLD", firmware stored on an external data carrier (hard disk, floppy disk or the like) is loaded to controller (serial communication with controller).
  4. Loading parameter values can take place via commissioning tool "IndraWorks Ds/D/MLD" or control master:
    - Commissioning tool "IndraWorks Ds/D/MLD"  
By selecting the respective menu item, the parameter values stored on an external data carrier (hard disk, floppy disk or the like), immediately before the device was replaced, according to list parameters S-0-0192 and P-0-0195 are loaded to the controller (serial communication with the controller or via SYSDA/SERCOS interface). With safety technology available, further actions are required (see index entry "Replacing the controller without stationarily plugged MMC").
    - Control master  
The axis-specific parameter values saved before having replaced the device can also be loaded via the control master. The parameter values saved immediately before the replacement of the device on a master-side data carrier (according to list parameters S-0-0192 and P-0-0195) are loaded to the controller by the control master. With safety technology available, further actions are required (see index entry "Replacing the controller without stationarily plugged MMC").
- 5. Put Machine Into Ready-For-Operation Status**
1. Put machine into ready-for-operation status again according to machine manufacturer's instructions.
  2. Check functions of drive.

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## Possible Problems During Controller Replacement

### Load Parameter Values in Case of Total Breakdown of Device

The paragraphs below give a brief description of critical problems and their recommended handling.

If it should have been impossible to save the parameter values according to the list parameters S-0-0192 and P-0-0195 immediately before replacing the device (total breakdown of device), the parameter values saved after initial commissioning have to be loaded.



In the case of drives with absolute value encoder and modulo format, the position data reference has to be established again after having loaded the parameter values saved after initial commissioning, even if the actual position values are signaled to be valid via the parameter "S-0-0403, Position feedback value status"!



**WARNING**

**The parameter values saved after initial commissioning are not generally suited for reestablishing the operability of the drive after replacement of devices!**

⇒ Before setting drive enable, check actual position values and active target position and, if necessary, PLC retain data!

## 10.8 Enabling of Functional Packages

### 10.8.1 Brief Description

The scope of functionality of the IndraDrive firmware can be scaled by the user. This allows adjusting the scope of firmware functions to the respective requirements and, if necessary, reducing its complexity.

The drive functionality is scaled by licensing (enabling) optional expansion packages that are available in addition to the standard base package of the respective IndraDrive firmware.



In the case of drives of double-axis design (firmware variant MPD), it is only possible to enable the same functional packages for both axes. In case the enabling for drive 1 is changed, the enabling for drive 2 is automatically changed, too.

See also "Overview of Functions/Functional Packages"

#### Features

- Display of activated functional packages in "P-0-2004, Active functional packages"
- Firmware type designation in "S-0-0030, Manufacturer version" dynamically adjusted to the active functional packages displayed in P-0-2004
- Functional packages activated/deactivated via parameter
- Count of operating hours counter at last change of access enable is stored

#### Pertinent Parameters

- S-0-0030, Manufacturer version
- P-0-2002, Oper. hours of contr. sect. at change of functional packages
- P-0-2003, Selection of functional packages
- P-0-2004, Active functional packages

#### Pertinent Diagnostic Messages

- C0202 Parameter limit error (->S-0-0423)
- C0299 Configuration changed. Restart



## 10.8.2 Functional Description

### Changing the Active Functional Package Selection

The functionality of the drive firmware is divided into several functional packages. By enabling certain packages, it can be adjusted to the requirements of the respective application.

Basically, there are the following possibilities of subsequent scaling of the drive functionality:

- **Reducing** the already licensed scope of functions in order to reduce the complexity of the firmware
- **Expanding** the scope of functions originally ordered (additional licensing)



Non-licensed functional packages mustn't be used. Enabling functional packages which aren't part of the originally ordered scope of functions requires additional licensing that is not free of charge! If you use a non-licensed function, any guarantee on the part of Bosch Rexroth will expire.

The count of the operating hours counter at the change of access enable for functional packages is stored in parameter P-0-2002. The Bosch Rexroth staff can therefore provide evidence of non-licensed drive functions that have been enabled.

Parameter P-0-2003 is available for selecting the functional packages; parameter P-0-2004 for displaying the activated packages.

The following assignment applies:

Bit No.	Name of package (Bit = 1 → package is selected)	Rules for selection via P-0-2003
0	Base package "open-loop"	- As an alternative to bit 1 - Not with safety technology
1	Base package "closed-loop"	- As an alternative to bit 0 - Not with CSB-01.1N-FC
2	Not used	--
3	Not used	--
4	Expansion package "servo function" (SRV)	- As an alternative to bit 5 or 6 - Not with "Open-Loop"
5	Expansion package "synchronization" (SNC)	- As an alternative to bit 4 or 6 - Not with CSB-01.1N-FC
6	Expansion package "main spindle" (MSP)	- As an alternative to bit 4 or 5 - Not with "Open-Loop" for CDB01.1C
7	Not used	--
8	Additional package "IndraMotion MLD Advanced" (MA)	- only for MPH - only in conjunction with bit 1 (closed-loop) and bit 9 (IndraMotion MLD)

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Bit No.	Name of package (Bit = 1 → package is selected)	Rules for selection via P-0-2003
9	Additional package "IndraMotion MLD" (ML or TF) <sup>1)</sup>	- Not with CDB01.1C
10 to 31	Not used	--

1) MLD design "ML" for MPH firmware; "TF" for MPB firmware  
 Fig. 10-47: Selecting the Functional Packages via Parameter P-0-2003



You can purchase the functional package option "ALL" and thereby license all three above-mentioned expansion packages (SRV, SNC, MSP). This allows you using any of these expansion packages.

**Example** Enabling the base package "closed loop" and the expansion package "servo function", for example, requires the following setting in P-0-2003:

- Bit 1 = 1 for the base package "closed loop"
- Bit 4 = 1 for the expansion package "servo function"

→ P-0-2003 = 0x0012

These settings are displayed in parameter P-0-2004, in case parameter P-0-2003 is changed they are only displayed after repeated booting process.

The figure below illustrates the interaction of the parameters involved in enabling of functional packages.

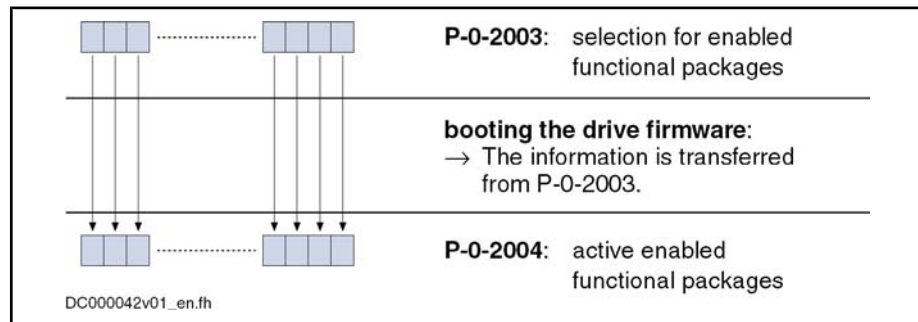


Fig. 10-48: Interaction of Parameters for Functional Package Selection

Every change of the functional package selection is recorded via an entry of the current count of the operating hours counter in "P-0-2002, Oper. hours of contr. sect. at change of functional packages".



Bosch Rexroth can at any time provide evidence of non-licensed functional packages that have been enabled subsequently.

The table below shows the presently possible combinations for input in parameter "P-0-2003, Selection of functional packages". **Whether the respective combination can be used, depends on the available hardware design.**

Base package/expansion package(s)	Content of P-0-2003
<b>Open-Loop Packages</b>	
Open-Loop <b>without expansion packages</b>	0x0000 0001
Open loop <b>with synchronization (SNC)</b>	0x0000 0021
Open-Loop <b>with main spindle (MSP)</b>	0x0000 0041
Open-Loop <b>with IndraMotion MLD (ML)<sup>1)</sup></b>	0x0000 0201

Base package/expansion package(s)	Content of P-0-2003
Open-Loop with synchronization (SNC) + IndraMotion MLD (ML) <sup>1)</sup>	0x0000 0221
Open-Loop with main spindle (MSP) + IndraMotion MLD (ML) <sup>1)</sup>	0x0000 0241
<b>Closed-Loop Packages</b>	
Closed-Loop without expansion packages	0x0000 0002
Closed loop with servo function (SRV)	0x0000 0012
Closed loop with synchronization (SNC)	0x0000 0022
Closed loop with main spindle (MSP)	0x0000 0042
Closed-Loop with IndraMotion MLD (ML) <sup>1)</sup>	0x0000 0202
Closed-Loop with servo function (SRV) + IndraMotion MLD (ML) <sup>1)</sup>	0x0000 0212
Closed-Loop with synchronization (SNC) + IndraMotion MLD (ML) <sup>1)</sup>	0x0000 0222
Closed-Loop with main spindle (MSP) + IndraMotion MLD (ML) <sup>1)</sup>	0x0000 0242
Closed-Loop with IndraMotion MLD Advanced (MA) <sup>2)</sup>	0x0000 0302
Closed-Loop with servo function (SRV) + IndraMotion MLD Advanced (MA) <sup>2)</sup>	0x0000 0312
Closed-Loop with synchronization (SNC) + IndraMotion MLD Advanced (MA) <sup>2)</sup>	0x0000 0322
Closed-Loop with main spindle (MSP) + IndraMotion MLD Advanced (MA) <sup>2)</sup>	0x0000 0342

- 1) MLD design for MPB firmware has type designation "TF"  
 2) "MA" (IndraMotion MLD Advanced) also includes the functionality of the MLD design "ML"

*Fig. 10-49: Possible Combinations of Functional Packages of Firmware MPx05*



Changes in "P-0-2003, Selection of functional packages" are only accepted by the drive after repeated booting process.

## Reducing the Active Functional Packages

The user can at any time reduce the scope of functions of the firmware by deactivating individual functional packages. To do this, the bits assigned to the functional packages which are not required are reset in "P-0-2003, Selection of functional packages".

## Subsequent Expansion (Additional Licensing)

The required functions are normally licensed by ordering the IndraDrive firmware. At delivery, the licensed functions are indicated as firmware type on the type plate of the control section and in addition internally registered by Rexroth.



Bosch Rexroth can at any time prove which scope of functions had been activated and thus licensed at delivery. If you use a non-licensed function, any guarantee on the part of Bosch Rexroth will expire!

In individual cases, it is possible make an additional licensing, if you wish to enable other functions than the ones contained in the ordered and paid functionality. The procedure is described in the following section "Notes on Commissioning".

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## 10.8.3 Notes on Commissioning

### Condition as Supplied

When a drive is delivered, the licensed functional packages have been enabled. For package "ALL", the package "servo function" (SRV) has been enabled ex works.



The firmware type printed on the firmware type plate has to comply with the content of "S-0-0030, Manufacturer version" (or contain the package identifier "ALL").

The content of S-0-0030 can be read via the standard control panel (see "Control Panels of the IndraDrive Controllers").

The following example shows the connection for firmware MPH05V02 and functional package "closed-loop, synchronization and IndraMotion":

- Example**
- Content of S-0-0030 → FWA-INDRV\*-MPH05V02-MS-1-SNC-ML
  - Imprint on type plate → FWA-INDRV\*-MPH05V02-MS-1-SNC-ML  
- or (with complete licensing) -  
→ FWA-INDRV\*-MPH05V02-MS-1-ALL-ML

### Reducing the Functionality

The drive functionality is scaled by selecting functional packages via an entry in "P-0-2003, Selection of functional packages".

The scaling can be changed by directly writing data to the parameter via the master communication or the corresponding dialog in the "IndraWorks Ds/D/MLD" commissioning tool.

The time of change is registered by an entry in "P-0-2002, Oper. hours of contr. sect. at change of functional packages".



A change in P-0-2003 only takes effect after repeated booting process. The active functional packages are then displayed in "P-0-2004, Active functional packages".

### Additional Licensing (Expansion of Functionality)

If the firmware originally ordered and delivered does not contain all required functions, it is possible to subsequently enable further functional packages. This requires additional licensing that is not free of charge.



For test purposes, it is possible to enable non-licensed functional packages via parameter P-0-2003 for a limited time (max. 2 weeks).

**If you use a non-licensed functional package permanently, any guarantee on the part of Bosch Rexroth will expire!**

#### How to Proceed for Additional Licensing

For additional licensing proceed as follows:

1. Enable required functional packages in P-0-2003
2. Reboot drive and check content of P-0-2004 (content must comply with that of P-0-2003!)
3. See parameter "S-0-0030, Manufacturer version" for firmware type and write it down; this parameter displays current firmware configuration defined via P-0-2003.

4. See "P-0-1511, Circuit board code control section" (list element 3) for serial number of control section and write it down
5. Send purchase order to Bosch Rexroth indicating serial number (from P-0-1511) and desired firmware configuration (from S-0-0030)
6. Receive adjusted firmware type plate from Bosch Rexroth to stick it on type plate of control section so that content of S-0-0030 complies with firmware description on type plate

If there hasn't any functional package been previously enabled by the customer, the additional licensing can start with step 4. In step 5, the desired new firmware configuration then cannot be read from S-0-0030, but has to be taken from the overview of firmware types (see "Firmware Types" in section "Overview of Functions/Functional Packages").



For handling the purchase order, please contact your Bosch Rexroth sales representative!

---

**Scope of Supply** The scope of supply consists of

- ordered new firmware type as FWA file incl. parameter file (as files or on MMC)
- and -
- adjusted firmware type plate (to stick on).

## 10.8.4 Verifying the Enabled Functional Packages

When the transition command "C0200 Exit parameterization level procedure command" is executed, a check is run to find out whether the value entered in parameter "P-0-2003, Selection of functional packages" corresponds to valid enabled packages. If not, the diagnostic command message C0202 is generated and the parameter IDN "P-0-2003, Selection of functional packages" entered in list parameter "S-0-0423, IDN-list of invalid data for parameterization levels".



See also Troubleshooting Guide "C0202 Parameter limit error (->S-0-0423)"

When the enabling of functional packages has been changed, you have to reboot the drive so that the change becomes active and is applied to P-0-2004. When the transition command "C0200 Exit parameterization level procedure command" is executed, a check is run to find out whether the value entered in P-0-2003 corresponds to the value in P-0-2004. If there is a difference, the diagnostic command message "C0299 Configuration changed. Restart" is displayed.



See also Troubleshooting Guide "C0299 Configuration changed. Restart"

## 10.9 Extended Diagnostic Possibilities

### 10.9.1 Monitoring Function

#### Brief Description



The so-called "monitor function" implemented in the drive is **for internal use** only, or can be used as an extended possibility of diagnosis in the case of error.

---

## Handling, Diagnostic and Service Functions

The monitoring function provides the following options:

- Displaying memory ranges
- Changing storage locations
- Writing/reading EEPROM memory cells (controller and encoder)
- Adjusting analog measured values
- Displaying internal system states
- Executing several test routines for software and hardware



Using the monitor function requires a VT100 terminal, an ANSI terminal or a corresponding emulation. It is recommended to have a 132-column display.

---

**Pertinent Parameters**

- P-0-4021, Baud rate RS-232/485
- P-0-4025, Drive address of master communication
- P-0-4095, RS-232/485 Parity

**Notes on Commissioning/Operation****Serial Interface**

Connection to the drive is realized via the serial interface. The setting has to be made in accordance with the parameterization of the serial interface in the drive (parameters P-0-4021, P-0-4025, P-0-4095).

Default settings of the serial interface:

- 9600 baud
- 8 data bits
- No parity
- 1 stop bit
- Hardware protocol

**Opening the Communication Channel**

After starting the terminal (Windows hyper terminal) and the drive, there isn't any output appearing on the terminal.

In order to establish connection to the drive, the following input is required:

→"**BCD**:<drive address>"

The drive address corresponds to the number set in parameter P-0-4025 (or can be read on the display, default address in "99"). The drive now responds with

"**E**<drive address>:>".



After the input no "echo" appears on the terminal (i.e. the input is invisible when the local echo of the terminal was disabled).

---

To get to the monitoring mode, make the following input:

→"**mon**"

If successful, the drive responds with

"INDRAMAT \_ IMON166 \_ V1.3 \_ May 27 2002 [? = Hilfe ]"

as a header with dark background and the prompt "HPC> ".



The monitoring function was started!

---

**Handling**

The monitor structure is organized in menus. The content of the individual menus can be displayed by inputting

→ "?".

As a matter of principle, the input is made according to the pattern

"`command option1 option2 ... Option N".

Submenus are called like normal commands. The submenu is exited by entering

→ "exit".



With the "exit" command the monitoring mode is exited, too, and the drive switches to normal RS232 communication again.

---

The content of the screen can be cleared with the command "cls".

## 10.9.2 Logbook Function

### Brief Description

A logbook function is realized in the drive firmware in order to obtain a detailed diagnostic error message in the case of error. The information provided by the logbook function allows reproducing the internal firmware sequence, if required.

#### Pertinent Parameters

- P-0-0478, Logbook event
- P-0-0479, Logbook time stamp

### Functional Description

The list parameters "P-0-0478, Logbook event" and "P-0-0479, Logbook time stamp" are organized as ring buffers and can contain 128 elements. The entries in these parameters are realized automatically by the controller subject to internal states. The entry in P-0-0478 marks the event (or the status); the time of the entry is stored in P-0-0479.

#### Content and Format of the Logbook Entries

The entries in parameter P-0-0478 are hexadecimal numbers with the following assignment:

- **Bits 31 to 16** → module code
- **Bits 15 to 0** → internal diagnosis key

The displayed values of this parameter can only be interpreted with internal knowledge of the drive firmware.

Handling, Diagnostic and Service Functions

The screenshot shows a software window titled "IndraDrive [1] CCD-Master". At the top, there is a dropdown menu for "IDN" set to "P-0-0478". Below this is a toolbar with various icons. The main area contains a table with the following data:

Name	Logbook event
Status	OK
Min / Max	-- / --
Elements	Act: 128 Max: 128
0	0x003B0018
1	0x003B000C
2	0x00160003
3	0x00220027
4	0x0021000B
5	0x003B001A
6	0xFFFFFFFF
7	0x00000000
8	0x00000000
9	0x00000000
10	0x00000000
11	0x00000000
12	0x00000000
13	0x00000000
14	0x00000000
15	0x00000000
16	0x00000000
17	0x00000000

Fig.10-50: Logbook Entries (Example)



Each time the control section is switched on, "0xFFFFFFFF" is entered in P-0-0478 as a separator in order to mark the "restart" .

The entries in P-0-0479 contain the operating hours of the control section in seconds at the time of the respective event.



Name	Logbook time stamp
Status	OK
Min / Max	-- / --
Elements	Act: 128 Max: 128
0	0.0
1	0.0
2	0.0
3	0.0
4	0.0
5	0.0
6	0.0
7	0.0
8	0.0
9	0.0
10	0.0
11	0.0
12	0.0
13	0.0
14	0.0
15	0.0
16	0.0
17	0.0

Fig.10-51: Content of Parameter P-0-0479 (Example)

### 10.9.3 Patch Function

#### Brief Description

The patch function can be used for reading and writing any storage location (or internal variable) as a data object via the master communication, the analog output or the oscilloscope function.

In conjunction with the analog output or the oscilloscope function, this functionality can be used for locating errors.

The PLC patch function serves for diagnosis of internal signal states and internal data of the PLC by developers and instructed users.



When using the patch display in the oscilloscope you have to take into account that first the patch address and then the oscilloscope signal is assigned. This must be repeated after every change in the patch address.



As it is a **function for exclusive use by the development staff**, the patch display parameters P-0-0485 and P-0-0491 write-protected with the master password.

The configuration parameters of the patch function are **not stored in the flash**, but are lost when the drive is switched off.

Handling, Diagnostic and Service Functions

**Pertinent Parameters**

General patch functions:

- P-0-0480, Patch function 1, source pointer
- P-0-0481, Patch function 1, attribute
- P-0-0482, Patch function 1, bit maskP
- P-0-0483, Patch function 1, exponent
- P-0-0485, Patch function 1, display
- P-0-0486, Patch function 2, source pointer
- P-0-0487, Patch function 2, attribute
- P-0-0488, Patch function 2, bit mask
- P-0-0489, Patch function 2, exponent
- P-0-0491, Patch function 2, display

PLC Patch function:

- P-0-0492, PLC patch function 1, data source
- P-0-0493, PLC patch function 1, display
- P-0-0494, PLC patch function 2, data source
- P-0-0495, PLC patch function 2, display
- P-0-0496, PLC patch function 3, data source
- P-0-0497, PLC patch function 3, display
- P-0-0498, PLC patch function 4, data source
- P-0-0499, PLC patch function 4, display

**Functional Description - General Patch Function**

**Read Access (Displaying Internal Storage Locations/Signals)**

The patch function allows transforming any storage location into a data object that can be read via the master communication. For this purpose, a storage location is specified via parameters "P-0-0480, Patch function 1, source pointer" and "P-0-0486, Patch function 2, source pointer". The access to this address is configured via the bits 0 to 2 of parameters "P-0-0481, Patch function 1, attribute" and "P-0-0487, Patch function 2, attribute". INT4 reads a 4-byte integer value starting from the source pointer, INT2/INT1 read 2 bytes or 1 byte accordingly. FLOAT8 reads an 8-byte floating-point value (DOUBLE), FLOAT4 reads 4 bytes accordingly (FLOAT).

Due to the processor architecture, the possible memory accesses are subject to certain restrictions. A 4-byte access, for example, is only allowed for storage locations the address of which can be divided by 4. The table below contains a complete overview of the allowed and prohibited memory accesses.



If you want to change the access mode via bits 0 to 2 of the patch attribute parameters (P-0-0481/P-0-0487), this is only possible if the patch source pointer that has just been set (P-0-0480/P-0-0486) allows the new access mode (see table).

Access as...	Possible access to source addresses that ...		
	...can be divided by 4 (DWORD-aligned)	... can be divided by 2, but not by 4 (WORD-aligned)	... do not have any particular alignment (BYTE-aligned)
INT4	■	-	-
INT2	■	■	-

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Access as...	Possible access to source addresses that ...		
	...can be divided by 4 (DWORD-aligned)	... can be divided by 2, but not by 4 (WORD-aligned)	... do not have any particular alignment (BYTE-aligned)
INT1	■	■	■
FLOAT8	■	–	–
FLOAT4	■	–	–

- Access allowed
- Access prohibited

Fig. 10-52: Possible Access Modes of the Patch Function

The desired display format is set via bits 4 to 7 of the patch attribute parameters (P-0-0481/P-0-0487). This allows interpreting the value read as a decimal number with or without sign, as a hexadecimal number or as a binary number. When selecting "BOOL" as the display type, "1" is output when a value unequal zero was read, otherwise "0" is displayed.

If a storage location is read as integer and output in a non-float format, the value read is ANDed with the bit mask set via the patch bit mask parameters (P-0-0482/P-0-0488). The standard setting of this mask is "0xFFFFFFFF" so that the value read is not changed.

When a storage location is read as a float value and a non-float format is selected for display, the value read is multiplied with  $10^{-\text{exponent}}$ . This allows making an adjustment to the displayed value range (-2147483648 to 2147483647, value range of a "signed int"). The exponent can be set via parameters "P-0-0483, Patch function 1, exponent" or "P-0-0489, Patch function 2, exponent".



If the value read and scaled with the exponent is outside the possible range of display, one of the extreme values is displayed. In this case, it is necessary to select a different exponent.

### Write Access (Changing Internal Storage Locations/Signals)

In analogy to read access, it is possible to write any storage location. A bit mask possibly set (P-0-0482/P-0-0488) is taken into account (ANDed) as is a preset patch exponent (P-0-0483/P-0-0489).



Please observe that in the "BOOL" display mode, it is impossible to write the storage location, because it is impossible to assign an unequivocal numeric value to the value "TRUE" (displayed as "1"). Any value unequal zero is interpreted as "TRUE".



As in the case of read access, odd addresses in the case of write access are only allowed in the INT1 mode. In contrast to read access, the write access is directly carried out as a byte access. You should therefore avoid activating addresses outside the DRAM in this way, because this can lead to undefined hardware behavior.

### Examples of Application

#### Patch Function in Conjunction With "Analog Output"

In conjunction with the "analog output" function it is possible to transmit the content of a storage location to an analog output. To do this, the IDN of the desired patch display (P-0-0485/P-0-0491) has to be entered in one of parameters "P-0-0420, Analog output, assignment A, signal selection" or "P-0-0423, Analog output, assignment B, signal selection".

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Please observe that changes in the patch attributes (P-0-0481/P-0-0487) are not automatically transmitted to the parameters P-0-0418/P-0-0419 and P-0-0422/P-0-0425. After a change in the patch attribute, you should therefore write the parameters P-0-0420/P-0-0423, P-0-0418/P-0-0419 and P-0-0422/P-0-0425 again.

See also "Analog Outputs"

## Functional Description - PLC Patch Function

### General Information

For reading internal PLC data four patch channels are introduced. Each channel consists of one parameter for data source and one for display.

### Input Data Sources

The parameters of the "data source" group ("channel no." and "data source") are defined as character string with maximum 265 values. Definition can be carried out in two formats:

- By input of range and offset
- By input of a symbol string

#### Input of Range and Offset

Range and offset are set as follows:

- (Range/offset), data type, output format

The addresses can be generated offline in IndraLogic by creating a symbol file. The defined input string (range/offset) is registered; the values are entered as decimal numbers. A storage address is determined via the range value, the offset is added.

The following strings are permitted:

- BOOL (1 byte)
- BYTE USINT (1 byte without sign)
- SINT (1 byte with sign)
- WORD, UINT (2 bytes without sign)
- INT (2 byte with sign)
- DWORD, UDINT (4 bytes without sign)
- DINT (4 bytes with sign)
- REAL (4 bytes)

In the case that none of these strings is detected or no string is entered, "BYTE" is the default string type.

After a "point" as separator for data type, the output format is read.

The following strings are evaluated:

- 2# → binary display
- 10# → decimal display
- 16# → hexadecimal display

The hash sign "#" must be the last sign of the string output format. If none of the output formats is identified, "decimal" is the default setting.

The data type "REAL" is always displayed as float value, so that an additional parameter exponent becomes superfluous. The "BOOL" data type is always displayed as "boolean".

#### Example for Input of Range and Offset

The following example illustrates a possible input for "range/offset":

- (4/1000),WORD,2#  
→ Variable range 4, offset 1000, data type WORD, display binary
- Input via Symbol String** For this type of addressing a symbol file is required in the drive. For this an MMC is required and the desired signals must be configured.
- The input is evaluated as character string and a symbol string is extracted from it. The requested storage address is read in the symbol table by means of the symbol string.
- For the input "symbol string" the data type from the symbol table is provided, the optionally read type is ignored.
- Example: Symbol String** Example for the input of a symbol string:
- PLC\_PRG.bVar1,16#  
→ Data type is known, display format is hexadecimal

### Display of PLC Data

The output is carried out via parameters of the "Display" group ("channel no." and "display").

### Write Access

Writing on PLC data is **not permitted**.

## 10.10 Oscilloscope Function

### 10.10.1 Brief Description

The oscilloscope function can be used to record drive-internal and external signals and status variables (parameter contents). This function can be effectively used both for initial commissioning and debugging. Its functionality can be compared to that of a 4-channel oscilloscope.

The total scope of the oscilloscope function is divided into the following function blocks:

- **Recording measured values**  
It is possible to record 4 channels at the same time, the signals being selected by configuration of signal selection lists (IDN lists).
- **Configuration (basic settings)**  
The control/status block determines the basic functions (start/stop, time resolution, size of memory, operating mode). The current status (status diagram) of the oscilloscope is continuously transmitted to the master.
- **Trigger function**  
Besides extensive trigger functions, the drive provides the possibility of triggering at different signals and events in the drive.

**Features** The oscilloscope function is characterized by the following features:

- **Recording measured values**
  - 4 channels, each with a maximum of 8192 measured values
  - Time resolution to be freely selected in steps of the position loop clock (see "Performance Data")
  - Signal selection by indicating the IDN of the respective parameter
- **Configuration (basic settings)**
  - 4-channel display in "IndraWorks Ds/D/MLD"
  - More than 100 different measuring and trigger signals (cf. P-0-0149)

## Handling, Diagnostic and Service Functions

- Expanded oscilloscope function using patch function
- **Trigger function**
  - Trigger signal selection by indicating the parameter IDN
  - Internal trigger or external trigger
  - External trigger with trigger offset determination for synchronizing multiple-axis measurements
  - Unit of trigger level adjusting to trigger signal selection
  - Possibility of triggering at internal memory contents with patch signal

**Pertinent Parameters**

## Control/status:

- P-0-0028, Oscilloscope: control word
- P-0-0029, Oscilloscope: status word
- P-0-0031, Oscilloscope: time resolution
- P-0-0032, Oscilloscope: size of memory
- P-0-0149, Oscilloscope: signal selection list
- P-0-0150, Oscilloscope: number of valid measured values

## Measuring channels:

- P-0-0021, Oscilloscope: list of measured values 1
- P-0-0022, Oscilloscope: list of measured values 2
- P-0-0023, Oscilloscope: signal selection 1
- P-0-0024, Oscilloscope: signal selection 2
- P-0-0145, Oscilloscope: list of measured values 3
- P-0-0146, Oscilloscope: list of measured values 4
- P-0-0147, Oscilloscope: signal selection 3
- P-0-0148, Oscilloscope: signal selection 4

## Trigger function:

- P-0-0025, Oscilloscope: trigger mask
- P-0-0026, Oscilloscope: trigger signal selection
- P-0-0027, Oscilloscope: trigger level
- P-0-0030, Oscilloscope: trigger edge
- P-0-0033, Oscilloscope: number of measured values after trigger event
- P-0-0035, Oscilloscope: control offset
- P-0-0036, Oscilloscope: external trigger signal
- P-0-0037, Oscilloscope: internal trigger signal

### 10.10.2 General Information on the Oscilloscope Function

#### Sequence of a Measurement (Status Diagram)

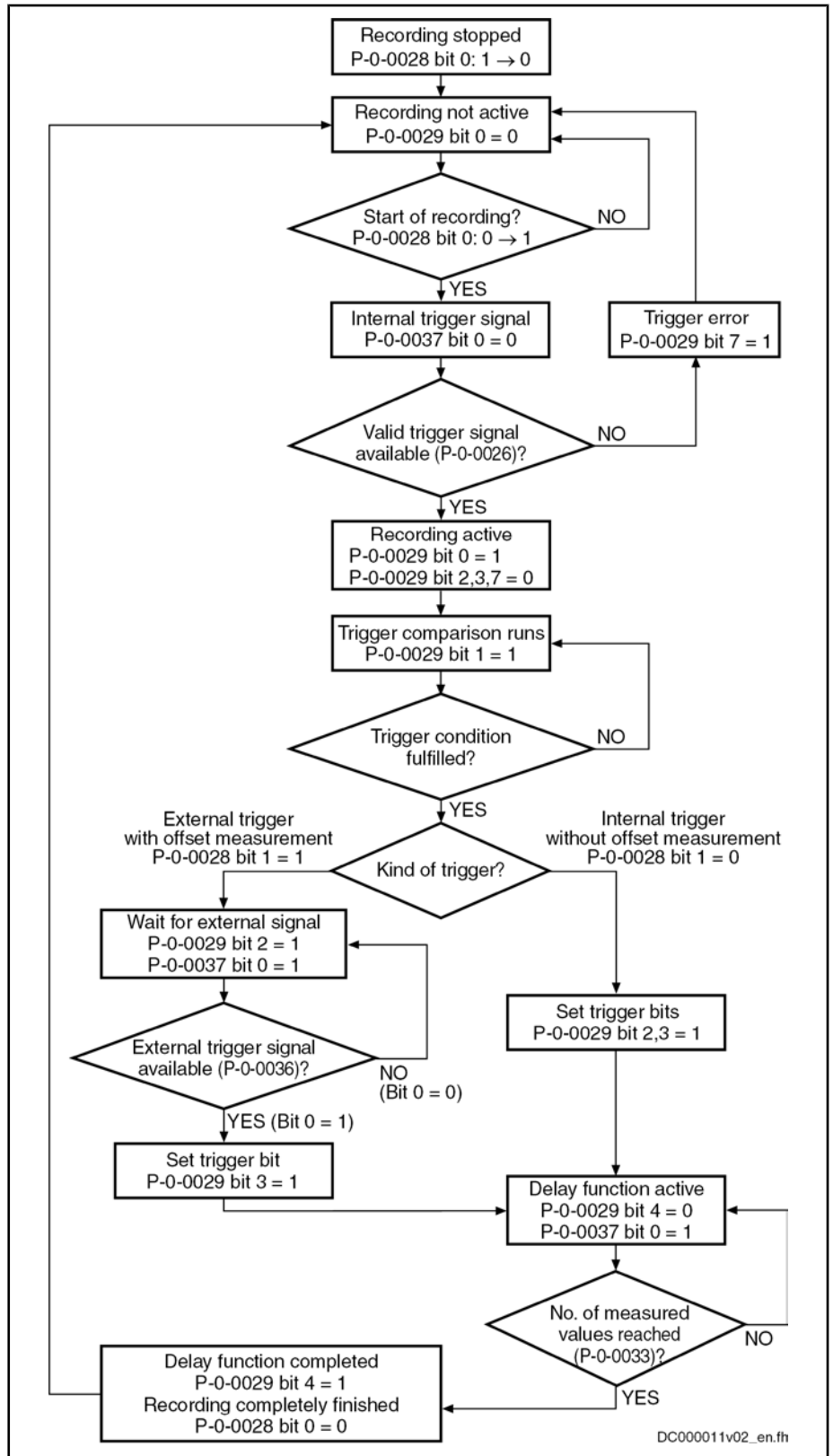


Fig. 10-53: Status Diagram of Oscilloscope Function

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## Configuring the Measured Value Channels

A measured value channel is configured by inputting the IDN of the desired parameter in the respective signal selection parameter:

- P-0-0023, Oscilloscope: signal selection 1
- P-0-0024, Oscilloscope: signal selection 2
- P-0-0147, Oscilloscope: signal selection 3
- P-0-0148, Oscilloscope: signal selection 4

### Signal Selection List (P-0-0149)

All IDNs contained in parameter "P-0-0149, Oscilloscope: signal selection list" can be entered.

P-0-0149 contains all parameters that are suitable as trigger signal (P-0-0026) or measuring signal (P-0-0023, P-0-0024, P-0-0147, P-0-0148). By reading P-0-0149, the master can recognize the signals that can be recorded in the drive.



At present, all cyclically configurable parameters (> 100) are contained in the list!

### Example of Signal Selection

Example of the signal selection of the oscilloscope function:

- "S-0-0051, Position feedback value 1" is selected as signal to be recorded
- Position feedback 1 value (S-0-0051) is written to parameter "P-0-0023, Oscilloscope: signal selection 1"

→ When the limiting conditions occur, actual position value of axis 1 is recorded in the oscilloscope and transmitted to the master.

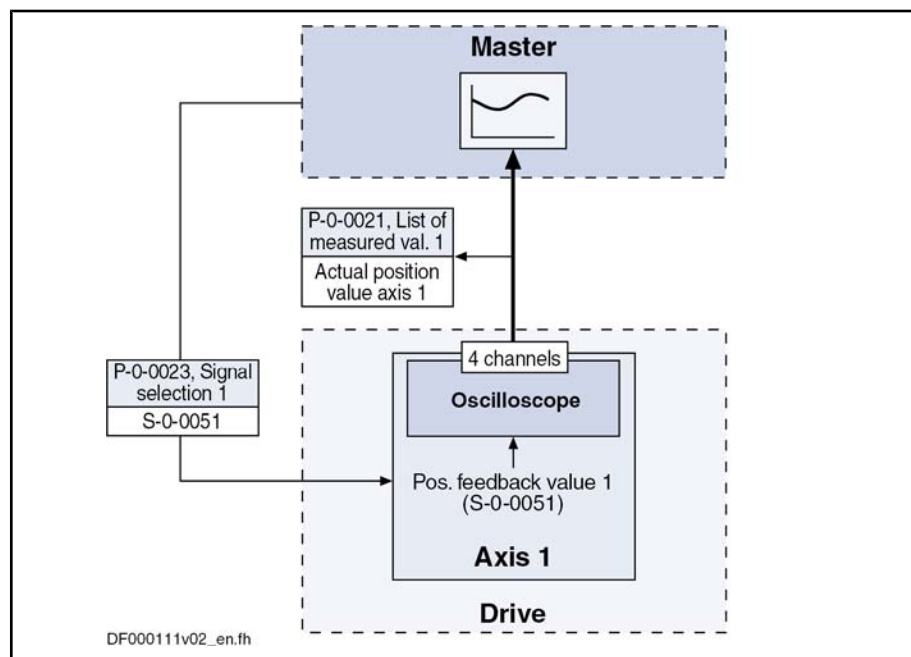


Fig.10-54: Example of Signal Selection

## Expanded Oscilloscope Function (Patch Function)

Besides the recording of parameter contents via the oscilloscope function, the drive provides the possibility of recording any internal signal, i.e. memory address (patch function).





Using the patch function is only possible with information about the structure of the internal data memory; therefore, this function can be used effectively only by the developers of the IndraDrive firmware.

In order to record internal signals (memory address contents), "P-0-0485, Patch function 1, display" or "P-0-0491, Patch function 2, display" have to be configured in one of the signal selection parameters (P-0-0023, P-0-0024, P-0-0147, P-0-0148).



The patch function has to be parameterized before the assignment as trigger or measuring signal.

See also "Patch Function"

## Activating the Oscilloscope Function

The oscilloscope function is activated/deactivated by means of parameter "P-0-0028, Oscilloscope: control word".

### P-0-0028, bit 0:

- Bit 0 = 1 → starting a measurement
- Bit 0 = 0 → stopping a measurement

Setting bit 0 in P-0-0028 activates the oscilloscope function, i.e. the recording of measured values of the selected signal starts. The oscilloscope function waits for the selected trigger edge or level to occur. At detection of a valid edge the measured values keep being written to the measured value memory until the number of measured values defined in "P-0-0033, Oscilloscope: number of measured values after trigger event" has been reached (delay function).



With SERCOS master communication, start of signal recording and of trigger evaluation are delayed until the next feedback acquisition starting time T4 (S-0-0007 and S-0-1007).

This causes the recording data and the data in the AT telegram to be identical and several drives at one SERCOS bus to simultaneously start the recording within one SERCOS cycle.

After the defined number of measured values has been recorded, the bit "delay function completed" (bit 4) is set in parameter "P-0-0029, Oscilloscope: status word". The recording is complete and automatically terminated. Bit 0 in parameter P-0-0028 is reset and the list of measured values can be read.



Depending on the parameterization of the size of memory, the time resolution, the number of measured values after trigger event and the point of time the trigger event occurs, the entire measured value memory for the current measurement is not always written.

This means that there may still be old measured values in the memory that are not valid for the current measurement!

## 10.10.3 Trigger Function

### Trigger Signal Selection

#### Triggering at Standard Signals

The drive provides extensive and flexible possibilities of triggering.

The trigger signal is selected in parameter "P-0-0026, Oscilloscope: trigger signal selection" by directly inputting parameter IDNs. Only such IDNs are al-

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lowed that are contained in the list "P-0-0149, Oscilloscope: signal selection list".



If there is no valid trigger signal available when the oscilloscope function is activated, bit 7 for "trigger error" is set in parameter "P-0-0029, Oscilloscope: status word".

**Triggering at Any Signal**

"P-0-0026, Oscilloscope: trigger signal selection" determines which signal is monitored with regard to the parameterized edge reversal or threshold value.

Besides the triggering of parameter contents, the drive provides the possibility of recording any internal signal, i.e. memory address (patch function).



Using the patch function is only possible with information about the structure of the internal data memory; therefore, this function can be used effectively only by the developers of the IndraDrive firm-ware.

**Patch Function**

In order to trigger at internal signals (memory address contents), "P-0-0485, Patch function 1, display" or "P-0-0491, Patch function 2, display" have to be configured in P-0-0026.

See also "Patch Function"

**Internal or External Trigger**

The kind of trigger can be selected in parameter "P-0-0028, Oscilloscope: control word".

**P-0-0028, bit 1:**

- Bit 1 = 0 → Internal trigger without offset measurement
- Bit 1 = 1 → External trigger with offset measurement

**Trigger Event**

The trigger event is the point of time at which trigger signal (P-0-0026) and trigger level (P-0-0027) are matching, taking the determined trigger edge into account (P-0-0030). When the trigger event occurs, the internal trigger is released.

**Internal Trigger (Without Offset Measurement)**

When "internal trigger" is selected (P-0-0028; bit 1 = 0), the external trigger source (P-0-0036, bit 0) is not taken into account. Until the trigger event is reached the current status of the comparison "signal/trigger level" is displayed in "P-0-0029, Oscilloscope: status word".

When the trigger event has been reached, the bit "internal trigger event" is set in parameter "P-0-0029, Oscilloscope: status word" and recording is continued until the defined number of measured values after trigger event (P-0-0033) has been reached. Only then is the bit "delay function completed" set (P-0-0029; bit 4). Setting this bit terminates the complete recording. Independent of the trigger source, the bit indicates the end of the recording.

When internal trigger source has been selected, the status bit "trigger function completed" (P-0-0029, bit 3) is set simultaneously with the bit for "internal trigger event" (P-0-0029, bit 2) (see status diagram).

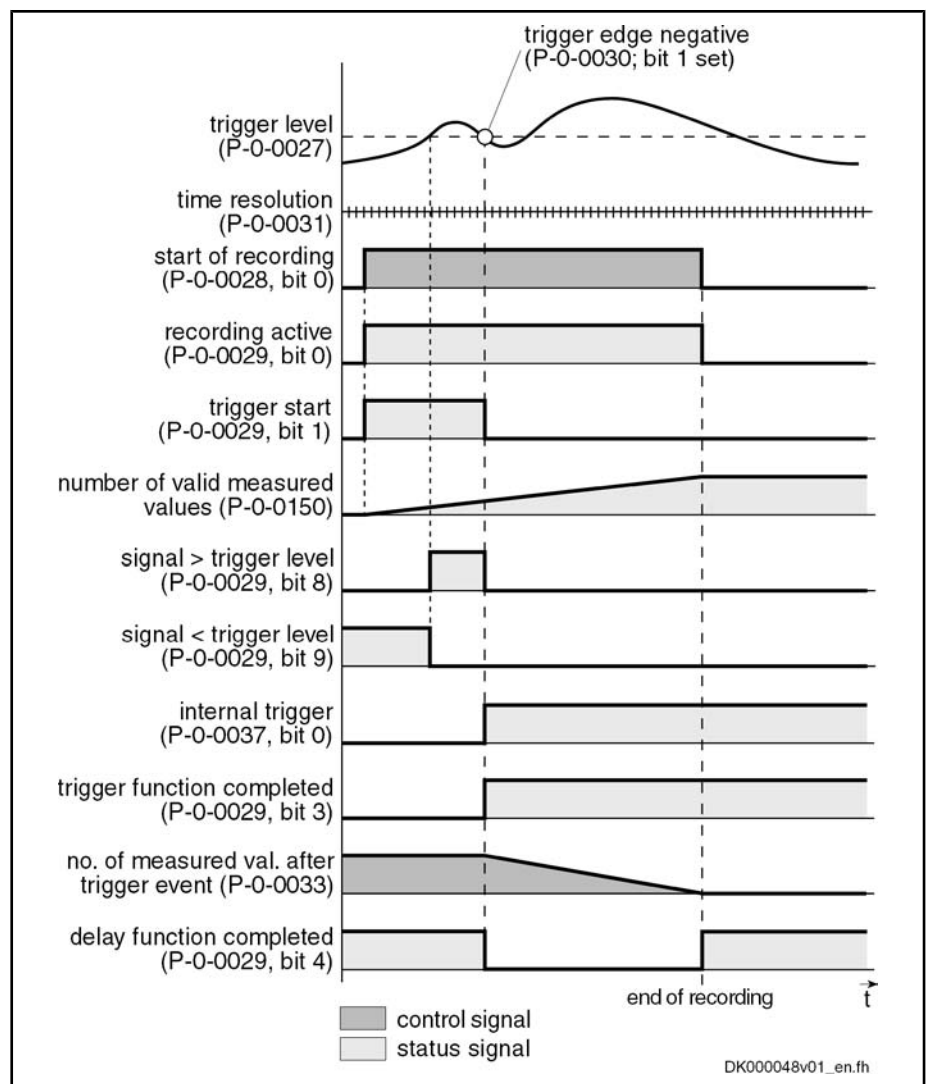


Fig. 10-55: Internal Trigger Without Offset Measurement (P-0-0028; Bit 1 = 0)



Parameterizing P-0-0036 (external trigger signal) in "P-0-0026, Oscilloscope: trigger signal selection" allows releasing the internal trigger function by the external trigger input.

**External Trigger With Offset Measurement**

When the kind of trigger "external trigger with offset measurement" (P-0-0028; bit 1 = 1) has been selected, the internal and external trigger are used for the master axis.

When "external trigger" has been selected, the behavior, until the internal trigger event has been reached, corresponds to the behavior for the case when trigger source "internal trigger" has been selected. Until the external trigger signal occurs (P-0-0036; bit 0), the trigger offset between both trigger events is determined and displayed in P-0-0035. Then the bit "trigger function completed" (P-0-0029; bit 3) is set in the status word. The rest of the sequence is the same as in the case of internal trigger source without offset measurement.

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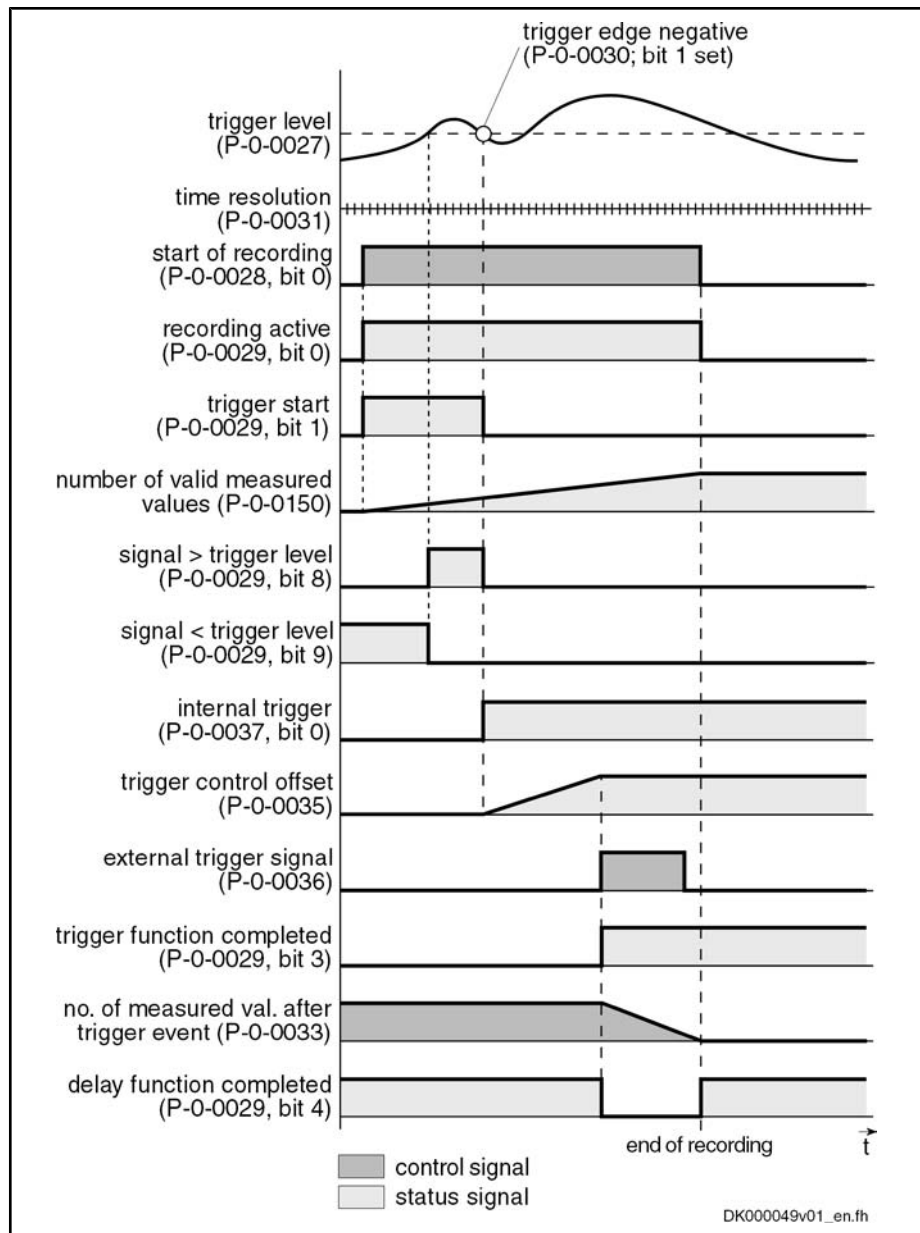


Fig.10-56: External Trigger With Offset Measurement (P-0-0028; Bit 1 = 1)



The use of the external trigger source with trigger offset determination is described in section "Synchronizing the Measuring Signals of Several Axes" (see below).

### Selecting the Trigger Edges

#### Trigger Edge (P-0-0030)

In parameter "P-0-0030, Oscilloscope: trigger edge" it is possible to set at which edge of the trigger signal the internal trigger is released. The following options are available:

- Triggering at the **positive** edge
- Triggering at the **negative** edge
- Triggering at **both** edges
- Triggering when trigger signal **equals** trigger level



See Parameter Description "P-0-0030, Oscilloscope: trigger edge"

## Setting the Trigger Delay

### Trigger Delay Function

Via "P-0-0033, Oscilloscope: number of measured values after trigger event" it is possible to reach a trigger delay independent of the preset trigger source (external/internal). For this purpose, the number of measured values that is to be recorded after the respective trigger event is set in parameter P-0-0033.



It is also possible to record measured values before the trigger event occurs (trigger delay functions of an oscilloscope).

By entering "0" in P-0-0033, only data available before the trigger event will be recorded.

If the value of parameter P-0-0032 is entered, only the measured values that occurred after the trigger event will be recorded.

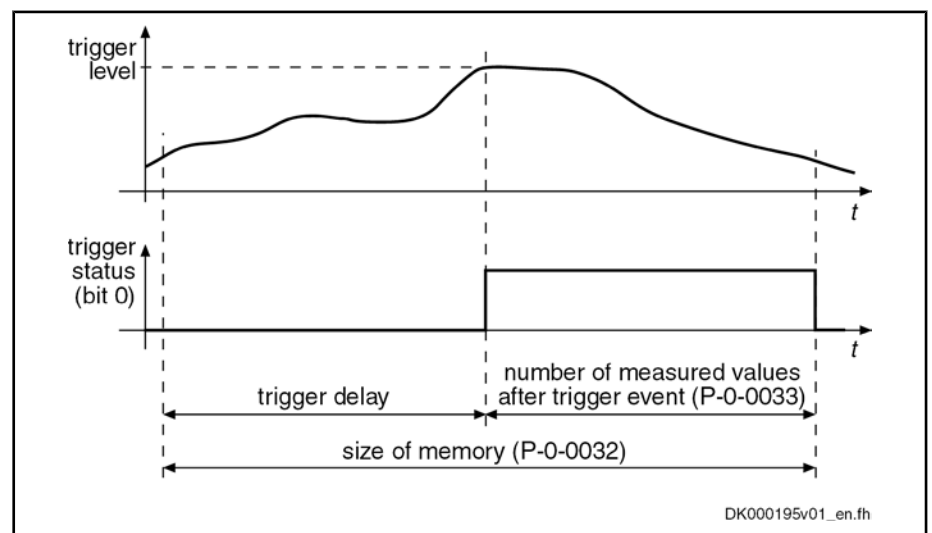


Fig. 10-57: Trigger Delay: Number of Measured Values After Trigger Event

## Expanded Trigger Functions

### Trigger Mask (P-0-0025)

With Parameter "P-0-0025, Oscilloscope: trigger mask", it is possible to trigger at certain events. For trigger signals with the display formats "Bin" and "Hex", it is possible to mask the trigger signal and the trigger level.



See Parameter Description "P-0-0025, Oscilloscope: trigger mask"

### Trigger Level (P-0-0027)

The trigger level can be freely set via parameter "P-0-0027, Oscilloscope: trigger level", the attribute, unit, etc. being adjusted to the selected trigger signal.



See Parameter Description "P-0-0027, Oscilloscope: trigger level"

## 10.10.4 Synchronizing the Measuring Signals of Several Axes

The parameter "P-0-0035, Oscilloscope: control offset" contains the number of measured values between the occurrence of the internal trigger event (P-0-0029; bit 2) and the external trigger event (P-0-0036; bit 0).

### Trigger Control Offset (P-0-0035)

The transmission of the trigger event via the master causes a delay between the detection of the trigger event and the release of the trigger. This delay is

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measured by drive 1 (master drive) and stored in parameter "P-0-0035, Oscilloscope: control offset". A time-correct display of the signals of several drives can be guaranteed by taking this parameter into account for the visualization of the measured values.

See also above "Internal or External Trigger"

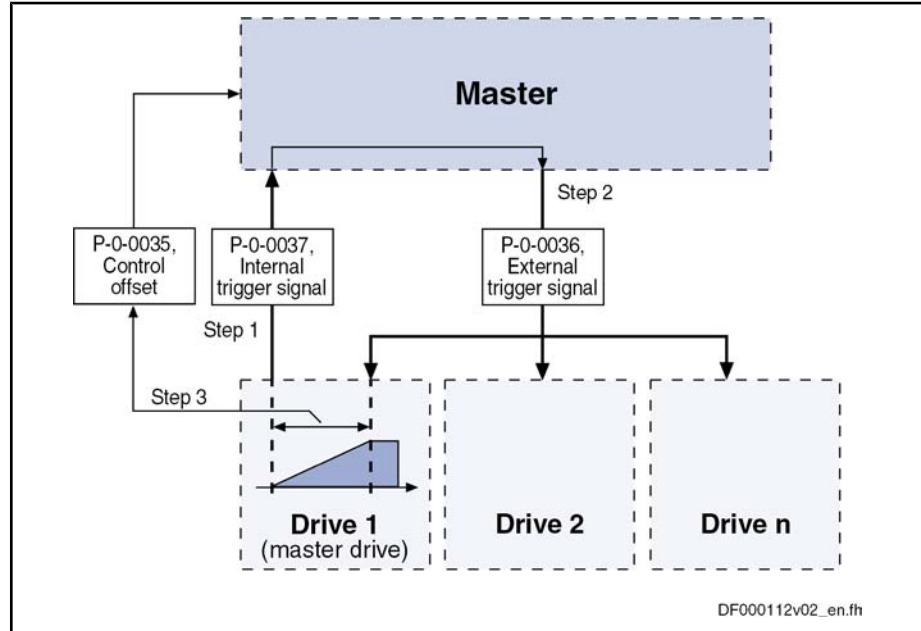


Fig.10-58: Application for Trigger Source "External" With Determination of Trigger Offset



The value in parameter P-0-0035 can be used by the master for synchronizing the measuring signals of several axes with the internal trigger event of the master axis.

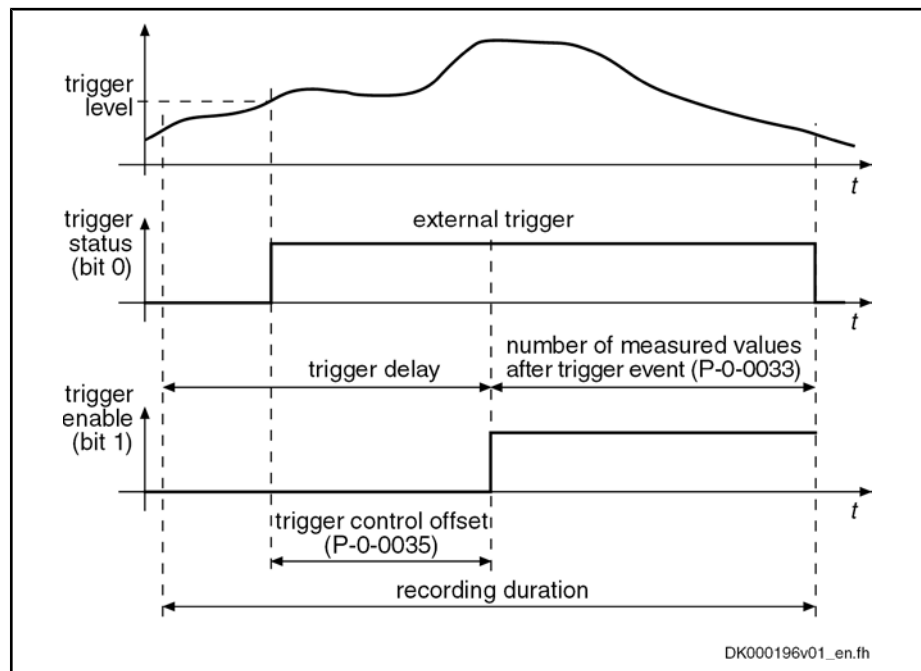


Fig.10-59: Trigger Control Offset

**Status of Internal Trigger  
(P-0-0037)**

Upon successful comparison of trigger signal and trigger condition, bit 0 is set in parameter "P-0-0037, Oscilloscope: internal trigger signal" (trigger status), but the trigger is not released. It is thereby possible for the master to signal the trigger event via the real-time status bits and real-time control bits to several drives at the same time and to release the trigger.

**External Trigger Signal (P-0-0036)**

"P-0-0036, Oscilloscope: external trigger signal" can be parameterized as real-time control information, both in the real-time channel of the interface and as hardware input. This allows triggering at external signals that are preset via

- the master communication
- or -
- an analog or digital input.

## 10.10.5 Parameterizing the Oscilloscope Function

### Recording Duration

The recording duration is determined according to the following relationship:

$$t_A = (P-0-0031) \times (P-0-0032)$$

$t_A$	Recording duration (in $\mu\text{s}$ )
P-0-0031	Oscilloscope: time resolution
P-0-0032	Oscilloscope: size of memory
<i>Fig. 10-60:</i>	<i>Determining the Recording Duration</i>

### Parameterizing the Selection of Measured Values

For the oscilloscope function, it is possible to select 4 signals that are defined by the IDNs of their respective parameters and assigned to the following parameters:

- P-0-0023, Oscilloscope: signal selection 1
- P-0-0024, Oscilloscope: signal selection 2
- P-0-0147, Oscilloscope: signal selection 3
- P-0-0148, Oscilloscope: signal selection 4

Only such parameter IDNs are allowed that are contained in the list parameter "P-0-0149, Oscilloscope: signal selection list".



The selected signal (parameter IDN) defines the unit of the data stored in the list of measured values.

### Parameterizing the Trigger Function

See above "Trigger function"

### Parameterizing Time Resolution and Size of Memory

The recording range or the recording duration can be adjusted to the measurement requirements via the following parameters:

- P-0-0031, Oscilloscope: time resolution
- P-0-0032, Oscilloscope: size of memory

**Size of Memory of Oscilloscope  
Function**

The number of measured values is determined via "P-0-0032, Oscilloscope: size of memory". A maximum of 8192 measured values per channel can be recorded.

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<b>Time Resolution of Oscilloscope Function</b>	<p>"P-0-0031, Oscilloscope: time resolution" determines the time intervals in which measured values are recorded (sampling rate). It is possible to select the time resolution on the time base of the position loop clock (<math>T_{\text{osci}} = N \times T_{A\_\text{position}}</math>; <math>N = 1, 2, 3, 4, \dots</math>).</p> <p>The position loop cycle time depends on the control performance. The control performance in turn depends on the hardware design of the controller and the setting in parameter P-0-0556.</p> <p>See "Performance Data"</p>
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## 10.10.6 Diagnostic and Status Messages

### Status of the Oscilloscope Function

Parameter "P-0-0029, Oscilloscope: status word" displays the current status of the oscilloscope function.

P-0-0029 contains, for example, status information on:

- Start/end of recording
- Trigger function
- Status of trigger signal
- Delay function



See also Parameter Description "P-0-0029, Oscilloscope: status word"

Via parameter "P-0-0037, Oscilloscope: internal trigger signal", the master is informed of the status of the internal trigger. This parameter can be parameterized as real-time status information, both in the real-time channel of the interface and as hardware output.

### Displaying the Number of Valid Measured Values

After a measurement, the parameter "P-0-0150, Oscilloscope: number of valid measured values" displays the number of detected measured values in the ring buffer. When the ring buffer has been completely filled with the length determined in parameter "P-0-0032, Oscilloscope: size of memory", the size of memory is displayed in this parameter.



See also Parameter Description "P-0-0150, Oscilloscope: number of valid measured values"



# 11 Engineering/Diagnostic Interfaces

## 11.1 Serial Communication

### 11.1.1 Overview of Serial Communication

#### General Information

The serial interface of the drive controller is used as a universal medium of communication for different services. It can be used for master communication (in addition to SERCOS), for reading and writing parameters, for replacing the firmware, for locating errors and for other services. The physical standard used is RS232 (with accessory HAS05.1-005 "RS232/RS485 converter", RS485 is possible, too).

Two protocols are supported for serial communication:

- ASCII-based protocol
- SIS protocol (Rexroth-standard serial binary protocol)



The protocol is automatically recognized by the drive!

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The following functions are made possible via the serial interface:

- Reading and writing parameters via terminal or commissioning tool in parallel with the existing master communication
- Connecting a control terminal (BTV04)
- Firmware update with "IndraWorks Ds/D/MLD"

The maximum baud rate is 115 kB.

#### Pertinent Parameters

- P-0-4021, Baud rate RS-232/485
- P-0-4022, Drive address of serial interface
- P-0-4050, Answer delay RS-232/485
- P-0-4095, RS-232/485 Parity

#### Interface Mode

The serial interface can optionally be operated in one of the following modes:

- RS232 Mode
- RS485 Mode



Communication via RS485 is only possible in conjunction with an external RS232/RS485 converter (e.g. with accessory module HAS05.1-005 by Bosch Rexroth).

Depending on the mode, it is necessary to use different cables (see corresponding "Project Planning Manual").

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#### Transmission Protocols


Two different protocols are supported on the drive side:

- ASCII protocol
- SIS protocol

When switching on the 24 V supply voltage, automatic protocol detection is activated when receiving signals via the serial interface.

As soon as either

Engineering/Diagnostic Interfaces

<p>Properties of ASCII Protocol</p>	<ul style="list-style-type: none"> <li>• a valid ASCII start sequence</li> <li>- or -</li> <li>• a valid SIS telegram</li> </ul> <p>was received, the drive internally switches to the respective kind of protocol.</p> <ul style="list-style-type: none"> <li>• Transmission rates 9600 and 19200 baud</li> <li>• 8-bit ASCII protocol</li> <li>• No parity bit</li> <li>• One stop bit</li> </ul> <hr/> <p> There isn't any telegram frame used, but the transmitted ASCII signs are converted and interpreted. It is only necessary to comply with a certain order.</p> <hr/>
<p>Properties of SIS Protocol</p>	<ul style="list-style-type: none"> <li>• Binary protocol</li> <li>• Checksum test (higher Hamming distance D)</li> <li>• all telegrams are identified by an unequivocal start character ("0x02")</li> <li>• Defined structure of the telegram frame</li> <li>• It is possible to activate motions (e.g. jogging)</li> </ul>

## 11.1.2 Functional Principle Independent of Protocol

### Basic State After Applying the Control Voltage

After the control voltage has been switched on, the serial communication in the drive is in the "passive mode". Communication is impossible in the passive mode.

Determining the Protocol

In order to establish the serial communication with the drive, it is necessary to determine the kind of communication (protocol) by

- a CHANGE DRIVE command (in the case of ASCII protocol)
- or -
- a valid SIS telegram (in the case of SIS protocol).

### Setting the Drive Address

The drive address of the serial interface is set by writing data to parameter "P-0-4022, Drive address of serial interface".


This can be done, for example, by means of the standard control panel or the "IndraWorks Ds/D/MLD" commissioning tool.

**Exception:** If the value "256" (default value) was entered in parameter P-0-4022, the device address set in parameter "P-0-4025, Drive address of master communication" is used for serial communication.

RS232 Mode

In this mode, it is **not obligatory** to set the drive address, because only one node is connected (peer-to-peer connection).

---

 When communicating via the SIS protocol, the address "128" is provided for peer-to-peer communication. Independent of the setting in parameter P-0-4022, the address "128" is always valid.

---

RS485 Mode

In the case of communication via RS485 bus, it is obligatory to set the drive address, because each bus node is addressed via a specific bus address.



In order to avoid access conflicts, each drive address may be assigned only once.

## Communication Via RS232 Interface

The RS232 interface is particularly intended to be used for connecting a PC with installed "IndraWorks Ds/D/MLD" commissioning tool.

- Features**
- Transmission rates from 9600 to 115,200 baud
  - Max. transmission distance 15 m
  - ASCII protocol or SIS protocol (8-bit each)
  - Parity bit according to parameter "P-0-4095, RS-232/485 Parity"
  - One stop bit

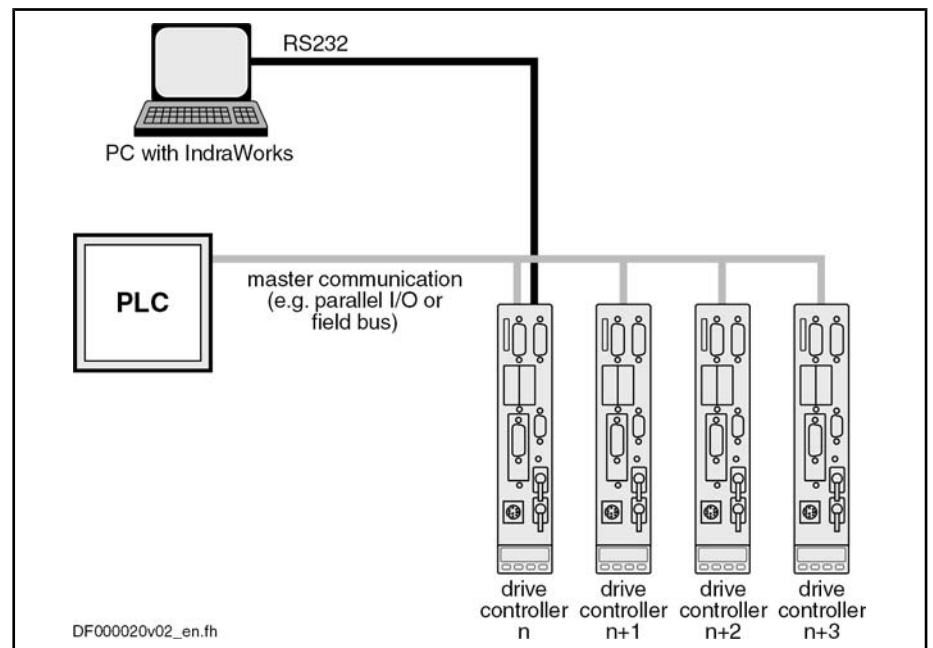


Fig.11-1: Communication Via RS232 Interface (Example: "IndraWorks Ds/D/MLD")

## Communication Via RS485 Interface

### General Information

The communication via the RS485 interface allows realizing a serial bus with the following data:

- Features**
- It is possible to connect up to 31 drives with one bus master
  - Transmission rates from 9600 to 115,200 baud
  - Max. transmission distance 500 m
  - Semi-duplex operation via 2-wire line
  - ASCII protocol or SIS protocol (8-bit each)
  - Parity bit according to parameter "P-0-4095, RS-232/485 Parity"
  - One stop bit



Communication via RS485 is only possible in conjunction with an external RS232/485 converter.

### Operating Several Drives With "IndraWorks Ds/D/MLD"

**Advantages for Application**

- Commissioning several drive controllers without plugging the interface cable into a different connection (central parameterization and diagnosis connection)
- Realizing a central PC-based visualization unit

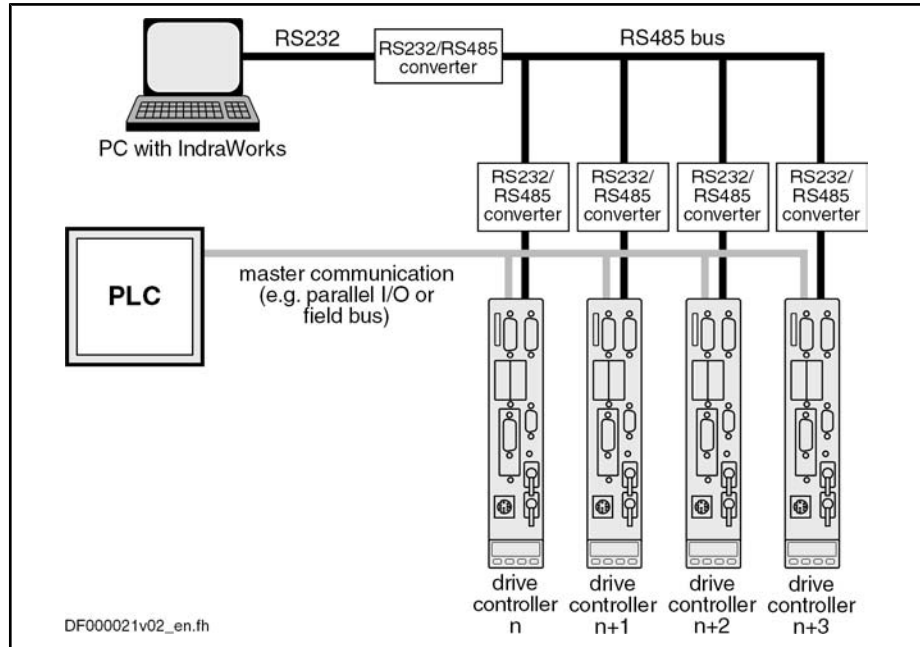


Fig. 11-2: Operating Several Drives With "IndraWorks Ds/D/MLD"



Using "IndraWorks Ds/D/MLD" via the RS485 interface is only possible as of version 05.

### Parameterization and Diagnosis Via PLC

**Advantages for Application**

- Parameters can be changed via PLC (e.g. adjustment of positioning blocks)
- Extended diagnostic possibilities for the PLC by reading in the error code

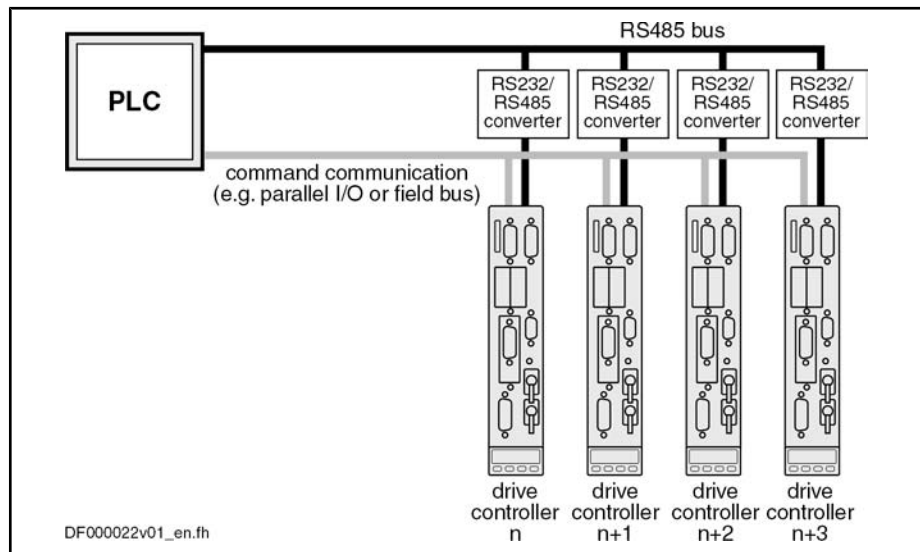


Fig. 11-3: Parameterization and Diagnosis Via PLC

### Parameterization and Diagnosis of Drive Groups by an Operator Unit

**Advantages for Application**

- Realizing a central visualization unit

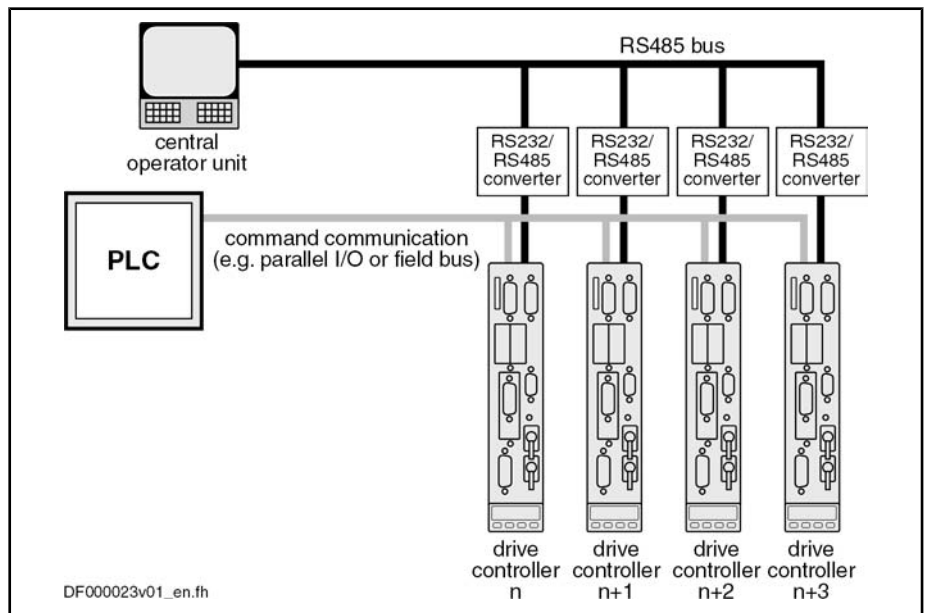


Fig. 11-4: Parameterization and Diagnosis of Drive Groups by an Operator Unit

### Connection System



See separate documentation "Drive Controllers, Control Sections; Project Planning Manual"

### Error Messages With Serial Communication

The error codes defined in the SERCOS interface specification are used for the different errors (see "Specification SERCOS interface", section "Service Channel Error Messages"). These codes are also used in the case of incorrect access to control and system parameters.

Error code		Explanation
Hexadecimal	Decimal	
0x1001	4097	No IDN
0x1009	4105	Invalid access to element 1
0x2001	8193	No name
0x2002	8194	Name transmission too short
0x2003	8195	Name transmission too long
0x2004	8196	Name cannot be changed (read only)
0x2005	8197	Name is write-protected at this time
0x3002	12290	Attribute transmission too short
0x3003	12291	Attribute transmission too long
0x3004	12292	Attribute cannot be changed (read only)
0x3005	12293	Attribute is write-protected at this time
0x4001	16385	No units

Engineering/Diagnostic Interfaces

Error code		Explanation
Hexadecimal	Decimal	
0x4002	16386	Unit transmission too short
0x4003	16387	Unit transmission too long
0x4004	16388	Unit cannot be changed (read only)
0x4005	16389	Unit is write-protected at this time
0x5001	20481	No minimum input value
0x5002	20482	Minimum input value transmission too short
0x5003	20483	Minimum input value transmission too long
0x5004	20484	Minimum input value cannot be changed (read only)
0x5005	20485	Minimum input value is write-protected at this time
0x6001	24577	No maximum input value
0x6002	24578	Maximum input value transmission too short
0x6003	24579	Maximum input value transmission too long
0x6004	24580	Maximum input value cannot be changed (read only)
0x6005	24581	Maximum input value is write-protected at this time
0x7002	28674	Operation data transmission too short
0x7003	28675	Operation data transmission too long
0x7004	28676	Operation data cannot be changed (read only)
0x7005	28677	Operation data is write-protected at this time (reason: communication phase or mode)
0x7006	28678	Operation data is smaller than the minimum input value
0x7007	28679	Operation data is greater than the maximum input value
0x7008	28680	Invalid operation data (e.g. IDN not supported, invalid bit number, invalid bit combination, invalid list length)
0x7009	28681	Operation data write protected by a password
0x700A	28682	Operation data is write protected, it is configured cyclically (IDN is configured in the MDT or AT. Therefore writing via the service channel is not allowed).
0x700B	28683	Invalid indirect addressing (e.g., data container, list handling)
0x700C	28684	Operation data is write protected, due to other settings (e.g., parameter, operation mode, drive enable, drive on etc.)
0x7010	28688	Procedure command already active
0x7011	28689	Procedure command not interruptible
0x7012	28690	Procedure command at this time not executable (e.g., in this phase the procedure command cannot be activated)
0x7013	28691	Procedure command not executable (invalid or false parameters)

Fig.11-5: SERCOS Error Codes

## 11.2 TCP/IP Communication

### 11.2.1 Brief Description



The section "TCP/IP Communication" describes all information required for standard Ethernet communication. Apart from TCP/IP communication, communication via UDP/IP is possible, too.

To avoid confusion with the master communication "Ethernet/IP interface" the description "Ethernet communication" is not used in this connection.

It is possible to communicate with an IndraDrive controller via standard Ethernet telegrams. These Ethernet telegrams contain TCP/IP or UDP/IP telegrams for application-side connection. For communication with the device, the CSMA/CD access method is applied. As connection options, a variety of interfaces are available, such as the Engineering Port of the control section CSH01.2 or a free port of a SERCOS III interface (master or slave).

For SERCOS III, in addition to the time-controlled transmission of SERCOS-type Ethernet telegrams (MDT and AT), an NRT channel (NonRealTime or IP channel) exists, for which telegrams are sent in a specially reserved time slot.

Therefore, for SERCOS III, another option for asynchronous data transmission is available in addition to the existing service channel, that is very well suitable for large amounts of data due to the maximum lengths of useful data of approx. 1500 bytes.

#### Possible Applications

With the utilization of the Ethernet communication in the drive, different application options are available, which are summarized in the following table.

Connection	Server application	Possible client applications
SIS protocol	Parameterization via SIS-based parameter services, integrated in TCP	Addressed client-sidedly via SCP in IndraWorks
Com-Server	Access to parameters and PLC variables for HMI connection	VCP / VEP
3S-TCP	Programming/debugging/boot program download for IL run-time	1. IL programming environment 2. See 3S Gateway for OPC Server
3S-UDP	Cyclic exchange of network variables between Codesys-based controls	
FTP server	FTP server for uploading (writing to target device) and downloading (reading from target device) of files of the MMC	FTP client program on the master computer, engineering PC, ...

Fig. 11-6: Overview of the Possible Applications

#### Pertinent Parameters

- S-0-1019, Master comm. engineering over IP: MAC address
- S-0-1020, Master comm. engineering over IP: IP address
- S-0-1021, Master comm. engineering over IP: Network mask
- S-0-1022, Master comm. engineering over IP: Gateway address
- P-0-1044, Master comm. engineering over IP: Status IP communication
- P-0-1534, C6100 Command Activate IP settings
- P-0-1530, Engineering: MAC address
- P-0-1531, Engineering: IP address
- P-0-1532, Engineering: Network mask
- P-0-1533, Engineering: Gateway address

Engineering/Diagnostic Interfaces

- P-0-1544, Engineering: Status IP communication
  - P-0-1640, CCD: MAC address
  - P-0-1641, CCD: IP address
  - P-0-1642, CCD: network mask
  - P-0-1643, CCD: gateway address
  - P-0-1644, CCD: status IP communication
- Pertinent Diagnostic Messages**
- C6101 Incorrect IP settings
  - F2190 Incorrect Ethernet configuration

## 11.2.2 Functional Description

### Basic Information on the Function

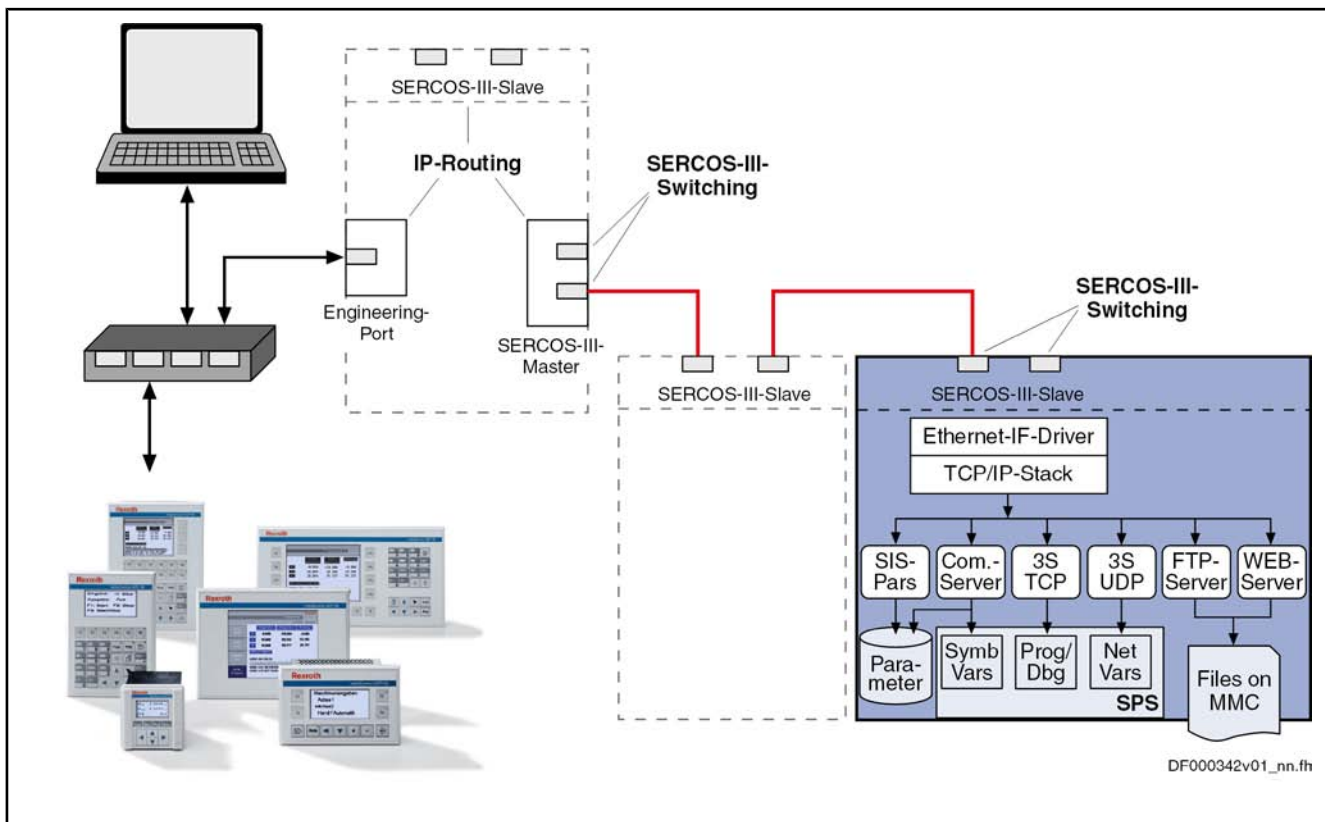


Fig. 11-7: Overview of TCP/IP Communication

#### Components for TCP/IP Communication

In one drive a maximum of up to three components can be available (see Device Class C\*), via which TCP/IP communication is possible. These components are:

- Industrial Ethernet slave interface
- SERCOS III master interface
- Ethernet engineering interface (at controller CSH01.2/CSH01.3)

These three components are devices that are not dependent on each other with regard to TCP/IP communication (comparable to network card in a PC). Therefore, from a network point of view, for each device an IP address containing various IP subnetworks must be set.



If the same IP subnetworks are used for the devices, they must be connected to each other.



**Configuration** For IP communication, for each device the minimal IP address and network mask must be set.

In addition, in every device a gateway address can be set which is generally used as default gateway for the device.



In every device only one default gateway is possible. If a gateway is indicated in several devices, for the default gateway the following order for the settings within the device is utilized:

1. Industrial Ethernet slave
2. SERCOS III master
3. Ethernet engineering

The respective settings in the other devices remain without significance.

The settings of the above mentioned information is carried out in the drive by means of the respective parameters. In this, an independent set of parameters is available for every device.

Interface	IP address	Network mask	Gateway address
Industrial Ethernet slave	S-0-1020	S-0-1021	S-0-1022
SERCOS III master	P-0-1641	P-0-1642	P-0-1643
Ethernet engineering	P-0-1531	P-0-1532	P-0-1533

Fig. 11-8: Parameters for Setting Addresses and Network Masks

Changes become effective through restart or activation of a drive command.

**Structure of the IP Address**

The IP address of a communication node always comprises of a network address (network ID) and a host address (host ID).

In accordance with the SERCOS-III definitions, in one ring not more than 250 nodes can be available. Therefore, the supported subnetworks are defined as class C networks (network mask 255.255.255.0) for IP communication. The network ID corresponds to the first three bytes of the IP Address. The host ID is the fourth byte of the IP address.

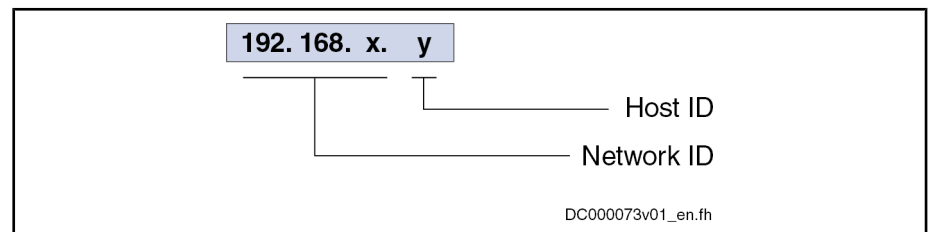


Fig. 11-9: Structure of the IP Address

A "private" area should always be utilized for the IP address range for communication in the IP channel of SERCOS III. The defined areas of the following networks are available

- Class A networks (10.x.x.x),
- Class B networks (172.16.x.x) or
- Class C networks (192.168.x.x).

It is recommended to utilize the private class C networks (192.168.x.x) for the IP address area or as default setting.

Engineering/Diagnostic Interfaces

Interface	IP address	Network mask	Gateway address
Industrial Ethernet slave	192.168.0.0	255.255.255.0	192.168.0.254 <sup>1)</sup>
SERCOS III master	0.0.0.0	255.255.255.0	0.0.0.0
Ethernet engineering	0.0.0.0	255.255.255.0	0.0.0.0

1) Automatically allocated; stored value corresponds to 0.0.0.0  
 Fig. 11-10: Default Values of the IP Address Setting

However, the values set in the parameters are not necessarily reset to the above mentioned values during loading of the basic parameters.

Through an adequate selection for the loading of the default values, instead the setting for Ethernet engineering or even for the entire settings can be maintained. If the "Index for load defaults procedure" is set with the option "Except Serial Communication", the settings for the engineering port will be preserved. If the communication parameters are completely excepted from the load defaults procedure, all parameter values for IP communication will also be preserved.

Automatic Settings



The settings of the IP information indicated in the parameters and utilized for communication can be different.

By means of the command "C1600 Command activate IP settings", IP settings made can be activated. Changes in a gateway are activated by switching off and on.

Default Gateway Address

Automatic setting of the default gateway address will only be executed if no gateway address for any device has been set manually.

The compilation of the gateway IP address is carried out with the network ID of the device and the maximal possible host ID (in a class C network this corresponds to "254"). For the setting, the respective device is utilized in the order described above.

IP Address of the SERCOS III Slave

Automatic setting of the IP address of a SERCOS III slave is only carried out if no or only limited manual settings have been carried out and if the network mask has been set for a class C network.

The IP address consists of:

- Network ID → Utilization 192.168.0 (network mask 255.255.255.0)
- Host ID → Master communication address

IP Address of the SERCOS III Master

Automatic setting of the SERCOS III master IP address is only possible to a limited extent.

In this case, the network ID has to be set manually.

If the host ID is not set manually, in a class C network the value will automatically be set to "254"

IP Address of the Engineering Port

Automatic setting of the IP address of the Engineering Port is impossible.

IP Port List

The following table contains an overview of the IP ports used in the drive and their configurability.

Communication	Port	Protocol	Configuration of port possible?
IndraWorks drive parameterization	5002	TCP	No
IndraLogic MLD programming system <sup>1)</sup>	1200	TCP	No
Network variables MLD (IndraLogic) <sup>1)</sup>	1202	UDP	Yes
ComServer	6042	TCP	No
ComServer UDPS	6040	UDP	No
WebServer <sup>2) 3)</sup>	80	TCP	No
Ethernet IP	44.818	TCP/UDP	No
Ethernet IP	2222	UDP	No
FTP <sup>3)</sup>	20 and 21	TCP	No
FTP - additional ports, dynamic <sup>3)</sup>	1023 et seq.	TCP	Yes
Recommended ports for individual programming in MLD <sup>1)</sup>	49.152 to 65.535		
Global port list "well known ports"	<a href="http://www.iana.org/assignments/port-numbers">http://www.iana.org/assignments/port-numbers</a>		

1) Only with activated MLD

2) Only in conjunction with firmware MPC

3) Only with MMC plugged

*Fig. 11-11: IP Port List*

## SERCOS Networks

For the setting of the IP configuration, in the determinations below it is presupposed that the individual SERCOS III rings are set as IP networks of class C. For utilization of another network class, the respective settings must be carried out.

### Simple SERCOS Ring

With a simple SERCOS III ring an automatic IP setting is possible for the SERCOS III interfaces (on utilization of the IP network 192.168.0.x). However, the existing engineering ports must be set manually.

Engineering/Diagnostic Interfaces

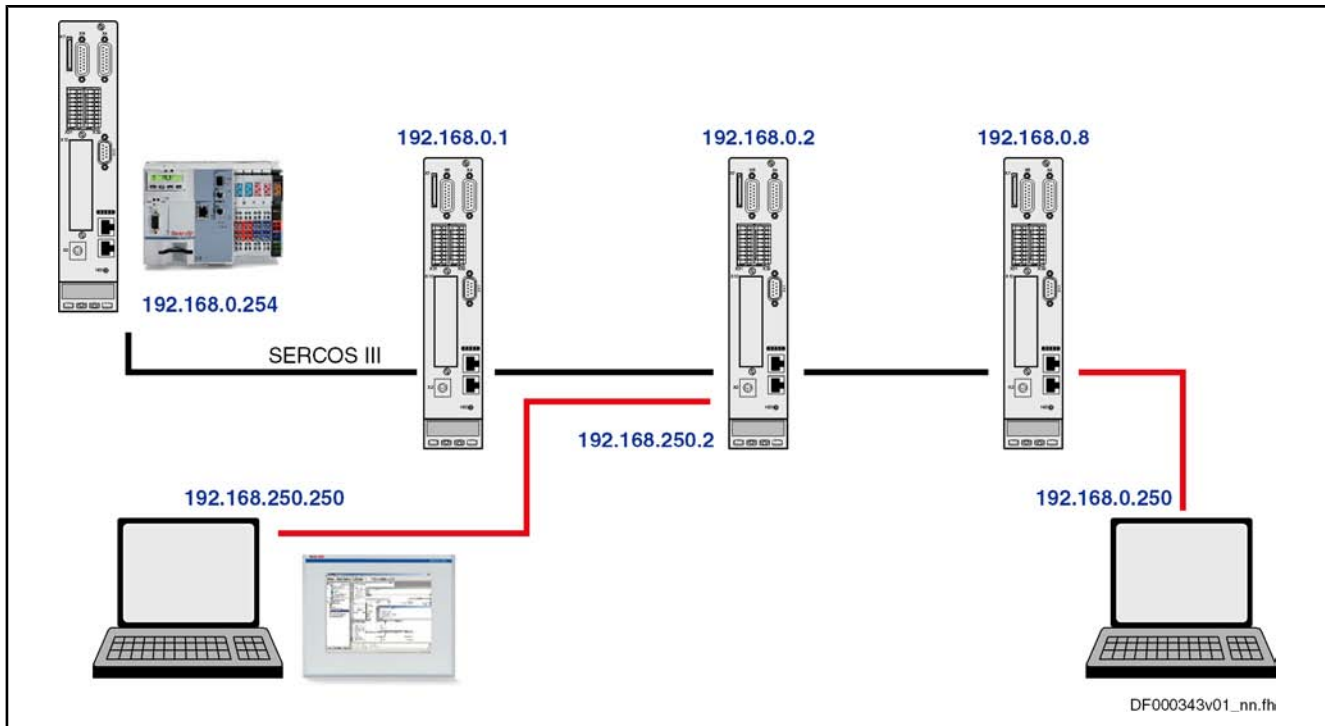


Fig.11-12: Example for a Simple SERCOS III Ring

Order of configuration of the SERCOS network:

1. Set network ID in every node
2. Host ID of master is "254"
3. Set default gateway to the address of the master in every slave

For the configuration of an engineering port an own subnetwork must be set manually.

The following must be taken into consideration for the configuration of external communication nodes (SERCOS line).

- Utilize free IP addresses from the IP network
- Set host ID to a value between "250" and "253"

**Control Ring with Subcarrier Rings**

For a control ring with subcarrier SERCOS III rings, an unambiguous network ID must be set manually in all rings (every node). For the network ID in the control ring, "192.168.254" is recommended.

The master of a subcarrier ring contains the network ID 192.168.<FKM> (<FKM> corresponds to the address of the master communication in the control ring). The host ID is allocated "254".

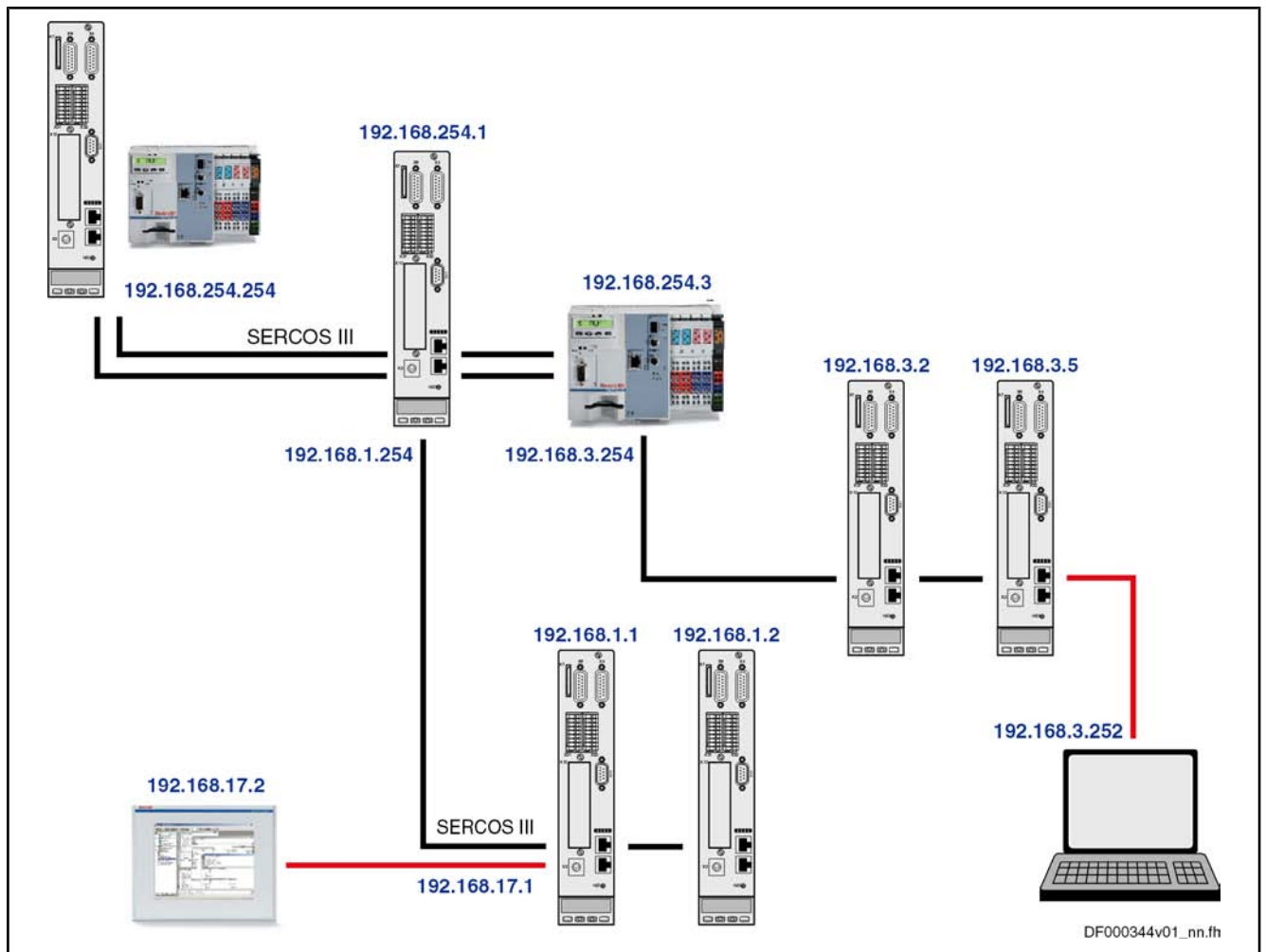


Fig.11-13: Examples for a Control Ring With Subcarrier Rings

In such a network, the following conditions and recommendations are effective:

- Network ID in the subcarrier ring corresponds to that of the respective master
- Host ID → Master communication address
- Set default gateway to the address of the master in every slave
- Definitions for the engineering port (external nodes) as for simple SERCOS ring

**"Golden Unit" Network**

The setting of such a network must be executed manually, in the same way as for the previous SERCOS network.

For a SERCOS master outside of the control ring, the master communication address in the network ID cannot always be used.

Engineering/Diagnostic Interfaces

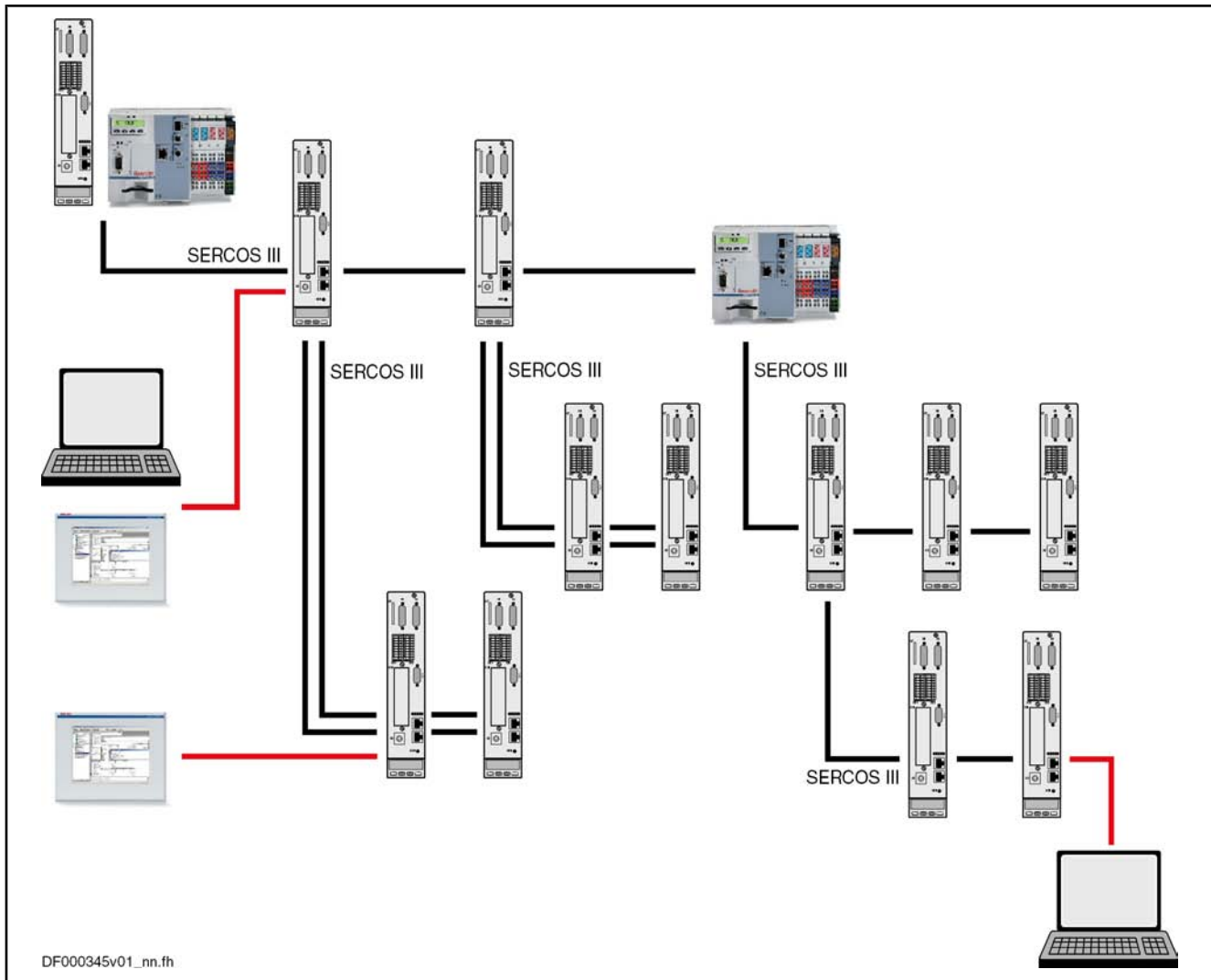


Fig.11-14: Example of a "Golden Unit" Network

## 11.3 SIS Ethernet Parameter Channel

### 11.3.1 Parameter Structure

All parameters of the drive controller are stored in a uniform parameter structure. Each parameter consists of 7 elements. The table below describes the individual elements and the possibilities of access. The following sections will also refer to the parameter structure below.

Element No.	Data block element	Possibility of access
1	IDN	Read
2	Name	Read
3	Attribute	Read
4	Unit	Read
5	Min. input value	Read

Element No.	Data block element	Possibility of access
6	Max. input value	Read
7	Operating data	Read / write

Fig. 11-15: Parameter Structure

## 11.3.2 Telegram Structure, Telegram Scope

### Basic Telegram Structure

In principle, a SIS telegram is divided into 3 blocks:

- Telegram header
- Useful data header
- Useful data

Telegram header	Useful data header	Useful data
-----------------	--------------------	-------------

Fig. 11-16: Structure of an SIS Telegram

### Structure of the Telegram Header

The SIS telegram header consists of a static and a dynamic part.

#### Static Part of the Telegram Header

The static part of the telegram header comprises of 8 bytes and is contained in every SIS telegram.

Byte	Name	Description of the bytes in the static part of the telegram header
1	<b>StZ</b>	Start character: STX (0x02)
2	<b>CS</b>	Checksum byte → The checksum is generated in three steps: <ol style="list-style-type: none"> <li>1. Clearing the "CS" byte</li> <li>2. All characters in the telegram are added byte by byte</li> <li>3. Saving the negated sum in the "CS" byte</li> </ol> The result if the byte-by-byte addition of all characters in an SIS telegram will always have the value zero!
3	<b>DatL</b>	Data length → The "DatL" byte contains the length of a telegram without the static telegram header. <b>The total length of an SIS telegram is limited to 255 bytes.</b> Therefore, only a maximum of 247 bytes of useful data can be transmitted.
4	<b>DatLW</b>	Data length repetition

Engineering/Diagnostic Interfaces

Byte	Name	Description of the bytes in the static part of the telegram header
5	<b>Ctrl</b>	Control byte (Control) → In the control byte, the telegram type and the structure of the dynamic telegram header are declared: <ul style="list-style-type: none"> <li>• Bit 0...2 → Not used by the drive in the static part</li> <li>• Bit 3 → Specifying whether dynamic telegram header contains "PaketN" (package number) byte Bit 3 = 0 → Without package number Bit 3 = 1 → With package number</li> <li>• Bit 4 → Determining the telegram type Bit 4 = 0 → Command telegram Bit 4 = 1 → Reaction telegram</li> <li>• Bit 5 → Not used by the drive in command telegrams; in reaction telegrams, system status change is signaled</li> <li>• Bit 6 → Not used in command telegrams; in reaction telegrams, bit 6 signals a system warning in the slave</li> <li>• Bit 7 → Not used in command telegrams; in reaction telegrams, bit 7 signals a system error in the slave</li> </ul>
6	<b>Service</b>	SIS service → The byte specifies the SIS service of the telegrams. Subservices are defined in some SIS services. In these cases the subservice is specified in the useful data header of the service. The useful data of the command and reaction telegrams can be defined in a different way for every SIS service and its subservice.
7	<b>AdrS</b>	Address of the transmitter: <ul style="list-style-type: none"> <li>• In command telegrams → Address of the master, valid from 0 to 126</li> <li>• In reaction telegrams → Address of the slave</li> </ul>
8	<b>AdrE</b>	Address of the receiver: <ul style="list-style-type: none"> <li>• In command telegrams → Address of the slave, valid from 0 to 126 Address 128 → Special address for a "point-to-point" connection; each slave reacts to the special address independent of its station number Address 254 → Collective message to all slaves in the direct hierarchical level Address 255 → Collective message to all slaves in the SIS network below the master Slaves do not respond to collective messages!</li> <li>• In reaction telegrams → Address of the master</li> </ul>

Fig. 11-17: SIS Telegram Header, Static Part

**Dynamic Part of the Telegram Header**

The dynamic part of the telegram header can contain up to 8 bytes. The telegram number ("PaketN" byte), when it was declared in the control byte ("Ctrl" byte in the static part), is always in the last place in the dynamic part of the telegram header. If not all subaddresses are required, they are not available in the telegram. When a command telegram is transmitted from one hierarchical level to the hierarchical level below it, the subaddress block is reduced by one address. On the way back, one address is added to the subaddress block in the reaction telegram.

Byte	Name	Description of the bytes in the dynamic part of the telegram header
9	<b>AdrES1</b>	Slave address in the 1st sublevel
10	<b>AdrES2</b>	Slave address in the 2nd sublevel
11	<b>AdrES3</b>	Slave address in the 3rd sublevel



Byte	Name	Description of the bytes in the dynamic part of the telegram header
12	<b>AdrES4</b>	Slave address in the 4th sublevel
13	<b>AdrES5</b>	Slave address in the 5th sublevel
14	<b>AdrES6</b>	Slave address in the 6th sublevel
15	<b>AdrES7</b>	Slave address in the 7th sublevel
16	<b>PaketN</b>	<p>Package number (when bit 3 was set in "Ctrl" byte):</p> <ul style="list-style-type: none"> <li>At the first request with a package number &lt;&gt;0 the request is processed. The reaction telegram is stored and transmitted by the slave.</li> <li>When the request is repeated (with the same package number), it is not processed. The slave transmits the stored reaction telegram.</li> <li>When there is another request with a new package number &lt;&gt;0 or when there is a changed request (static telegram header), the request is processed. The stored reaction telegram is overwritten with the new reaction telegram and the new reaction telegram is transmitted by the slave.</li> <li>When there is a request with package number = 0, it is always processed. The reaction telegram is transmitted by the slave but not stored. Reaction telegrams that still are stored are cleared (re-initialization)!</li> <li>When there is a request without package number, it is always processed. The reaction telegram is transmitted by the slave but not stored. Reaction telegrams that are still stored are maintained!</li> </ul> <p>Only with the package monitor is it possible to repeat individual sequential telegrams that were incorrectly transmitted, without canceling the running sequential telegram cycle!</p>

Fig. 11-18: SIS Telegram Header, Dynamic Part

## Structure of the Useful Data Header

### General Information on the Useful Data Header



The structure of the useful data header depends on the direction of transmission. The useful data headers described below are only valid for the services 0x80 ... 0x8F.

In the structure of the useful data header we distinguish between command telegram and reaction telegram.

### Command Telegram

The command telegram is the telegram the master (drive) transmits to the slave (master → slave).

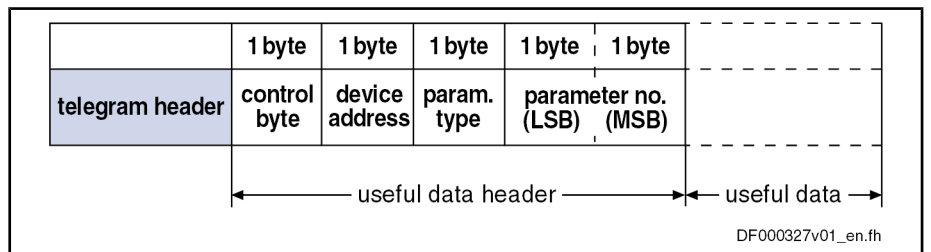


Fig. 11-19: Structure of the Useful Data Header in the Command Telegram

### Significance of the Useful Data Header

#### Control Byte

In the command telegram the useful data header describes the kind of request.

The control byte indicates the parameter element (data, name, ...) that is to be read or written. In addition, the control byte indicates whether other telegrams (sequential telegrams) are required for reading or writing.

Engineering/Diagnostic Interfaces

**Device Address** The device address that has been set at the address switches has to be entered in the "Device Address" block.

**Parameter Type and Number** The parameter number has the format defined in the specification for the SERCOS interface. In order to be able to address the control parameters, a byte for characterizing the parameter type precedes the address.

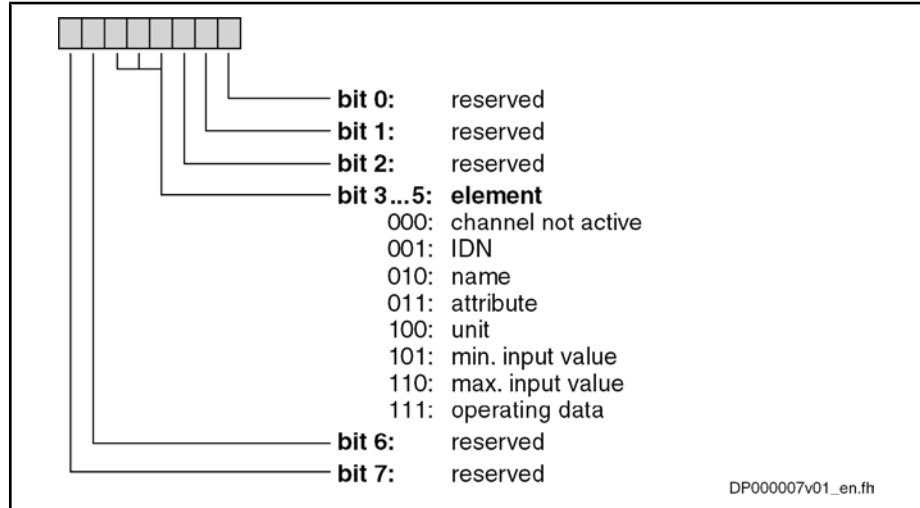


Fig. 11-20: Structure of the Control Byte

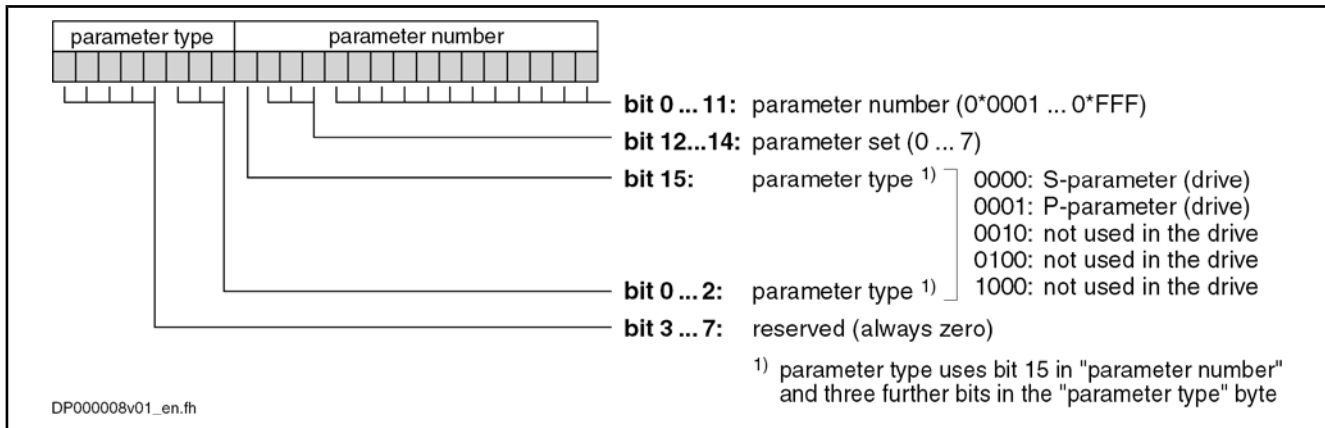


Fig. 11-21: Parameter Type and Number in the Useful Data Header

**Reaction Telegram**

The reaction telegram is the telegram the slave (drive) transmits to the master (slave → master).

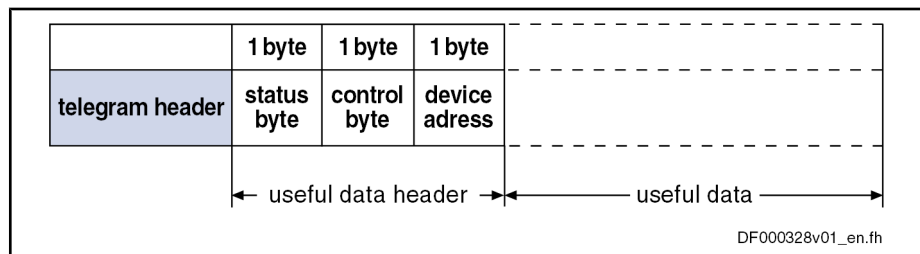


Fig. 11-22: Structure of the Useful Data Header in the Reaction Telegram

**Status Byte** In the status byte an error code is returned, if necessary. In the case of an error-free transmission, 0x00 is returned in the status byte.

**Control Byte** The control byte contains the information regarding which data block element of a parameter is accessed. Bit 2 controls the transmission of the sequential telegrams (writing lists in several steps).

**Device Address** The device address set in parameter "P-0-4022, Drive address of serial interface" has to be entered in the "Device Address" block.

**Structure of the Useful Data Field** In the useful data bytes it is possible to enter any value that is interpreted in a different way according to service. For flash programming, for example, binary characters are entered in the useful data and when writing a parameter the decimal numeric value is entered.

The number of bytes in the useful data field and of the useful data header are entered in the "DatL" and "DatLW" bytes.

**Status Messages**

Status byte	Description	Kind of error
0x00	Error-free transmission	Without error
0x01	During the execution of the requested service an error occurred. The <b>service-specific error code</b> is contained in the useful data of the reaction telegram.	Execution error
0xF0	The requested service is not supported by the addressed slave.	Telegram error
0xF8	In the sequential telegram, data in the useful data header, the transmitter address or the service have changed.	Telegram error
0xF9	The command telegram contains subaddresses. The routing of telegrams is not supported by the slave.	Telegram error
0xFA	Useful data are missing in the command telegram. The telegram cannot be executed.	Telegram error
0xFB	The requested subservice is not supported by the addressed slave.	Telegram error
0xFC	The requested component is not available in the addressed slave. The component address is invalid.	Telegram error

Fig.11-23: List of the Defined Telegram States

**Error Codes**

Error code	Service	Description
0x0700	0x03	Baud rate not supported
0x0800	0x03	Baud rate not supported
0x800C	0x80,0x81, 0x8E,0x8F	Access to parameter denied; the parameter is occupied by the sequential telegram channel.
0x9002	0x02	Firmware was deleted
0x9004	0x02	Shutdown not allowed in phase 4 (in FWA-MTx01VRS instead of 0x9010).
0x9010	0x02	Shutdown not allowed in operating mode (as of FWA-MPx02VRS)
0x9102	0x02	Firmware was deleted

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Error code	Service	Description
0x9104	0x02	Reboot not allowed in phase 4 (in FWA-MTx01VRS instead of 0x9110)
0x9110	0x02	Reboot not allowed in operating mode (as of FWA-MPx02VRS)
0x9200	0x02	Error when reading
0x920Bh	0x02	The requested data volume exceeds the maximum useful data volume in the reaction telegram.
0x9400	0x02	Timeout during deleting procedure
0x940A	0x02	Deleting only possible in loader
0x96E0	0x02	Verify error when programming the flash
0x96E1	0x02	Timeout when programming the flash
0x96FF	0x02	Error when writing to the flash
0x9701	0x02	Additional checksum incorrect
0x9702	0x02	CRC32 checksum incorrect
0xA001	0x02	Error when reading table
0xA002	0x02	Incorrect table type
0xA003	0x02	No backup medium available
0xA201	0x02	Error when reading the Hex header
0xA202	0x02	Incorrect header number
0xA501	0x02	Error when writing
0xA502	0x02	Creating the file is not allowed
0xA503	0x02	Not enough memory space
0xA601	0x02	Error when writing
0xA602	0x02	Access to file not allowed

Fig. 11-24: List of the Defined Error Codes

### 11.3.3 Communication via SIS Protocol

#### Addressing a Drive

In the case of communication with SIS protocols we distinguish between command telegrams and reaction telegrams, according to the direction of transmission. A node can only be addressed under its address (see Program Module) when a specific telegram format (frame) is observed.

##### Read Access

When the reading of a parameter is started in a command telegram, a check is run in the drive to determine whether a sequential telegram is required. In this case, bit 2 (current/last transmission) is kept at "0" in the control byte of the reaction telegram until the last reaction telegram is transmitted. In the last reaction telegram, bit 2 is set to "1".

The transmission of a sequential reaction telegram is activated by the repeated transmission of the unchanged command telegram.

##### Sequential Telegram Access

When the writing or reading of a parameter with sequential telegrams was started in the drive, it is necessary to complete or cancel this process before another service with sequential telegrams can be started. If another service was started

nevertheless, the "0x800C unauthorized access" error code is transmitted in the reaction telegram. The service with sequential telegram started before can then be normally processed or cancelled with the next command telegram.

## Supported Services and Subservices

SIS service	Description	Subservices	Subservices description	Notes
0x00	Node identification	0x01	Reading SIS version	Subservice is implemented but not active
		0x02	Reading firmware version	Supplies content of S-0-0030
		0x03	Reading controller type	Supplies content of S-0-0140
		0x04	Reading supported baud rates	9600 baud, 19200 baud, 38400 baud, 57600 baud, 115200 baud
0x01	Data transmission canceled	None		
0x02	Flash operations	0x90	Shutdown	Switches drive firmware to the loading mode
		0x91	Reboot	Causes restart
		0x92	Read flash	Reads content of the flash
		0x93	Find header	Supplies header address of the first IBF module
		0x94	Erase flash	Deletes content of the flash
		0x96	Program flash	Programs content of the flash
		0x97	Build checksum	Supplies CRC32 checksum of the indicated IBF module
		0x9F	Error reset in the slave	Clears error in loading mode
		0xA0	Read configuration	Supplies configuration table
		0xA2	Read header	Reads header of the corresponding module
		0xA5	Write file information	Generates corresponding file
		0xA6	Write file data	Writes content to the opened file
0x03	Initialization of the SIS communication	0x01	Determining TrS	Initializes max. reaction time in the slave
		0x02	Determining TzA	Initializes max. character interval on the bus
		0x03	Determining Tmas	Subservice is implemented but not active
		0x07	Determining the baud rate	Initializes the baud rate of the serial transmission
		0x08	Time-controlled baud rate test	Allows temporary change of the baud rate
		0xFF	Accepting the determined values	Activates the values initialized with the subservices 0x01, 0x02 and 0x07
0x10	Reading parameter	None		0x10 = 0x80
0x11	Reading list segment	None		Segment information in byte
0x1E	Writing list segment	None		Segment information in byte
0x1F	Writing parameter	None		0x1F = 0x8F
0x80	Reading parameter	None		0x80 = 0x10

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SIS service	Description	Subservices	Subservices description	Notes
0x81	Reading list segment	None		Segment information in word
0x8E	Writing list segment	None		Segment information in word
0x8F	Writing parameter	None		0x8F = 0x1F

Fig.11-25: Supported Services and Subservices

### Service 0x01: Canceling a Data Transmission

With this service it is possible to cancel a sequential telegram sequence. The sequential telegram channel is unlocked with the "Canceling a data transmission" service when the device address and the service to be cancelled correspond with the sequential telegram sequence. When the command telegram is transmitted without the device address and without service to be cancelled, this service is always executed.

**Command Telegram**

- Enter 0x01 in the service of the telegram header.
- Enter the service to be cancelled in the useful data.

**Reaction Telegram**

If there isn't any error, the reaction telegram has the following structure:



Fig.11-26: Structure of the Reaction Telegram

In the case of an error, the useful data that contain the error code are transmitted. The useful data header corresponds to the SIS specification.



Fig.11-27: Structure of the Reaction Telegram in the Case of Error



When there wasn't any sequential telegram processed and this service was transmitted nevertheless, there isn't any error reaction telegram transmitted!

### Service 0x80: Reading a Parameter

**Command Telegram**

A one-time read access is completed with one transmission step. The master enters the following information in the command telegram:

- In the control byte the desired element is selected in the bits 3 ... 5 ("element"). Bit 2 is set to "1" (last transmission).
- The device address is entered.
- Parameter type and number are entered.
- There aren't any useful data entered.

**Reaction Telegram**

The answer to a read access contains the following data:

- In the Ctrl byte of the telegram header bit 4 is set to "1" in order to identify it as a reaction telegram.
- The status byte of the useful data header contains the information whether an error occurred during the processing of the command telegram.
- The control byte is read from the command telegram and copied to the reaction telegram.
- The device address is read from the command telegram and copied to the reaction telegram.
- The requested data is written to the useful data.

**Example** The following example illustrates reading the "S-0-0044, Velocity data scaling type" parameter from the drive with the address "03". The parameter has the value "0x0042".

**Command Telegram:**

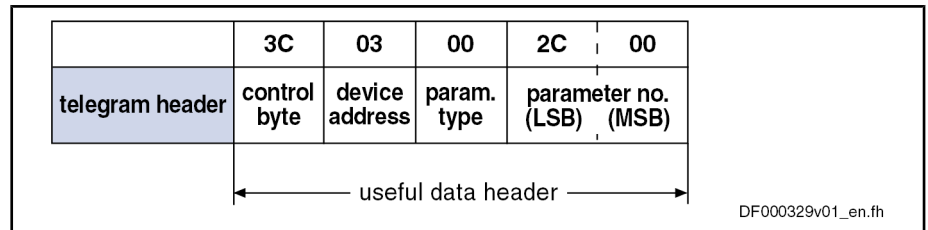


Fig. 11-28: Reading the S-0-0044 Parameter (Command Telegram)

**Reaction Telegram:**

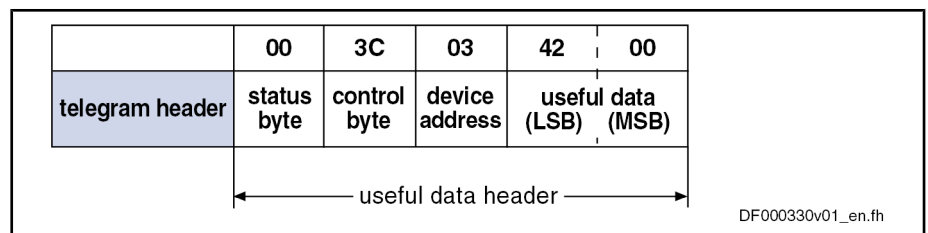


Fig. 11-29: Reading the S-0-0044 Parameter (Reaction Telegram)

## Service 0x8F: Writing a Parameter



By means of this service, all available commands can be started in the drive.

**Command Telegram** A one-time write access is completed with one transmission step. The master enters the following information in the command telegram:

- Enter "0x8F" in the service of the telegram header.
- Enter the parameter to be written in the "parameter type" and "parameter number" bytes of the useful data header.
- Enter the value to be written in the useful data.
- The device address is entered.
- In the control byte the operating data is selected in the bits 3 ... 5 ("element"). Bit 2 is set to "1" (last transmission).
- The IDN of the parameter to be written is written to the parameter number.
- The value of the operating data is written to the useful data.

**Reaction Telegram** The answer to a write access contains the following data:

- In the Ctrl byte of the telegram header bit 4 is set to "1" in order to identify it as a reaction telegram.
- The status byte of the useful data header contains the information whether an error occurred during the processing of the command telegram.
- The control byte is read from the command telegram and copied to the reaction telegram.
- The device address is read from the command telegram and copied to the reaction telegram.
- There aren't any useful data entered.

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**Example** The following example illustrates the transmission of parameter "S-0-0044, Velocity data scaling type" to the drive with the address "03". The value "0x0042" is written to the parameter.

**Command Telegram:**

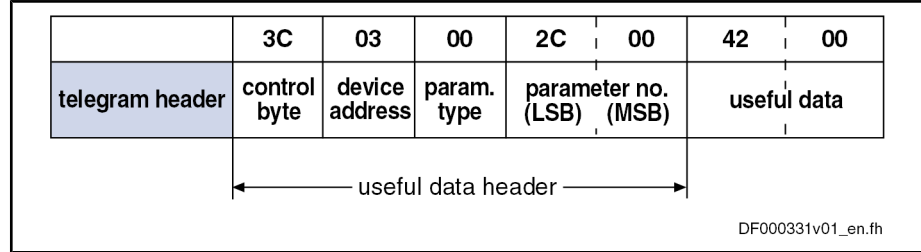


Fig. 11-30: Writing the S-0-0044 Parameter (Command Telegram)

**Reaction Telegram:**

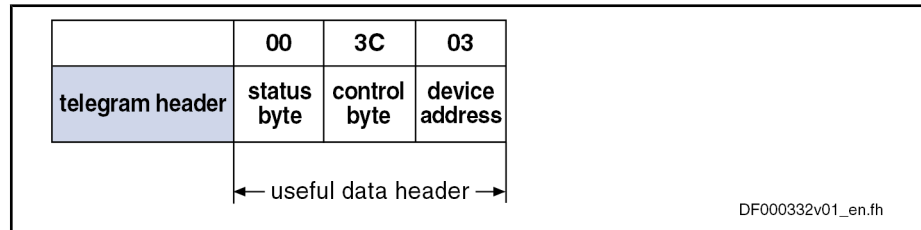


Fig. 11-31: Writing the S-0-0044 Parameter (Reaction Telegram)

**Starting a Command**

With the service 0x8F "Writing a parameter" all commands can be started in the drive via the SIS protocol.



Fig. 11-32: Structure of the Command Telegram

- Enter the value "0x8F" in the service of the telegram header.
- Enter the command to be activated in the "parameter type" and "parameter number" bytes of the useful data header.
- Enter the input of the command in the useful data byte.

**Service 0x81: Reading a List Segment**

**Command Telegram**

- Enter the value "0x81" in the service of the telegram header.
- Enter the parameter type and parameter number of the parameter to be read in the useful data header.
- Enter the offset in the useful data bytes 0 and 1 within the list as a word (= 16 bit).
- Enter the number of words to be read in the useful data bytes 2 and 3.

**Reaction Telegram**

- In the control byte of the reaction telegram the current/last transmission is marked with bit 2.



The output of a sequential telegram is activated by the repeated transmission of the unchanged command telegram.

**Service 0x8E: Writing a List Segment**

**Command Telegram**

- Enter the value "0x8E" in the service of the telegram header.
- Enter the parameter type and parameter number of the parameter to be read in the useful data header.



- Enter the offset in the useful data bytes 0 and 1 within the list as a word (= 16 bit).
  - Enter the number of words to be written in the useful data bytes 2 and 3.
- Reaction Telegram**
- A possible error is entered in the useful data in the reaction telegram.



With this service it is only possible to process list segments that are contained in the list currently available. If the actual list length is to be changed this list must specifically be written. Operation in the sequential telegram mode is not possible.

### 11.3.4 Examples of Application (Sequential Telegrams)

#### Service 0x8F: Write Access (With Sequential Telegrams)

Parameters of elements longer than 243 byte are read in several steps. The transmission of such lists is carried out in several steps. Bit 2 in the control byte marks the current transmission step as the current or last transmission.

The figures below illustrate the control word for a transmission in several steps.

1. Step

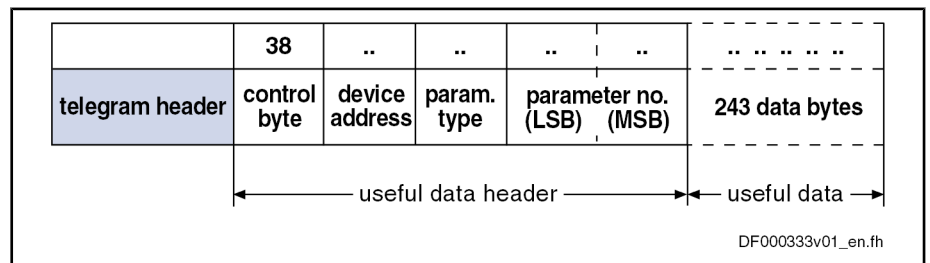


Fig. 11-33: Writing With Sequential Command Telegram (Step 1)

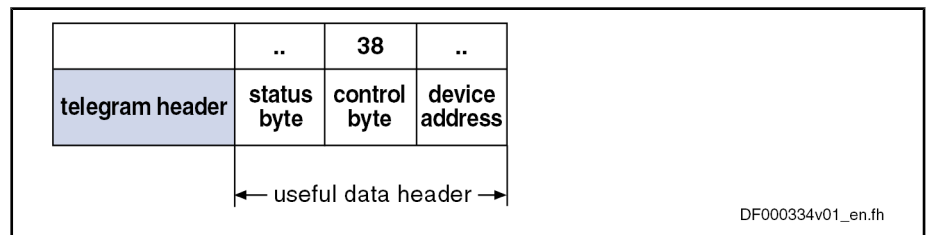


Fig. 11-34: Writing With Sequential Reaction Telegram (Step 1)

2. Step

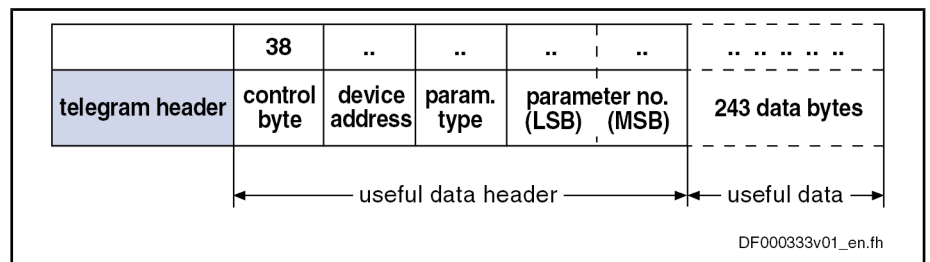


Fig. 11-35: Writing With Sequential Command Telegram (Step 2)

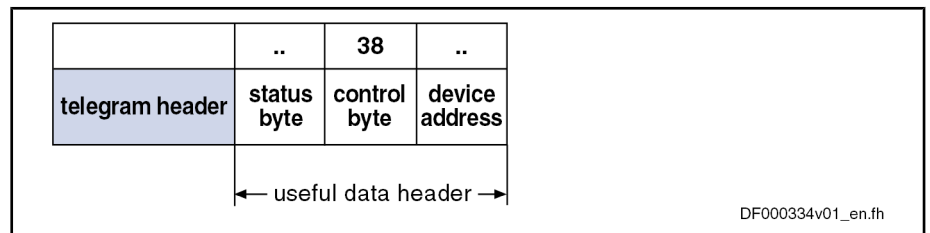


Fig. 11-36: Writing With Sequential Reaction Telegram (Step 2)

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3. Step

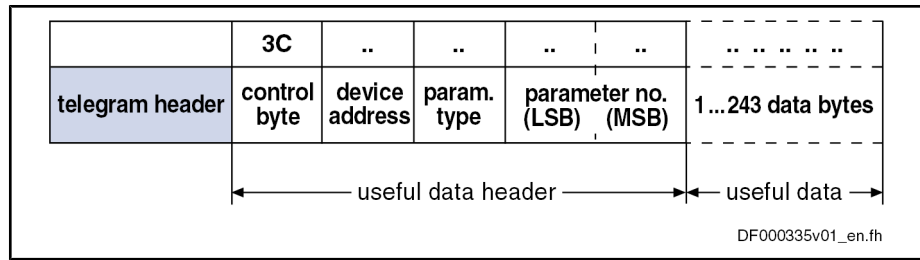


Fig. 11-37: Writing With Sequential Command Telegram (Step 3)

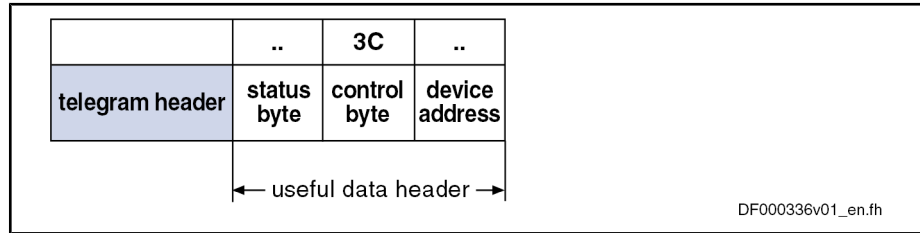


Fig. 11-38: Writing With Sequential Reaction Telegram (Step 3)

Service 0x80: Read Access (With Sequential Telegrams)

Parameters of elements whose length exceeds the maximum data field length of 245 byte are read in several steps. Bit 2 in the control byte of the reaction telegram marks the current transmission step as the current or last transmission.

The figures below illustrate the control word for a transmission in several steps.

1. Step

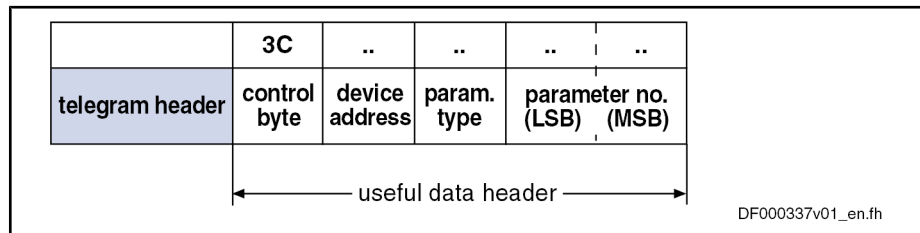


Fig. 11-39: Reading With Sequential Command Telegram (Step 1)

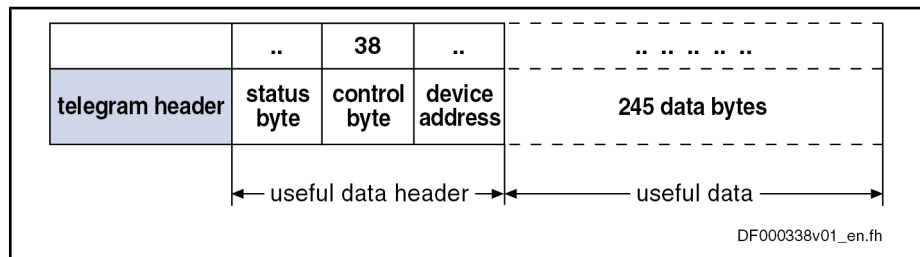


Fig. 11-40: Reading With Sequential Reaction Telegram (Step 1)

2. Step

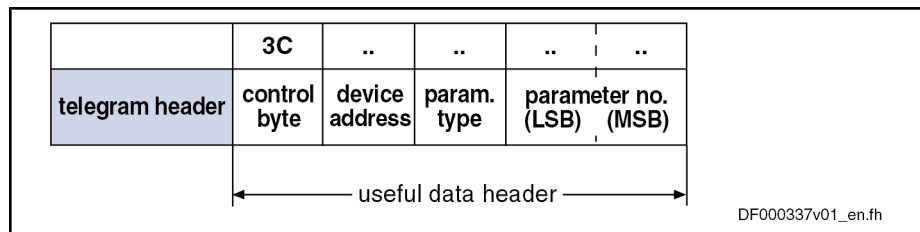


Fig. 11-41: Reading With Sequential Command Telegram (Step 2)

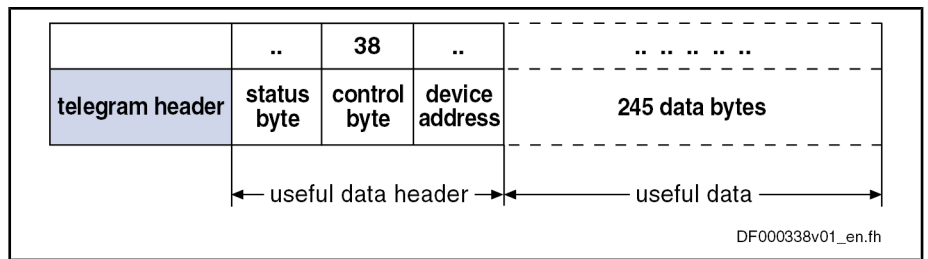


Fig. 11-42: Reading With Sequential Reaction Telegram (Step 2)

3. Step

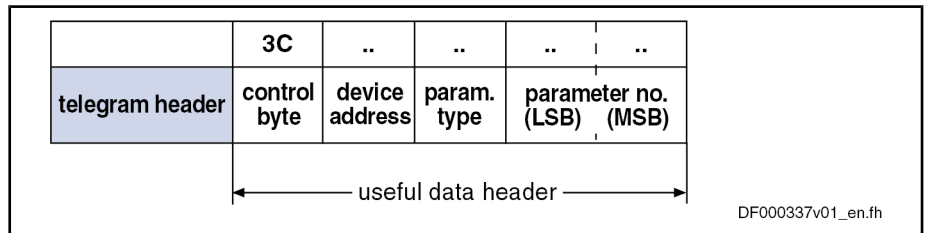


Fig. 11-43: Reading With Sequential Command Telegram (Step 3)

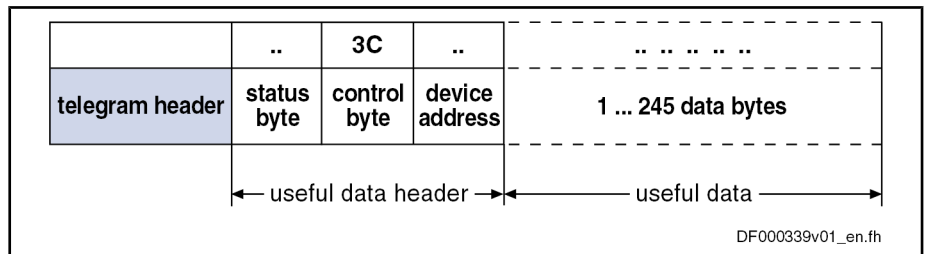


Fig. 11-44: Reading With Sequential Reaction Telegram (Step 3)

### 11.3.5 Error in the Case of SIS Communication

#### Error During Parameter Transmission

If an error occurs during the parameter transmission, an "error during parameter transmission" is signaled in the status byte.

The first two bytes of the useful data transmit an error code that describes the kind of error.

During the parameter transmission the following errors can occur:

Error code	Explanation
0x0000	No error
0x0001	Service channel not open
0x0009	Invalid access to element 0
0x8001	"Service channel currently occupied (BUSY)" → The desired access is currently impossible because the service channel is occupied.
0x8002	"Fault in service channel" → It is currently not possible to access the desired drive.
0x800B	"Transmission canceled (higher priority)"
0x800C	"Unauthorized access (service channel still active)" → A new request is started before the last transmission was completed.

Fig. 11-45: Error Messages in the Serial Protocol

## Execution and Protocol Acknowledgement

With each reaction telegram a status byte is transmitted. The status byte provides the result of a transmission in the form of a code number.

In general, the following applies:

Result of the transmission	Code number in the status byte
Transmission without error	0x00
Protocol error	0xF0 ... 0xFF
Execution error	0x01 ... 0xEF

Fig. 11-46: Definition of the Status Byte

Protocol error	Code number	Description of error
Invalid service	0xF0	The requested service is not specified or is not supported by the addressed node.

Fig. 11-47: Definition of the Protocol Error

Execution error	Code number	Description of error
Error during parameter transmission	0x01	When reading or writing a parameter an error occurred.

Fig. 11-48: Definition of the Execution Error

**Example** The following example illustrates a write access to the read-only parameter "S-0-0106, Current loop proportional gain 1".

The master tries to write the value "0" to the parameter. The drive acknowledges with the "0x7004" ("Data cannot be changed") error message.

**Command Telegram:**

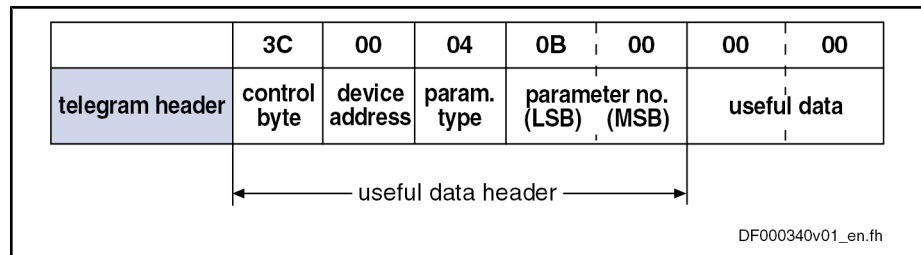


Fig. 11-49: Writing the S-0-0106 Parameter (Command Telegram)

**Reaction Telegram:**

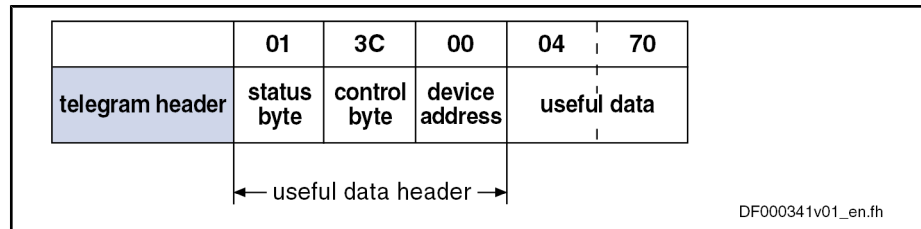


Fig. 11-50: Reading the S-0-0106 Parameter (Reaction Telegram)

## 11.4 File Handling by FTP via Ethernet

### 11.4.1 Brief Description



**Base package** of all firmware variants in **open-loop and closed-loop** characteristic

Via an integrated FTP server, IndraDrive devices with Ethernet communication can access the data of the MMC programming module by means of FTP connection. This allows reading or writing data/directories on the MMC.

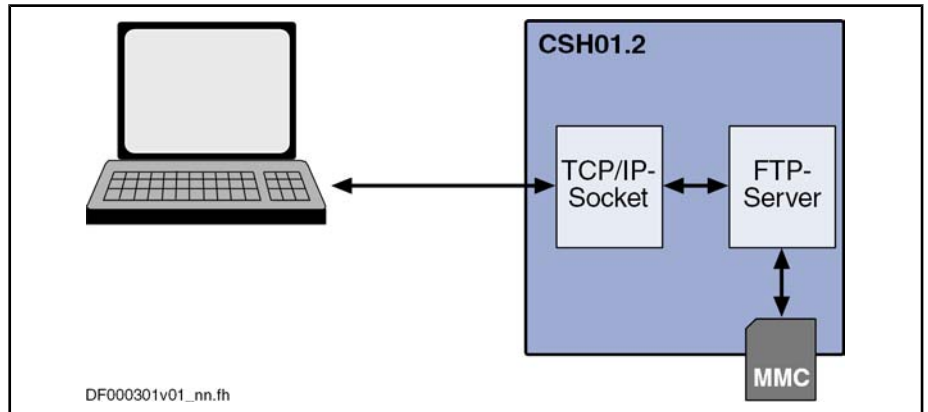


Fig. 11-51: Schematic Illustration of FTP File Handling

**Features** The FTP server of an IndraDrive device has the following features:

- Two kinds of login to the FTP server:
  - Anonymous login (read-only data access)
  - User login (read and write access to data)
- A maximum of 2 simultaneous connections
- Effective transmission rate depends on communication port used and processor load

The transmission rate at the Engineering Port of CSH01.2, for example, is approx. 20 kbyte/s for download (STOR command) and 50 kbyte/s for upload (RETR command). If both FTP connections are active at the same time, the transmission rate is distributed accordingly.

**Hardware Requirements** The following hardware requirements must have been fulfilled:

- Use a control section with Ethernet communication (e.g. CSH01.2C or CSH01.1C-S3)
- Plug MMC before booting

**Pertinent Parameters**

- S-0-1020, Master comm. engineering over IP: IP address
- P-0-4070, Parameter storage configuration

Additional for the utilization of a CSH01.2 control section:

- P-0-1531, Engineering: IP address
- P-0-1641, CCD: IP address

### 11.4.2 Functional Description

#### Connections

A maximum of 2 connections to the FTP server can be simultaneously established.

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- Establishing the Connection** After the drive has been booted, the FTP connection is not active yet. To establish the connection, log in to the FTP server using the correct IP address.
- Terminating the Connection** When there is no more data traffic, the drive automatically terminates the FTP connection after 5 min. If the connection is to be maintained, the FTP command "NOOP" can be cyclically sent.


**FTP Login**

Each time the connection is established, you have to log in to the FTP server. IndraDrive supports two kinds of login, standard login and anonymous login.

**Standard Login** For standard login to the FTP server, log in under the user name "boschrexroth" with the password "boschrexroth" (login according to Bosch Rexroth standard).

Upon successful standard login, you can access all files and directories of the MMC and carry out read access or write access.


---

 Only write access to the directory "/user/" and its subdirectories "/PLC/" and "documentation" is supported. Access to the system directories "Firmware" and "Parameters" is not allowed!

---

After each login, the FTP server opens the "USER" directory of the MMC. Only in this area, user data may be stored.

---

 If the MMC is operated as programming module (P-0-4070), you have read-only access to the drive parameter files in the "Parameters" folder.

---

```

A: .
+ --- Documentation
|
+ --- Firmware
|      FWA-INDRV_-MPH-05V02-D5.ibf
|
+ --- Parameters
|      Application_Type#1.pbf
|      Application_Type#2.pbf
|      Retain#1.rbf
|      Retain#2.rbf
|
+ --- Plc
|      SPS_Retain.pbf
|
\ --- User
    
```

DC000053v01\_en.fh

*Fig.11-52: Directory Structure of MMC via FTP Access (Example)*

**Anonymous Login** Anonymous login to the FTP server is possible, too. For this purpose, employ the user name "anonymous" and any e-mail address as a password (IndraDrive-specific login). With this kind of login, you have read-only access to all data and directories of the MMC.

After each login, the FTP server opens the "USER" directory of the MMC. This is the area in which the user data were stored.

**FTP Data Handling**

**File Date** Files created on MMC via FTP are created there as new files. The time from parameter "P-0-0197, System time" is used as the file date; the minimum date used as start value is "1980-01-01".

**File Names** When you choose file names and directory names, observe the following rules and restrictions:

- File names may only contain the following characters:
  - !#\$%&'()+-0123456789=?
  - ABCDEFGHIJKLMNOPQRSTUVWXYZ[]^\_
  - abcdefghijklmnopqrstuvwxyz{}~
- Lowercase letters "a" to "z" are converted into uppercase letters "A" to "Z".
- Files must not start with ".".
- The lengths of file names (incl. file path) mustn't exceed 80 characters.

**FTP Commands** The FTP server accepts the commands contained in the following table. If commands are entered via a user interface (e.g. FTP client), some different commands are used (e.g. "dir" instead of "LIST"). In these cases, the FTP client converts the commands, which the user entered, to the below-mentioned syntax.

Command syntax	Description
USER xxxx	Log in with user name xxxx
PASS xxxx	Enter password xxxx
TYPE x	Enter transmission type: x = "A" for ASCII; x = "I" for IMAGE (binary)
STOR xxxx	Store a file of name xxxx on MMC
RNFR xxxx RNTD yyyy	Rename file xxxx, new name yyyy
CWD xxxx	Change working directory to xxxx
SYST	Request system information from FTP server
CDUP	Change working directory, go one level "up"
QUIT	Terminate the connection
STRU F	Set data structure type to "File"
APPE xxxx	Append data to file xxxx or create file xxxx
LIST	Request directory structure from server
STAT	Request status message of current settings of TYPE, STRU and MODE
RMD xxxx	Delete directory xxxx
XRMD xxxx	Delete directory xxxx
ACCT xxxx	Change user ID to xxxx
PORT xxxx	Transmit port number of host for data transfer
MODE S	Set transfer mode to "Stream"
ABOR	Abort current transmission
NLST	Transmit a file list to client
HELP	Transmit a list of supported FTP commands to client
PWD	Show current working directory
XPWD	Show current working directory

## Engineering/Diagnostic Interfaces

Command syntax	Description
<b>MKD xxxx</b>	Create directory xxxx
<b>XMKD xxxx</b>	Create directory xxxx
<b>PASV</b>	Open FTP server as "passive" connection
<b>RETR xxxx</b>	Transmit file xxxx to client
<b>DELE xxxx</b>	Delete file xxxx on server
<b>NOOP</b>	"No Operation" → Can be transmitted periodically to maintain connection

*Fig. 11-53: Function Commands for FTP Data Handling*



## 12 Commissioning

### 12.1 Commissioning Motors

#### 12.1.1 Checking the Installation/Assembly

##### Checking the Assembly



Check the assembly of the IndraDrive controllers and supply units as well as motors with regard to correct implementation, according to the data contained in respective Project Planning Manual.

##### Checking the Installation



Check the wiring of control cabinet and machine with regard to correct implementation, according to the data contained in the Project Planning Manual and the recommendations in the documentation "Electromagnetic Compatibility (EMC) in Drive and Control Systems".

#### 12.1.2 Initial Commissioning/Serial Commissioning

##### Brief Description

	The drive can be commissioned after assembly and installation have been correctly implemented.
<b>Initial Commissioning</b>	<p>The initial commissioning of a drive differs from the commissioning of other identical drives (serial commissioning).</p> <p>The initial commissioning is carried out in the following steps:</p> <ul style="list-style-type: none"> <li>• Establishing the operatability of the drive (including the required measuring systems)</li> <li>• Adjusting the drive behavior to the requirements of the application</li> <li>• Adjusting the master communication interface between master and drive</li> <li>• Integrating drive functionalities in the machine processes</li> </ul> <p>In each of the mentioned steps, values of relevant parameters are adjusted to the requirements. The result of the initial commissioning is a drive the behavior of which is exactly adjusted to the axis. By storing the values of the initial commissioning in the form of a parameter set the drive behavior can be reproduced.</p>
<b>Serial Commissioning</b>	<p>For the commissioning of other identical axis drives on machines of the same type, the set of parameter values determined during the initial commissioning is loaded to the respective controller (serial commissioning). This allows</p> <ul style="list-style-type: none"> <li>• exactly reproducing the drive behavior</li> </ul> <p>- and -</p> <ul style="list-style-type: none"> <li>• reducing the effort for further commissioning to a little adjustment work and, if necessary, search and elimination of assembly/installation errors.</li> </ul>
<b>Possibilities of Commissioning</b>	<p>As a matter of principle, commissioning can be carried out by means of</p> <ul style="list-style-type: none"> <li>• the "IndraWorks Ds/D/MLD" commissioning tool by Bosch Rexroth connected to the drive via SERCOS interface or via a serial interface, via Ethernet or a field bus.</li> <li>• the control panel of the controller and digital and analog input signals,</li> <li>• a control unit connected to the drive via a master communication interface.</li> </ul>

Commissioning

**Two-Step Commissioning**

It is basically recommended to always carry out both the initial commissioning and the serial commissioning in two steps:

- 1st objective: Initial Start of the Motor
- 2nd objective: Providing drive functions for the machine axis

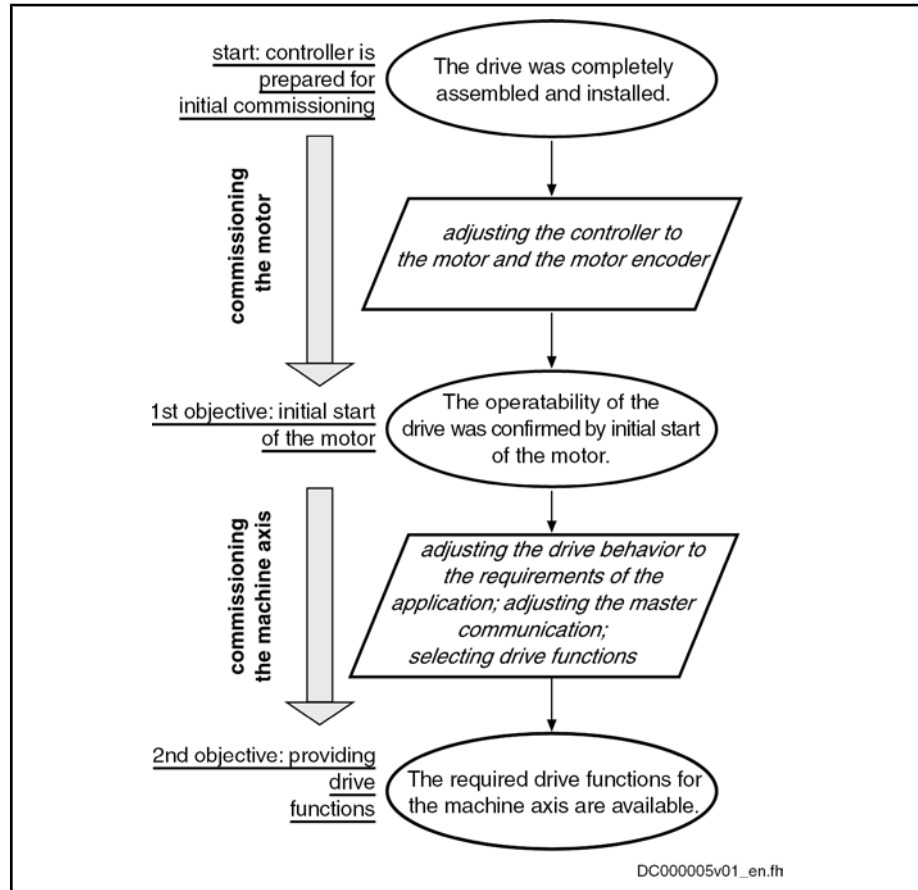


Fig.12-1: Two-Step Drive Commissioning (Schematic)

In the first step, the two-step procedure ensures the operability of the drive (1st objective during initial commissioning and serial commissioning). In the second step, the drive functions required for the machine axis and the drive's advantageous properties are individually adjusted to the machine axis in a reasonable order (2nd objective during initial commissioning) or the expected functional principle is checked (2nd objective during serial commissioning).



As a matter of principle, it is advantageous to establish the operability of a drive independent of a higher-level control system. The drive should therefore first be commissioned as a self-contained unit via "IndraWorks Ds/D/MLD" or in the "easy startup" mode!

See following sections:

- "Initial Start in "Easy Startup" Mode"
- "Initial Start With the Commissioning Tool"

**Notes on Commissioning**

**Initial Start of the Motor**

See "Initial Start in Easy Startup Mode"

See "Initial Start With the Commissioning Tool"

**Providing Drive Functions** See "Commissioning Machine Axes"

**Initial Commissioning** After initial commissioning has been carried out the defined application-specific parameter values have to be saved. The saved parameter values allow reproducing the drive behavior required at the respective machine axis.



For saving the parameter values the drive provides parameter lists supporting the complete storage of the relevant parameter values.

By reloading the saved parameter values the initial status after initial commissioning can be established again for the axis drive!

See also "Parameters, Basics: Loading, Storing and Saving Parameters"

**Reestablishing the Original Status**

**Attention:** For drives with absolute encoders, it is necessary to reestablish the original status after initial commissioning!



**CAUTION**

**Possible property damage for drives with absolute encoders caused by incorrect actual position value after repeated loading of parameter values saved according to S-0-0192!**

? Save parameter values by means of accordingly modified IDN list of parameter S-0-0270 (see below)

For drives with absolute value encoder and modulo scaling it is recommended to determine the parameter set for saving the parameter values after initial commissioning by means of a list of "S-0-0270, IDN-list of selected backup operation data" modified by the customer so that there cannot occur any actual position value error when the saved parameter values are loaded to the same axis drive again.



This is only possible via a control master. MMC and "IndraWorks Ds/D/MLD" only work with the content of the list parameter S-0-0192!

In its initial status, the content of the list parameter S-0-0270 first corresponds to the list parameter S-0-019 and should be modified as follows:

- Remove the IDNs P-0-0177 and P-0-0178

These parameters contain information on the current position data of the absolute encoders at the time of parameter backup. If the current data of P-0-0177 and P-0-0178 during the loading of the saved parameter values were overwritten with data referring to a different axis position current at the time of parameter backup, the actual position values would then correspond to the other axis position! The actual position values would remain valid (S-0-0403, Position feedback value status) because it still is the same absolute value encoder.



The incorrect actual position value generated in this case cannot be detected on the drive side because otherwise unjustified errors would be generated in service cases when devices are replaced!

See also "Notes on How to Replace the Devices"



The list of S-0-0270 modified as described can also be used for saving and loading the parameter values of axes with relative measuring systems, because the parameters P-0-0177 and P-0-0178 in this case do not contain relevant information!

## Commissioning



The content, possibly modified, of the list parameter S-0-0270 is contained in parameter S-0-0192, too! This means that when the backup is made via parameter S-0-0192, the content of parameter S-0-0270 can be read from the stored list, in order to load only these individually selected parameter values!

**Serial Commissioning**

The serial commissioning of axis drives of machines of the same type is supported by the application-specific parameter set of the respective axis drive saved after initial commissioning.

During serial commissioning the saved parameter sets are loaded to the controllers of the respective axis drives of other machines of the same type. This allows easily reproducing the behavior of the drives of a "model machine"!

After the application-specific parameter set of an axis drive has been loaded only some more adjustments are required:

- Setting the drive address (see "Basic Functions of Master Communication: Setting the Axis Address")
- "Establishing position data reference" for axes with measuring systems that can be evaluated in absolute form (see "Establishing Position Data Reference: Establishing Position Data Reference for Absolute Measuring Systems")

See also "Parameters, Basics: Loading, Storing and Saving Parameters"

## 12.2 Initial Start in "Easy Startup" Mode

### 12.2.1 Brief Description

The so-called ""easy startup" mode" allows moving the drive without connected or active control unit (or master communication master) or external command value box. When using a Rexroth motor with encoder data memory, this is also possible without using a commissioning PC, because all motor and controller parameters are stored in the encoder data memory.



The easy startup mode is therefore particularly suited for **initial commissioning** of individual axes, as well as for maintaining an **emergency mode** when the control unit has failed.

**Features**

- **Activation** of the "easy startup" mode is possible in two ways:
  - By activating the command parameter "P-0-4085, Command Activate easy startup mode" via serial interface or digital input
  - Via control panel of controller (pressing the corresponding keys in a certain order triggers activation of P-0-4085)
- Automatic **deactivation** of master communication interface (see P-0-4077, S-0-0134) and activation of "P-0-0120, Control word easy startup"
- Activation of **drive enable** (P-0-0120, bit 15) via:
  - The digital input assigned to drive enable (different according to hardware design, see default assignment under "Automatic Configuration of the Inputs")
  - Serial interface when configuration of digital inputs for "easy start-up" mode made before was removed
- Drive moves in "velocity control" mode with a parameterizable velocity command value (see P-0-1206) without external command value box

- Selection of **travel direction** (positive/negative) via digital input signals (see parameter "P-0-1200, Control word 1 velocity control")

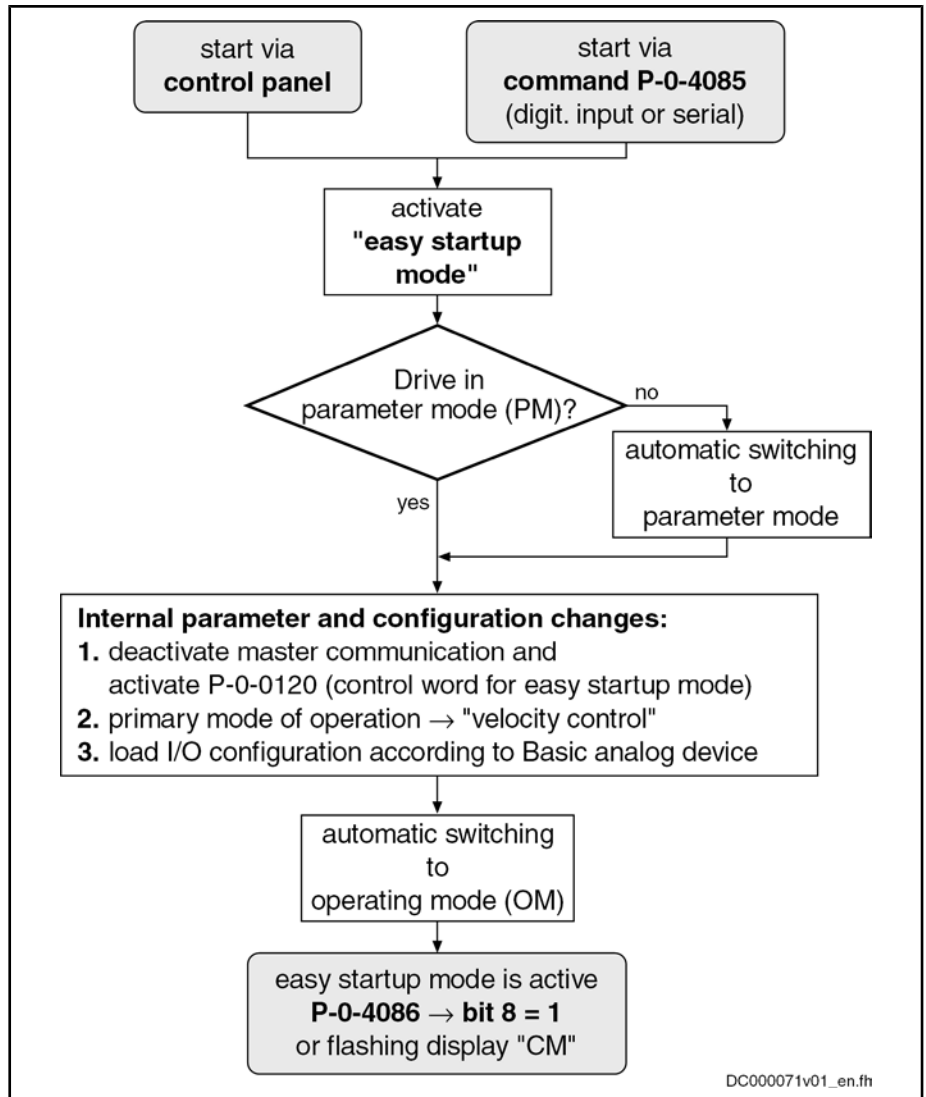


Fig. 12-2: Activating the Easy Startup Mode, Overview

#### Hardware Requirements

#### Control sections BASIC SERCOS, BASIC PROFIBUS, BASIC UNIVERSAL and ADVANCED

For using the easy startup mode, the digital inputs and outputs (X31, X32) must be connected as follows:

- Connect 24V/0V power supply to respective terminal connectors
- X31/4: +24 V for activating drive enable
- X32/7 and X32/8: 0V/+24V for activating positive or negative rotational direction  
or → X31/3 and X31/7 for control of motor potentiometer

#### Control sections BASIC UNIVERSAL double-axis

For using the "easy startup" mode, the digital inputs and outputs (X33, X34) must be connected as follows:

- Axis 1:

## Commissioning

- Connect 24V/0V power supply to respective terminal connectors
- X33/1: +24 V for activating drive enable
- X33/2 and X33/3: 0V/+24V for activating positive or negative rotational direction  
or → X33/4 and X33/5 for control of motor potentiometer
- Axis 2:
  - Connect 24V/0V power supply to respective terminal connectors
  - X34/1: +24 V for activating drive enable
  - X34/2 and X34/3: 0V/+24V for activating positive or negative rotational direction  
or → X34/4 and X34/5 for control of motor potentiometer

**Control sections BASIC OPENLOOP and BASIC ANALOG**

For drives with these control sections, the "easy startup" mode actually is not required, because these drives can easily be moved with an analog command value (see "Analog Interface").

**IndraDrive Mi**

For using the "easy startup" mode, the digital inputs and outputs (X37, X38) must be connected as follows:

- Connect 24V/0V power supply to respective terminal connectors
- X37/2: +24 V for activating drive enable
- X37/4 and X38/4: 0V/+24V for activating positive or negative rotational direction

**Pertinent Parameters**

- S-0-0032, Primary mode of operation
- S-0-0091, Bipolar velocity limit value
- P-0-0120, Control word easy startup
- P-0-0300, Digital I/Os, assignment list
- P-0-0301, Digital I/Os, bit numbers
- P-0-0302, Digital I/Os, direction
- P-0-1200, Control word 1 velocity control
- P-0-1206, Memory of velocity command values
- P-0-4085, Command Activate easy startup mode
- P-0-4086, Master communication status

**Pertinent Diagnostic Messages**

When the "easy startup" mode is used, additional simple diagnostic texts appear on the display of the control panel in "light writing":

- When the "easy startup" mode has been activated, the display changes between the drive address and the message "CM" (Commissioning Mode).
- During commissioning, the relevant messages appear on the display (see fig. "Activating the "Easy Startup " Mode Via the Control Panel").

**12.2.2 Functional Description****Requirements**

The following requirements and conditions must have been fulfilled for using the "easy startup" mode:

- The wiring of the drive is complete and correct.
- There shouldn't any master communication have been activated.

**Attention:** The "easy startup" mode switches off any possibly active master communication!

- The controller must be supplied with control voltage and it must be possible to switch power on.
- There mustn't any error message be present.

For Rexroth motors with encoder data memory, there is no commissioning PC required; otherwise the motor parameters have to be set during commissioning, if necessary with a PC.

#### General Information on How to Activate the Easy Startup Mode

The "easy startup" mode can be activated both in the parameter mode (phase 2) and in the operating mode (phase 4), by activating "P-0-4085, Command Activate easy startup mode".



If the drive already is in the "easy startup" mode and this mode is activated again, the display reads "easymode active"!

The "easy startup" mode can be activated in the following ways:

- Via the control panel of the controller
- Via a digital input
- Via the serial interface



By activating "P-0-4085, Command Activate easy startup mode", the drive automatically switches to the parameter mode and configures the "velocity control" mode with values from the memory of fixed command values (P-0-1206).

#### Activation Via Control Panel

The figure below illustrates how the easy startup mode is activated via the control panel of the IndraDrive controllers:

Commissioning

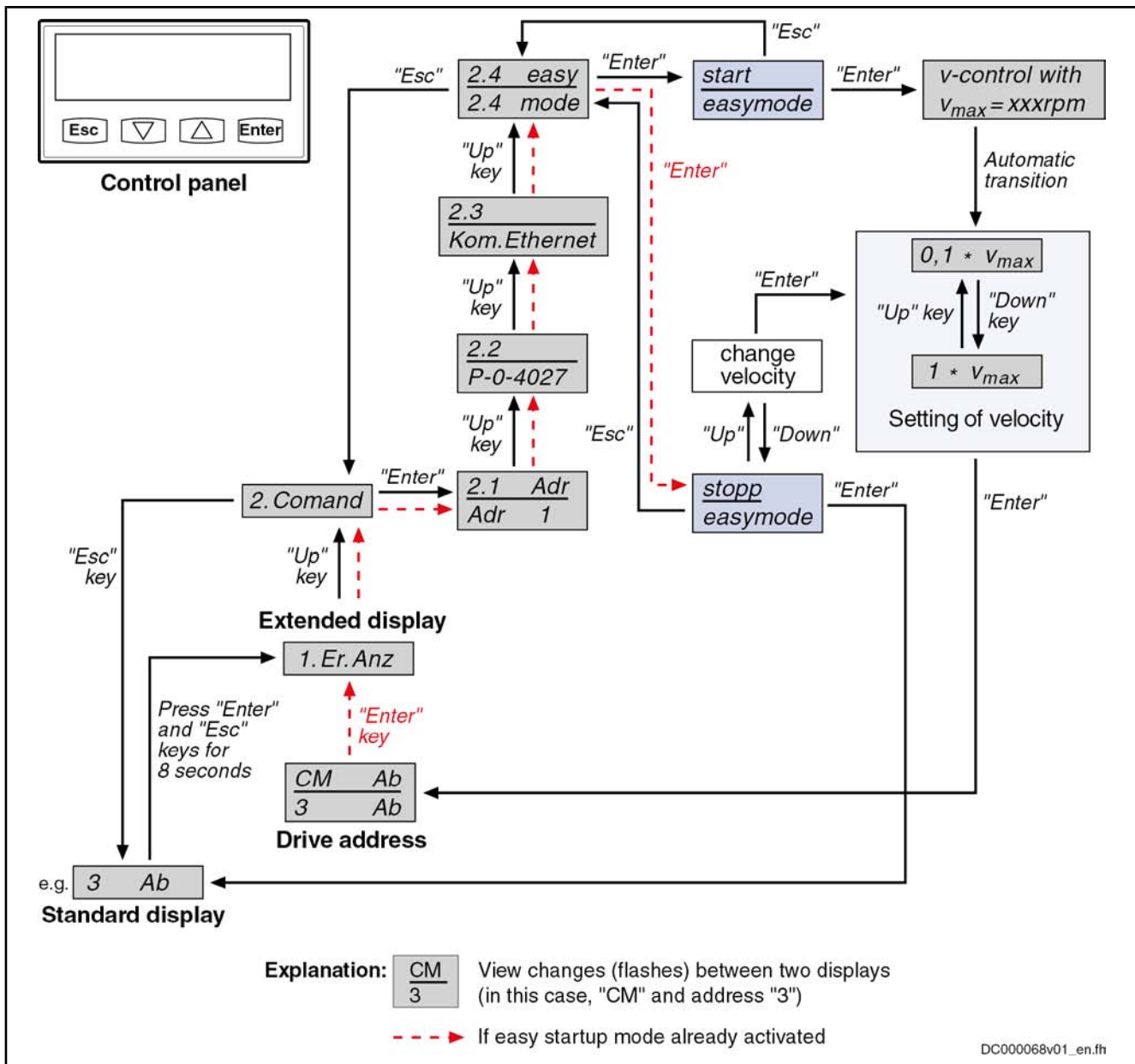


Fig. 12-3: Activating the Easy Startup Mode Via the Control Panel

See also "Control Panels of the IndraDrive Controllers"

**Activation Via Digital Input**

If the "easy startup" mode is activated via a digital input, bit 0 of parameter P-0-4085 has to be assigned to a digital input.

See "Digital Inputs/Outputs"

**Activation Via Serial Interface**

If the "easy startup" mode is activated via the serial interface, parameter P-0-4085 has to be written via SIS telegrams.

See "Serial Communication"



"P-0-4085, Command Activate easy startup mode" can also be directly written via the master communication (e.g. SERCOS or field bus), but in this way the master would deactivate itself!

**Acknowledging the Active "Easy Startup" Mode**

The active "easy startup" mode is acknowledged by:



**Automatic Configuration of the Inputs**

- Setting bit 8 in "P-0-4085, Command Activate easy startup mode"
  - Changing the display on the control panel between "CM" (Commissioning Mode) and the drive address
- For automatic configuration of the inputs, the following actions are performed:
- Deactivation of master communication interface and activation of drive enable in parameter "P-0-0120, Control word easy startup"
  - Setting of operation mode "velocity control" with values from memory of fixed command values (P-0-1206)
  - Assignment of the command velocity selected via the control panel (in percent) of "S-0-0091, Bipolar velocity limit value" to element 1 or element 2 of "P-0-1206, Memory of velocity command values" (with positive sign to element 1, with negative sign to element 2).
  - Assignment of allocation of inputs



The actual configuration of the inputs/outputs depends on the available digital inputs of the control section (see tables below).



The automatic configuration of the inputs/outputs for the "easy startup" mode takes place **in volatile form**, i.e. any I/O configuration existing before is reestablished when the command is completed. This is not the case, if the I/O configuration was specifically (manually) changed with the command being active.

IndraDrive single-axis control sections (CSB, CSH)			
Connection	Signal	Function	I/O assignment
X31.3	I_1	Motor potentiometer, ramp +	P-0-1200, Control word 1 velocity control (bit 8)
X31.4	I_2	Drive enable	P-0-0120, Control word easy startup (bit 15)
X31.7	I_5	Motor potentiometer, ramp –	P-0-1200, Control word 1 velocity control (bit 9)
X32.7	I/O_9	Selection of memory of fixed command values	P-0-1200, Control word 1 velocity control (bit 0)
X32.8	I/O_10	Selection of memory of fixed command values	P-0-1200, Control word 1 velocity control (bit 1)

Fig. 12-4: Automatic I/O Configuration for Easy Startup Mode With Single-Axis Control Sections

IndraDrive double-axis control sections (CDB)				
Connection	Signal	Axis	Function	I/O assignment
X33.4	I_15	1	Motor potentiometer, ramp +	P-0-1200, Control word 1 velocity control (bit 8)
X33.1	I_12	1	Drive enable	P-0-0120, Control word easy startup (bit 15)
X33.5	I_16	1	Motor potentiometer, ramp –	P-0-1200, Control word 1 velocity control (bit 9)
X33.2	I_13	1	Selection of memory of fixed command values	P-0-1200, Control word 1 velocity control (bit 0)
X33.3	I_14	1	Selection of memory of fixed command values	P-0-1200, Control word 1 velocity control (bit 1)
X34.4	I_21	2	Motor potentiometer, ramp +	P-0-1200, Control word 1 velocity control (bit 8)
X34.1	I_18	2	Drive enable	P-0-0120, Control word easy startup (bit 15)

Commissioning

IndraDrive double-axis control sections (CDB)				
Connection	Signal	Axis	Function	I/O assignment
X34.5	I_22	2	Motor potentiometer, ramp –	P-0-1200, Control word 1 velocity control (bit 9)
X34.2	I_19	2	Selection of memory of fixed command values	P-0-1200, Control word 1 velocity control (bit 0)
X34.3	I_20	2	Selection of memory of fixed command values	P-0-1200, Control word 1 velocity control (bit 1)

Fig. 12-5: Automatic I/O Configuration for Easy Startup Mode With Double-Axis Control Sections

IndraDrive Mi (KSM)			
Connection	Signal	Function	I/O assignment
X37.2	I/O_3	Drive enable	P-0-0120, Control word easy startup (bit 15)
X37.4	I/O_1	Selection of memory of fixed command values	P-0-1200, Control word 1 velocity control (bit 0)
X38.4	I/O_2	Selection of memory of fixed command values	P-0-1200, Control word 1 velocity control (bit 1)

Fig. 12-6: Automatic I/O Configuration for Easy Startup Mode With IndraDrive Mi



IndraDrive Mi (distributed servo drive "KSM") only has a limited number of digital inputs/outputs (4 inputs/outputs), it has no analog input and no control panel!



See also "Optional Modules for Control Sections" in the separate documentation "Control Sections for Drive Controllers; Project Planning Manual"

"Load Basic Parameters" With Invalid Parameter Settings

After activating the "easy startup" mode, the drive normally is ready for operation ("bb" or "Ab" → communication phase 4). When the drive stops in communication phase 3 due to invalid parameter values, valid basic parameter values can be loaded via the control panel.

See also "Control Panels of the IndraDrive Controllers"

Controlling the Drive

According to master communication or setting of the device control, different control words take effect. Internally, however, all relevant control bits are always displayed in "P-0-0116, Device control: control word".

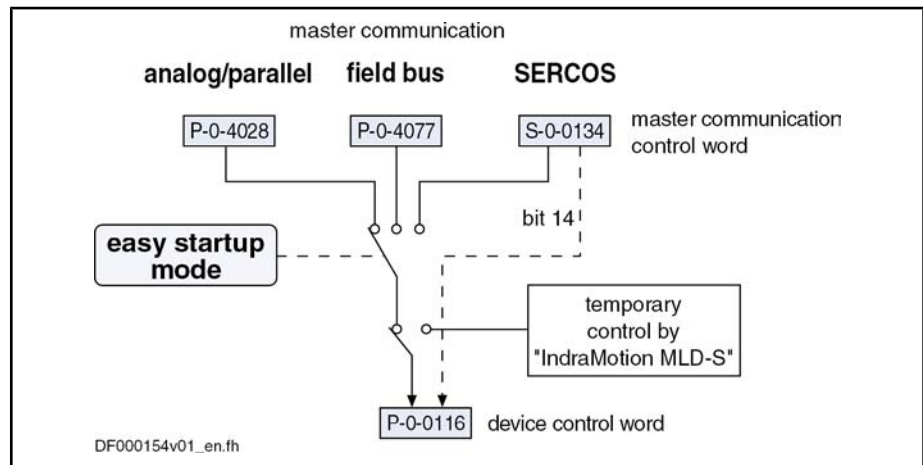


Fig. 12-7: Controlling the Drive in the "Easy Startup" Mode



In the case of temporary control of the PLC, bit 14 (drive enable) is nevertheless taken from "S-0-0134, Master control word" for SERCOS interface! Only in the case of stand-alone "Motion Control" does the PLC also control bit 14. In the case of field buses, bit 14 is activated internally.

See also "Profile Types (With Field Bus Interfaces)"

The control parameter "P-0-0120, Control word easy startup" active in the "easy startup" mode can be changed or influenced in the following ways:

- Via digital inputs, if they were accordingly configured before
- Via the serial interface by directly writing P-0-0120  
→ In this case, the parameter has to be actively written at least every 2 s, otherwise the drive will automatically clear drive enable!

#### Terminating the "Easy Startup" Mode

The "easy startup" mode can only be terminated by switching the controller off! After the "easy startup" mode was terminated, the controller is in its initial status again and all configurations specifically made for this mode were undone.

After successful command execution, the drive is automatically switched to the operating mode again, if it had been in phase 4 before the start of the command!



If required, the "easy startup" mode has to be activated again.

## 12.2.3 Notes on Commissioning

#### Invalid Commands

The commands for backup of working memory ("P-0-0120, Control word easy startup" and "C2400 Selectively backup working memory procedure command") should not be triggered in "easy startup" mode, because otherwise the settings of the "easy startup" mode will be stored in the non-volatile memory and will be active again after the drive is switched on the next time!

#### Initial Commissioning

In the "easy startup" mode, initial commissioning of Rexroth motors with encoder data memory is easily done without commissioning tool, because the required parameter settings for motor control and motor encoder are automatically made via the command "load defaults procedure - load controller parameters".

For the "load defaults procedure", see "Default Settings in the Motor Encoder Data Memory" under "Drive Control: Overview".

Initial commissioning of Rexroth motors without encoder data memory or of third-party motors is only possible in the "easy startup" mode in conjunction with a commissioning tool "IndraWorks Ds/D/MLD" in order to load or enter the values for motor control parameters and motor encoder parameters. For synchronous motors with absolute measuring system, the commutation offset only has to be determined at initial commissioning. For synchronous motors with relative measuring system, the commutation offset is automatically determined every time drive enable is set for the first time after transition "PM → OM".

If for synchronous motors the commutation offset can only be determined by supplying current, this is only possible in the operating status "Ab" with "active easy startup" mode!

See "Initial Start With the Commissioning Tool"



**CAUTION**

**Danger of property damage during initial start in "easy startup" mode caused by incorrect parameter values!**

⇒ For motors without encoder data memory, the required motor and controller parameters must be checked before initial start in the "easy startup" mode!

## Commissioning

**Recommissioning** In "easy startup" mode, recommissioning (after initial commissioning having been carried out) of drives is possible without any problem, because the correct values of motor control parameters and motor encoder parameters are already available in the drive.

Only the commutation setting of synchronous motors with relative measuring system is automatically determined again every time drive enable is set for the first time after transition "PM  $\Rightarrow$  OM"!



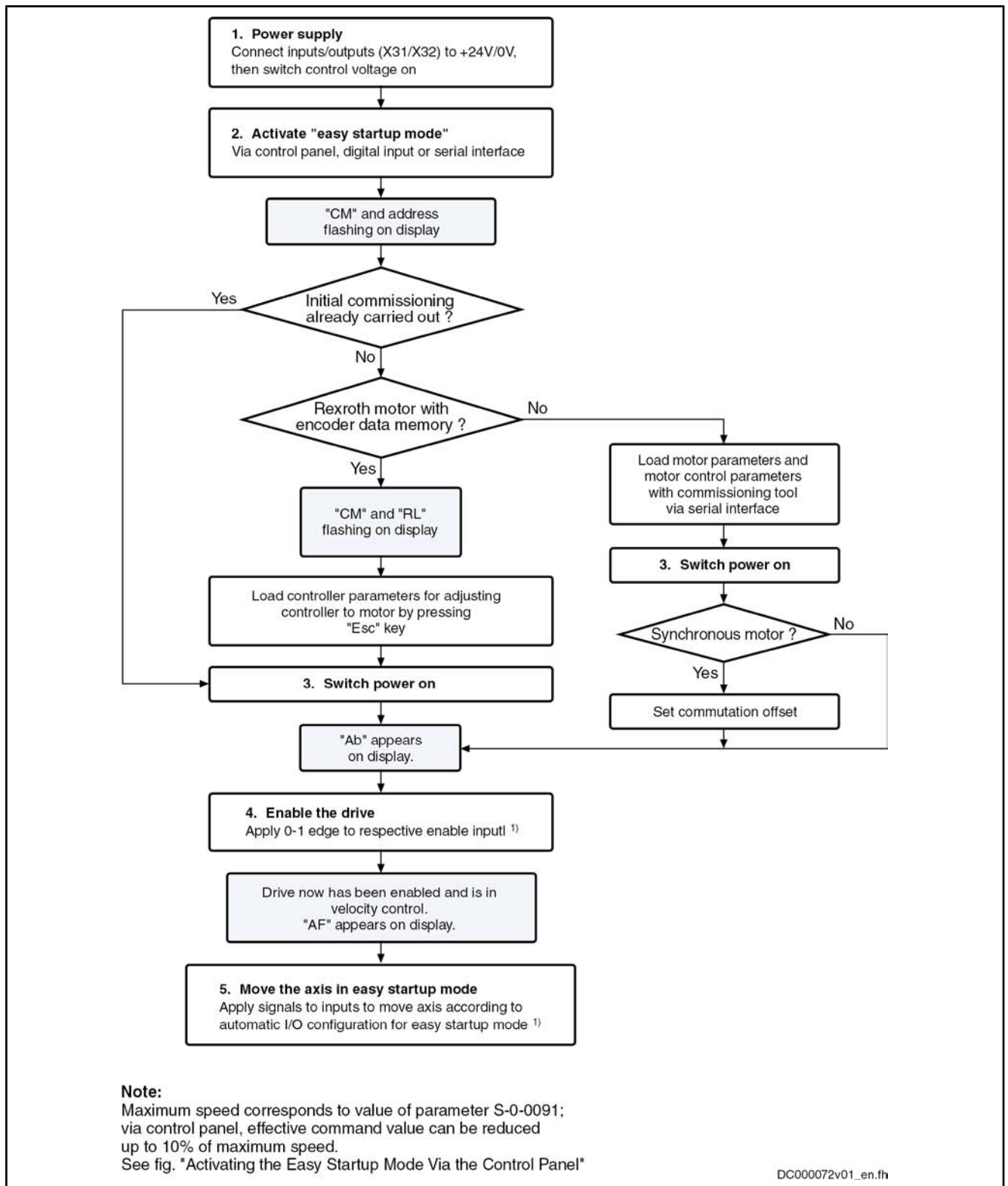
**CAUTION**

**Property damage caused by errors when controlling motors!**

$\Rightarrow$  The digital input signals must be applied with due caution!

---

The figure below summarizes the commissioning sequence with "easy start-up" mode:



1) See assignment tables for the different hardware designs under "Automatic Configuration of the Inputs"

Fig. 12-8: Commissioning Sequence With Easy Startup Mode

## Commissioning

## 12.3 Initial Start with the Commissioning Tool

### 12.3.1 Brief Description

**Establishing the Operability of the Drive**

After complete and correct assembly and wiring of the drive or the drives it is advisable to establish the operability. With drives of the IndraDrive family this is very easily done by means of initial start in "easy startup" mode (velocity-controlled operation, master communication master not required) in conjunction with the Rexroth "IndraWorks Ds/D/MLD" commissioning tool. With older drive families and connections via the SERCOS interface this is possible by means of the Rexroth "DriveTop" commissioning tool and the Rexroth-SERCOS-Master SYSDA02.2.

According to the available equipment, the initial commissioning of the motor is supported as follows:

- If there is **no** commissioning tool (e.g. PC) available, Rexroth motors with encoder data memory can be easily commissioned in "easy startup" mode. The motor parameters and motor control parameters of these motors are automatically loaded from the data memory to the controller by switching control voltage on.
- IndraDrive: If a PC with Rexroth commissioning tool is available, the motor parameters and motor control parameters of motors without encoder data memory can be loaded from the internal database of the commissioning tool to the controller via the serial interface. This allows initial commissioning in "easy startup" mode for these motors, too.
- EcoDrive/Diax: If a PC with the "DriveTop" commissioning tool (version 16VRS) and SYSDA02.2 is available, drives with SERCOS interface can be conveniently commissioned and moved via command values of SYSDA02.2.

**Available Commissioning Tools**

Bosch Rexroth provides the following commissioning tools (software) for drives:

- EcoDrive/Diax: DriveTop (version 16VRS)
- IndraDrive: IndraWorks Ds/D/MLD

**DriveTop**

"DriveTop" is a tool for parameterizing and commissioning drives. It supports the Rexroth SERCOS master SYSDA02.2 by means of which it is possible to move drives with SERCOS interface. The communication with the drive or with SYSDA02.2 is established via the serial interface RS232/RS485.

**IndraWorks Ds/D/MLD**

"IndraWorks Ds/D/MLD" is a component of the software range "IndraWorks", which supports parameterization and commissioning of control units and drives by Bosch Rexroth. "IndraWorks Ds/D/MLD" has been designed for interaction with the SERCOS master SYSDA02.2. The communication with the drive is established via the serial interface RS232/RS485.

The commissioning tools "DriveTop" and "IndraWorks Ds/D/MLD" provide the following possibilities and advantages:

- The functions and features made available by the drive are structurally visualized, the respective parameter values are displayed in their functional context.
- Parameter values can be directly changed and thereby adjusted to the respective requirements.
- The parameter values available in the drive can be saved drive-externally as a group (parameter set), e.g. on the PC hard disk, and can be reloaded from the hard disk.
- Diagnostic messages and operating status messages are displayed in clearly arranged form.
- For the purpose of commissioning, commands can be started.

- By means of the "easy startup" mode IndraDrive drives or, in conjunction with SYSDA02.2, all drives can be commissioned and travelled.

### 12.3.2 Functional Description

For the initial start of the motor the following steps have to be carried out:

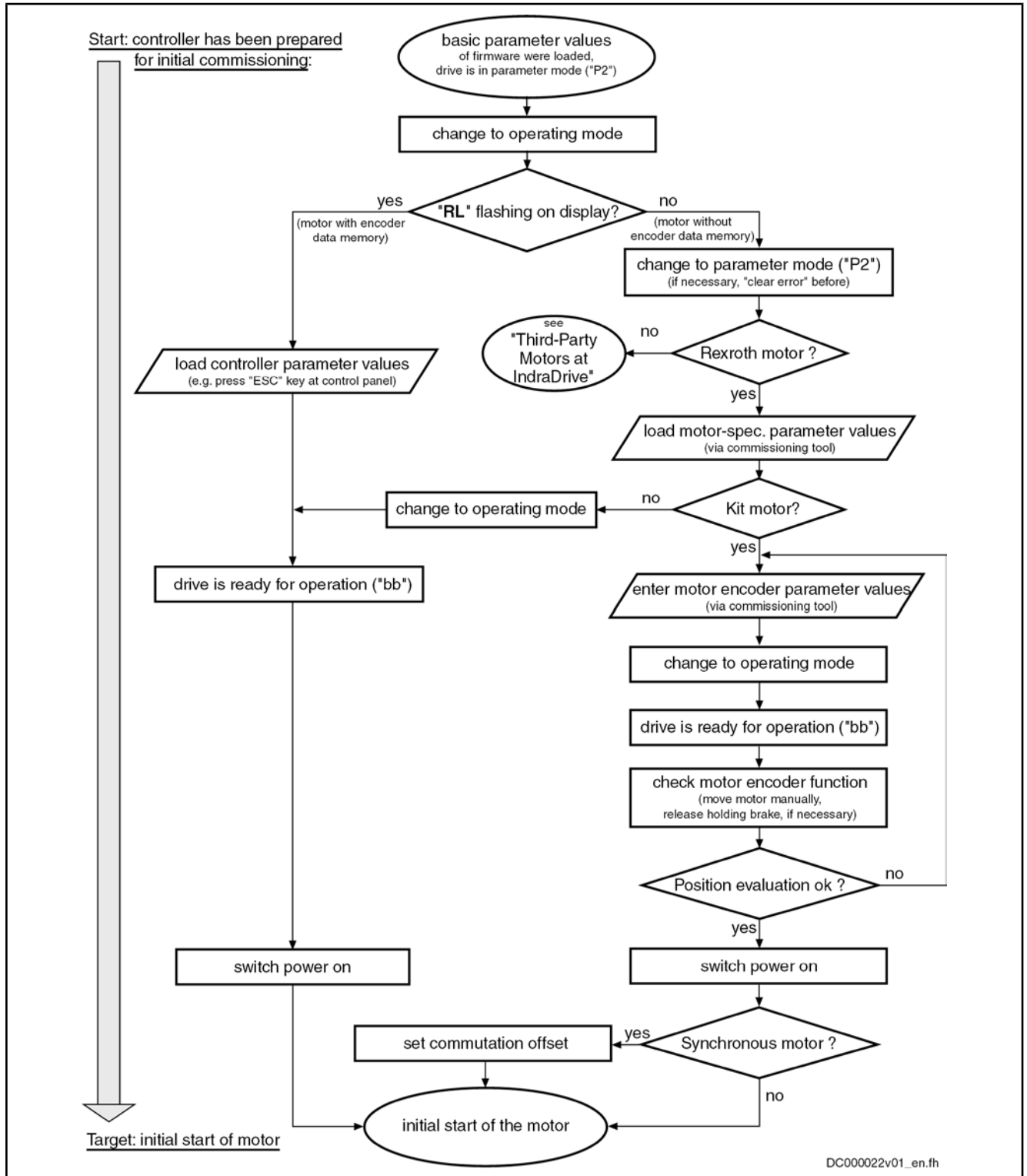


Fig. 12-9: Commissioning Steps for Initial Start of Rexroth Motors

## Commissioning

### 12.3.3 Notes on Commissioning for Using DriveTop and SYSDA02.2

The steps for initial start illustrated in the figure (above) are described below as a detailed sequence for a Rexroth motor in conjunction with DriveTop and SYSDA02.2 (SERCOS interface).

**Basic actions:**

1. Connect "SYSDA02.2" hardware according to installation instructions:  
Power supply must be available! Establish serial communication with PC that makes DriveTop available and establish fiber optic SERCOS connection to controller (observe Tx → Rx!) (see technical documentation of SYSDA02.2)!
  2. Switch on supply voltage of the controller(s):  
Display of controller(s) first shows booting phases. Then drive address and communication phase "P-1" will be displayed.
  3. In DriveTop, enter drive address appearing on display:  
Enter drive address or addresses in "System overview" (open "System overview" dialog under menu item "Setup" – "SERCANS basic configuration")!
  4. Change from communication phase "P-1" to parameter mode "P2":  
Activate "parameterization mode" ("P2") (press right mouse key, activate with cursor)!
  5. Now select drive in the SERCOS ring that is to be commissioned:  
Display list of drives connected by SERCOS ring and select a drive (to do this, activate "System overview" in menu item "Overview" and select a drive with cursor)!  
The drive to be commissioned can now be addressed via DriveTop.
  6. First prepare loading of basic firmware parameters:  
Write value "0x001" to parameter "P-0-4090, Configuration for loading default values" (select dialog "Drive commands" in menu item "Tools". Press right mouse key, select "Single parameters" with cursor, call "p4090" and write data)!
  7. Now load basic firmware parameters:  
Start C0700 Load defaults procedure command (select command "S-0-0262, C07\_x Load defaults procedure command" from list with cursor, start with corresponding button)!  
After command execution message, basic firmware parameter values (default parameter values) were loaded to drive parameters, drive now is in an operable initial status.
  8. From communication phase "P2" change to phase "bb" (operating mode, P4):  
Activate "operating mode" (press right mouse key, select with cursor)!  
If controller now requests loading of controller parameter values by "RL" flashing, continue with no. 9, if a different diagnostic message is displayed, continue with no. 11!
- Rexroth motor with encoder data memory:**
9. When "RL" is flashing on the display, a Rexroth motor with encoder data was connected to the controller. Now adjust controller to motor:  
Start command "Clear error" (press right mouse key, activate with cursor or "Esc" at control panel)!



Drive now is ready for operation, display of drive addressed by DriveTop reads "bb".

If there are other drives in the SERCOS ring, repeat steps from no. 5 onward!

10. Continue sequence with no. 16!

**Rexroth motor with motor encoder without data memory:**

11. If "RL" is not flashing on right side next to drive address at controller display, a five-digit diagnostic message text appears in most cases. In this case, motor does not have an encoder memory. Therefore, there aren't any motor-specific parameter values made available on motor side. If connected motor is a Rexroth motor, motor-specific parameter values can be loaded to controller via DriveTop:

Activate "parameter mode" (press right mouse key, select with cursor)!

On right side next to drive address display reads "P2".

12. Load motor-specific parameter values:

Select Rexroth motor type in "Motor parameters" dialog (Open "Drive functions – Motor parameters". Select tab page "Kit motor" or "without feedback data memory". Enter type designation of stator and rotor. Then activate "Edit motor parameters" if necessary, and activate "Set motor parameters")

Motor-specific parameter values are now loaded to drive. If the motor is a Rexroth housing motor without encoder data memory", change to operating mode (cf. no. 14), then continue with no. 16, if it is a Rexroth kit motor, continue with no. 13!

**Rexroth kit motor:**

13. Control motor encoder parameters, adjust to encoder used, if necessary:

Select motor encoder used in "Encoder settings" dialog, set line count, negation if necessary and encoder interface used (open "Drive functions – encoder settings" dialog)!

14. From communication phase "P2" change to phase "bb" (operating mode, P4):

Activate "operating mode" (press right mouse key, select with cursor)!

Drive now is ready for operation, display of drive addressed by DriveTop reads "bb".

15. Now check function of motor encoder:

To do this, manually move motor shaft or linear motor slide in positive direction (see requirements regarding direction of movement in Project Planning Manual of respective motor!). (To do this, select "Drive status" in menu item "Overview" with cursor)!

When actual position values of motor are increasing and traveled distance corresponds to actual position value difference displayed, motor encoder evaluation is okay; if not, return to no. 13 of sequence!

**Switching power on:**

When displays of all drives in SERCOS ring read "bb", power can be switched on via supply unit.

When DC bus voltage was supplied, controller displays read "Ab" (ready for power output).

**Configuring and activating command value box:**

## Commissioning

16. Each drive in SERCOS ring can be individually addressed with command values via DriveTop.

Select respective drive in system overview (to do this, activate "System overview" in menu item "Overview" and select a drive with cursor)!

**Note:** In the case of synchronous kit motors, commutation setting has to be carried out first; see "Rexroth Kit Motors, Synchronous". This process is also supported by DriveTop (see "Drive commands" dialog in menu item "Tools")!

Configure command value box of SYSDA02.2 via DriveTop (via menu bar "Tools" – "Command value box" – "Command value box selection" select command value function "configured" and the desired operating mode)!

**Note:** For initial start of kit motors, it is important first to check correct direction of movement in torque/force control! For moving the drive during initial start a velocity-controlled operating mode is useful.

Activate command value box of SYSDA02.2 via DriveTop (via DriveTop menu bar "Tools" – "Command value box" – "Command value box adjustments" set travel profile of selected operating mode)!

**Note:** Reduce velocity and torque/force limits to safe values!

**Put drive into operation:**

17. Set drive enable (activate "Enable" button with cursor)!

Negatively acknowledge warning dialog for possibly dangerous movements if requirements for safe drive functioning have not been fulfilled (activate "Cancel" button with cursor)!

Positively acknowledge warning dialog if requirements for safe drive functioning have been fulfilled (activate "OK" button with cursor)!

**Caution! Possible damage caused by errors when controlling motors and moving parts!** ⇒ Only enable axis from safe initial position; E-Stop push-button must be available in position easy to reach!

18. Correctly moving the drive according to preset command values confirms operability of drive.

If drive does not follow command values, shut it down fast as can (activate "Drives OFF" button with cursor or press E-Stop pushbutton)!

If drive follows command values, this is the basis for further commissioning steps regarding master communication via NC and further machine-axis-related functions.



DriveTop does not provide dialogs for parameter set switching! If it is necessary to switch parameters, the individual parameters have to be called (e.g. with the right mouse button) and directly written!

### 12.3.4 Notes on Commissioning for Using "IndraWorks Ds/D/MLD"

For Rexroth motors without encoder data memory in conjunction with "IndraWorks Ds/D/MLD" (without SERCOS-Master), the steps illustrated in the figure "Commissioning steps for initial start of Rexroth motors" (see above) can only be carried out in the "easy startup" mode (initial start without active master communication)!

With "IndraWorks Ds/D/MLD" the values for the motor, motor control and motor encoder parameters, for motors without encoder data memory, can be loaded from the internal data base of the commissioning tool via the serial interface of the controller.



In the case of synchronous kit motors, commutation setting has to be carried out first (see "Commutation Setting"), and the sequence required for this is supported by commands. If the motor has to be supplied with current in this case, the active "easy startup" mode is required!

See "Initial Start in the "Easy Startup" Mode"

## 12.4 Commissioning Machine Axes

### 12.4.1 Procedure for Commissioning

The drive supports different commissioning procedures. The type of commissioning depends on the existing machine components (control, drive controllers, motor, mechanical system). Commissioning is made using one of the commissioning tools available.

#### Commissioning Procedure

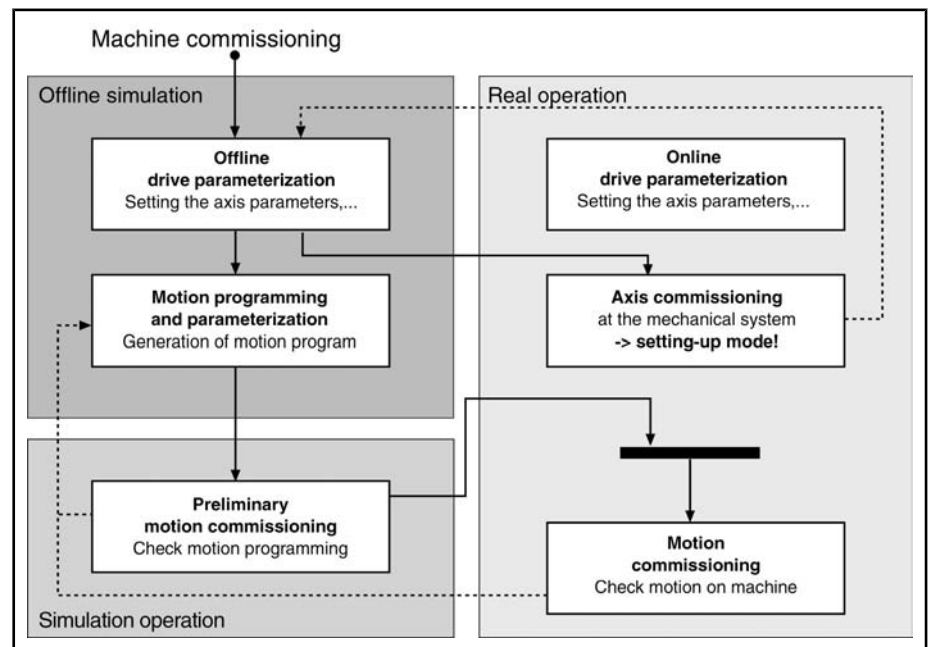


Fig. 12-10: Overview of Procedures for Commissioning

**Real Operation** In real operation all necessary components are available. The parameterization of the drive controller is made online; then commissioning of the axis system can be made in setting-up mode. The commissioning of the machine is made by means of a control.

**Offline Simulation** The offline simulation does not require any machine component. The parameterization of the drive controller is made offline. The parameters are applied to the drive controller during transition to real operation. The parameterization for a drive-internal control (MLD) can also be made offline, as well as creation of motion programs.

**Simulation Mode** In simulation mode only the drive controller is required, parameterization is made online. With the axis simulation the velocity and actual position values are simulated, the drive can be operated in velocity- and position-controlled operation modes. A higher-level control unit can thus test its motion programs even without motor or mechanical system.

Commissioning

## 12.4.2 Commissioning Real Operation

### Brief Description

Before commissioning machine axis-specific functions it is useful to make sure that the drive, consisting of controller, motor and motor encoder, is operational. The best way to do this is the initial start of the drive with the PC-based commissioning tool "IndraWorks Ds/D/MLD" by Bosch Rexroth (see "Initial Start With the Commissioning Tool").

The commissioning of machine axis-specific functions should also be carried out via "IndraWorks Ds/D/MLD", if possible. The advantage is that the correct sequence of an axis-specific function can be configured and ensured independent of the control unit. Further commissioning of the drive, with widely complete configuration, is then easier for the control unit.

### Schematic Sequence

Commissioning procedure as a sequence of steps:

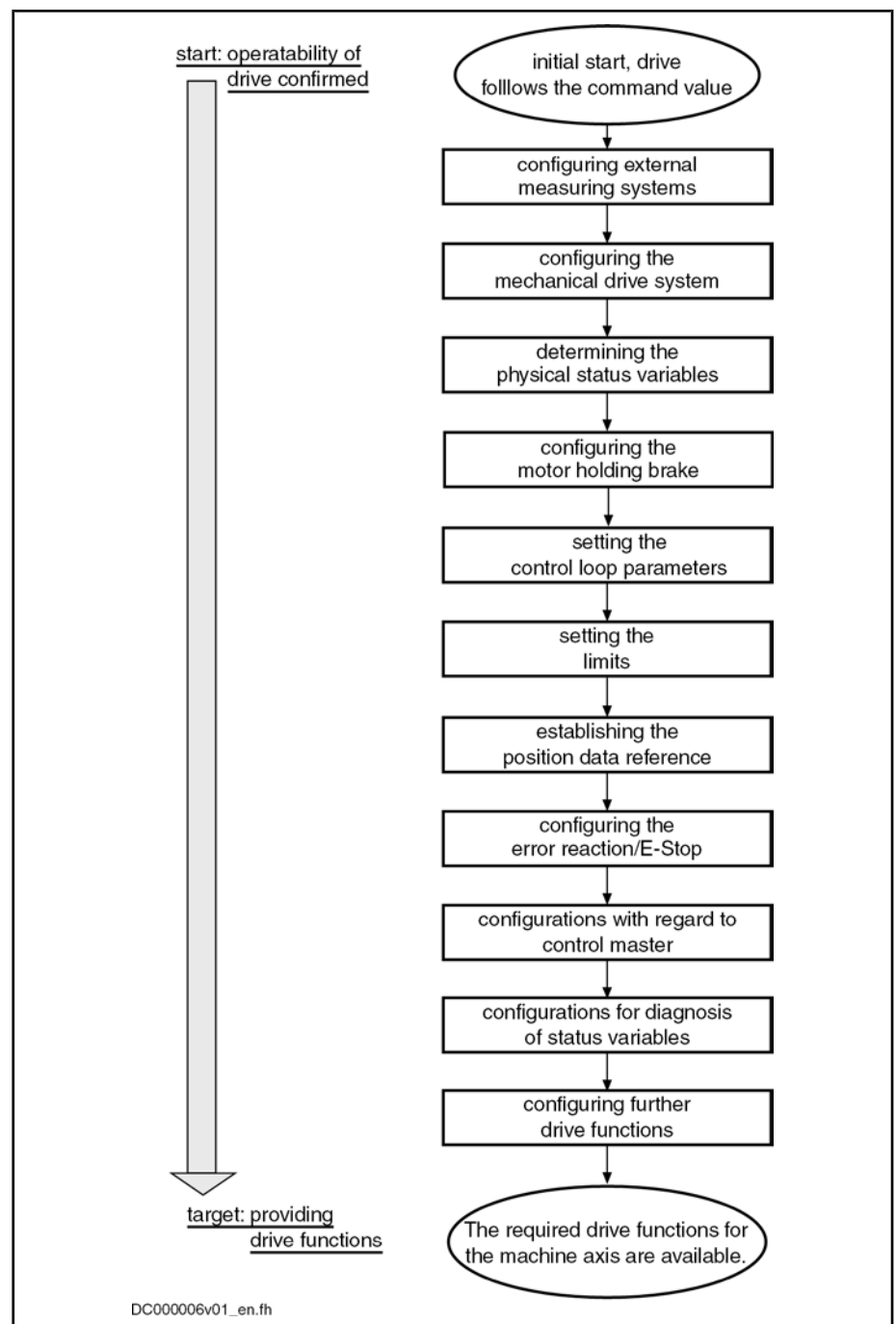


Fig. 12-11: Steps of Machine Axis-Related Commissioning

## Notes on the Commissioning Steps

The subjects of the individual commissioning steps are treated in detail in different chapters of this firmware documentation. The information contained in the chapter is basically divided into:

- Brief Description
- Functional Description
- Notes on Commissioning

To explain the individual commissioning steps we refer to the Notes on Commissioning for the respective subject, if possible.

## Commissioning



Detailed information about parameters is only contained in the separate documentation "Rexroth IndraDrive, Parameter Description" (reference list of all IndraDrive parameters).

### Configuring the Measuring Systems

<b>General Information</b>	Configure controller and encoder (set travel range, if necessary) See "Notes on Commissioning" in "Basics on Measuring Systems, Resolution"
<b>Relative Encoders</b>	Set initial position value; configure distance-coded measuring systems See "Notes on Commissioning" in "Relative Measuring Systems"
<b>Absolute Encoders</b>	Check whether absolute encoder evaluation is possible (depending on travel range), set initial position value See "Notes on Commissioning" in "Absolute Measuring Systems"
<b>Position Monitoring</b>	Set position monitors: <ul style="list-style-type: none"><li>• Axis position monitor (position at time drive is switched on) for absolute encoders</li><li>• Position difference monitor of motor encoder and external encoder</li><li>• Configure spindle encoder monitor</li></ul> See "Notes on Commissioning" in "Monitoring the Measuring Systems"

### Configuring the Mechanical Axis System

Depending on the mechanical properties, make the following settings:

- Enter load gear ratio
- Enter feed constant
- Enter motor encoder gear ratio
- Enter gear ratio for external encoder

See "Notes on Commissioning" in "Mechanical Axis System and Arrangement of Measuring Systems"

### Determining the Physical Status Variables

Make scaling settings for position, velocity, acceleration, torque/force and temperature data.

See "Notes on Commissioning" in "Scaling of Physical Data"

### Configuring the Holding Brake

If the motor to be controlled is equipped with a holding brake or the controller has to control an external holding brake (for kit motors, if necessary), make the following settings:

- Enter maximum "drive off" delay time
- Enter holding brake data (external brake), if necessary
- Configure type, functioning principle and monitor of brake in holding brake control word

See "Notes on Commissioning" in "Motor holding brake"

### Setting the Control Loop Parameters

Set controller and filter parameters for the control loops:

- Velocity control loop
- Position control loop

See "Notes on Commissioning for Control Loop Setting" in "General Information on Closed-Loop Axis Control"

## Setting the Limitations

The controller offers the possibility of limiting physical status variables of the drive. Depending on the application, limit values can be set for:

- Torque/force command value
- Velocity Command Value
- Position command values and actual position values

### Limiting the Torque/Force Command Value

On the user side, limitations are available for:

- Maximum allowed torque/force (S-0-0092, P-0-0109)
- Motive and regenerative load at stationary velocity (S-0-0082, S-0-0083)

The limit values currently effective due to the user-side limit settings are displayed in:

- P-0-0444, Actual value peak torque limit
- P-0-0442, Actual value torque limit positive (stationary)
- P-0-0443, Actual value torque limit negative (stationary)

Current command values are displayed in:

- P-0-0049, Effective torque/force command value
- P-0-0038, Torque-generating current, command value



See descriptions of the respective parameters in the separate documentation "Rexroth IndraDrive, Parameter Description"

Apart from the user-side limits, further limits take effect in the torque/force or current control loop:

- Absolute current limit values due to controller and motor
- Load-dependent (dynamic), thermal current limit values

See also "Current and Torque/Force Limitation"

### Limiting the Actual Velocity Value

On the user-side, the "torque/force control" mode allows limitation of the actual velocity value to the lower value of

- $1.125 \times$  Bipolar velocity limit value (S-0-0091)  
- and -
- maximum motor speed (S-0-0113)

.

See also "Torque/Force Control"

### Limiting the Velocity Command Value

On the user side, the "velocity control" mode allows limitation of the velocity command value via

- bipolar velocity limit value (S-0-0091)

and in the "position control" mode the limitation of the

- position command value difference (to values of S-0-0091 and S-0-0113)

.

See also "Velocity Control" and "Position Control With Cyclic Command Value Input"

### Limiting the Position

There are the following possibilities on the user side for limiting the position:

- limitation of actual position value (firmware "limit switch")

## Commissioning

- Limitation of travel range of the axis (hardware limit switch)  
See also "Limitations: Position Limitation/Travel Range Limit Switch"

**Establishing the Position Data Reference**

<b>Measuring Systems to be Evaluated in Absolute Form</b>	For measuring systems that can be evaluated in absolute form, the position data reference has to be established once during initial commissioning. See "Notes on Commissioning" in "Establishing Position Data Reference for Absolute Measuring Systems"
<b>Relative Measuring Systems</b>	For relative measuring systems all settings have to be made in such a way that the position data reference can be established internally and automatically (after switching on the machine at a command of the control master to the respective axis drive). See "Notes on Commissioning" in "Establishing Position Data Reference for Relative Measuring Systems"

**Configuring the Error Reaction/E-Stop**

The desired reaction of the drive to errors detected on the drive side has to be set.

See "Error Reactions"

The setting has to be made whether a drive is to carry out an E-Stop reaction at a hardware-side E-Stop signal and how the E-Stop reaction of the drive is to take place.

See "E-Stop Function"

**Configurations with Regard to Control Unit (Master)**

With regard to master-controlled drive operation the following settings are required:

- Presetting of operation modes (primary mode of operation and secondary operation modes)  
See "General Information on the Operation Modes: Operation Mode Handling"
- Settings for the determined primary or secondary operation modes  
See description of the respective operation mode in chapter "Operation Modes"

With regard to the master communication interface used by the control master, you can make presettings for:

- SERCOS interface  
→ When using the "IndraWorks Ds/D/MLD" commissioning tool, this is only appropriate via serial communication!
- PROFIBUS-DP
- Parallel interface
- Analog Interface

See description of the Respective Master Communication Interface

**Configurations for Diagnosis of Status Variables**

If status variables of the drive are to be evaluated during operation, these status variables can be transmitted to the control master in different ways.

Diagnostic possibilities with SERCOS interface:

- Content of a parameter cyclically updated that can be cyclically transmitted and that contains the value of the respective status variable



SERCOS interface

- Message in terms of whether a threshold value of the status variable was exceeded, via "S-0-0144, Signal status word"

See "Control Options/Additional Functions: Configurable Signal Status Word"

- Drive-internal oscilloscope function

See "Oscilloscope Function"

Diagnostic possibilities independent of the master communication interface:

- Analog output of the value of the respective status variable as voltage signal

See "Analog Outputs"

- Digital message in terms of whether a threshold value of the status variable was exceeded, by assigning bits from "S-0-0144, Signal status word"

See "Digital Inputs/Outputs"

## Configuring Further Drive Functions

Further configurable drive functions are:

- Drive Halt
- Friction torque compensation
- Detecting the marker position
- Spindle positioning
- Probe Function
- Digital Inputs/Outputs
- Analog Inputs
- Analog Outputs

See Description of the Respective Function

## 12.4.3 Simulation Mode

### Brief Description

Contained in **base package** of variants **MPH, MPC, MPB and MPD** in **open-loop and closed-loop** characteristic.

The "simulation mode" function is available for function check of controls. It enables the control to perform a program test without axis motion. To do so, the drive only needs one drive control section, the power supply, motor and encoder are not used. In operating mode, the drive is thus directly ready for enable "AB"

The function is realized via the command "Parking axis". In this process the function "permanently parked axis" is activated via parameter "P-0-0399, Configuration of simulation mode". The command and thus the axis simulation is automatically started at transition to the operating mode.

#### Pertinent Parameters

- P-0-0399, Configuration of simulation mode
- P-0-0612, Set absolute position control
- S-0-0139, C1600 Parking axis procedure command
- S-0-0147, Homing parameter

## Commissioning

## Functional Description

The function "permanently parked axis" is activated via bit 0 in parameter "P-0-0399, Configuration of simulation mode". The parameter can only be activated in parameter mode (communication phase "P2" or "P3"). When switching to the operating mode the command "Parking axis" is started automatically and the simulation mode active. The simulation mode has the following effects:

- Power control and PWM control are switched off
- Hardware monitoring encoder is switched off
- Commands for brake control are locked
- Switching to "AB" without power
- "SA" and axis number are displayed alternately in the display of the operating panel
- "AB" or "AF" are displayed in the control panel and the operation mode is displayed in the diagnostic system

The simulation mode can only be terminated by switching off bit 0 in "P-0-0399, Configuration of simulation mode" This is only possible in the parameter mode.

**Simulation Mode**

A simulation encoder (motor and external encoder) is defined which adds an actual position value from the command value of the velocity controller. This allows use of the operation modes with velocity control and position control. The axis is operated with an ideal velocity control, i.e. the command value input is converted to the actual value/mechanical system in ( $t = 0$ ).

The operation mode "torque/force" is not simulated and therefore should not be used. The same applies to the "Positive stop drive procedure" function. The torque limitation in the velocity loop remains active, the values for nominal torque and maximum torque are preset with exemplary values:

- $afMART\_NominalMoment[GLOB\_ULACHSE] = 10.0 \text{ Nm}$
- $afMART\_MaxMoment[GLOB\_ULACHSE] = 40.0 \text{ Nm}$

**Simulation Encoder**

An internal encoder type is defined for the simulation encoder. In an independent evaluation function the encoder value is integrated from the velocity command value of the velocity loop: The subsequent position processing remains unchanged. The simulation encoder cannot be set directly in parameter (P-0-0074/0075). It is only set internally.

The simulation encoder is defined as an encoder with 1024 lines (S-0-0116/0117), the multiplication (S-0-0256/0257) is calculated as known, with respect to the maximum travel range (S-0-0278).

The simulation encoder is defined as an absolute encoder and can be homed by means of "Set absolute position procedure". If the "homing" function is also required "homing" must be allowed in "P-0-0612, Set absolute position control" and "homing without home switch" and "homing without home marker" must be set in "S-0-0147, Homing parameter".



The external encoder is only simulated if encoder type 2 [P-0-0075, Encoder type 2 (optional encoder)] has been set.

---

## 13 Service and Support

Our service helpdesk at our headquarters in Lohr, Germany and our worldwide service will assist you with all kinds of enquiries. You can reach us **around the clock - even on weekend and on holidays**.

	Helpdesk	Service Hotline Worldwide
Phone	+49 (0) 9352 40 50 60	Outwith Germany please contact our sales/service office in your area first.  For hotline numbers refer to the sales office addresses on the Internet.
Fax	+49 (0) 9352 40 49 41	
E-mail	<a href="mailto:service.svc@boschrexroth.de">service.svc@boschrexroth.de</a>	
Internet	<a href="http://www.boschrexroth.com">http://www.boschrexroth.com</a> You will also find additional notes regarding service, maintenance (e.g. delivery addresses) and training.	

**Preparing Information** For quick and efficient help please have the following information ready:

- Detailed description of the fault and the circumstances
- Information on the type plate of the affected products, especially type codes and serial numbers
- Your phone, fax numbers and e-mail address so we can contact you in case of questions.



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## Notes

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