The Drive & Control Company

Rexroth
Bosch Group

Rexroth IndraDrive

Integrated Safety Technology "Safe Motion" (as of MPx-18)

Application Manual
R911338920

Edition 04

Title Rexroth IndraDrive
Integrated Safety Technology
"Safe Motion" (as of MPx-18)

Type of Documentation Application Manual

Document Typecode DOK-INDRV*-SI3*SMO-VRS-AP04-EN-P

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Purpose of Documentation This documentation

- is used to make oneself familiar with the subject of "Integrated Safety Technology "Safe Motion"",
- contains information on mounting and maintenance, on proper and safe operation and on the decommissioning of the integrated safety technology "Safe Motion" of IndraDrive Cs, IndraDrive Mi and IndraDrive M / IndraDrive ML / IndraDrive C with control sections of the Cxx02 type,
- is addressed to persons who mount, operate and maintain IndraDrive Cs, IndraDrive Mi and IndraDrive M / IndraDrive ML / IndraDrive C with control sections of the Cxx02 type with integrated safety technology "Safe Motion".

Record of revisions

Edition	Release date	Notes
DOK-INDRV*-SI3*SMO-VRS-AP01-EN-P to DOK-INDRV*-SI3*SMO-VRS-AP04-EN-P	2014-07 to 2017-07	See chapter "About this documentation", marginal note "Editions of this documentation"

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1 Introduction

1.1 Trademark information

	Sercos® is a registered trademark of Sercos International e.V.
	EtherCAT® is a registered brand and a patented technology licensed by Beckhoff Automation GmbH, Germany.
	Safety over EtherCAT® is a registered brand and a patented technology licensed by Beckhoff Automation GmbH, Germany.
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	Ethernet POWERLINK is an Ethernet-based, real-time capable field bus. Originally designed by B&R and published in 2001, the Ethernet POWERLINK is specified and further developed by the user organization Ethernet POWERLINK Standardization Group (EPSG). The specification of the protocol is open and freely accessible.
	PROFINET® (Process Field Network) is the open industrial Ethernet standard of Profibus & Profinet International (PI) for automation. PROFINET® is a registered trademark of the PROFIBUS Nutzerorganisation e. V.
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1.2 About this documentation

Editions of this documentation

Edition	Release date	Remark
DOK-INDRV*-SI3*SMO-VRS-AP01-EN-P	2014-07	First edition
DOK-INDRV*-SI3*SMO-VRS-AP02-EN-P	2016-08-12	• Optional safety technology modules (S5, SB, SD) and safety functions regarding MPx-20 *new safety functions:* – Safe absolute positions – Safe homing procedure • Pictured dialogs adjusted for commissioning with IndraWorks 14V14 • Safety bus communication "FSoE" • Explanations regarding Safe Motion firmware options (FWS) • Description of the components for controlling inductive loads "HAT02" New encoder types supported as safety technology encoders (see "Third-party motors/optional measuring systems": • ACURO®link • Resolver Description of the serial commissioning extended by version 4: "Automated serial commissioning (with new identifiers)"

<table>
<tr><th>Edition</th><th>Release date</th><th>Remark</th></tr>
<tr><td>DOK-INDRV*-SI3*SMO-VRS-AP03-EN-P</td><td>2016-12-09</td><td>Descriptions included:
• Safety function "Safe CAM (SCA)"
• Error reaction "Return motion" ("Error reaction/escalation strategy")
• Safety bus communication "PROFIsafe"
Corrections in "IO mapper inputs":
• Parameters for cam status bits of the cams corrected
• Functional connector in the example amended (create reference for the cams)
Amendment in "SDL": "P-0-3266.0.4, SMO: Tolerance time for Safe door locking"
Amendment in "error reaction": "P-0-3263.0.8, SMO: SMD-E jerk" takes effect during the delay monitoring of the safety functions SLE/SLP and error reaction
Comprehensive revision of "CIP Safety on Sercos"
Declarations of conformity updated due to new optional safety technology modules</td></tr>
<tr><td>DOK-INDRV*-SI3*SMO-VRS-AP04-EN-P</td><td>2017-07-25</td><td>• Information included on higher category and SIL in conjunction with a suitable measuring system and the firmware option "SIL3-MOTION" or "SIL3-PLUS" for the safety functions SMS, SDI, SOS, SLS, SLI, SS1, SS2 and SMD
• Formulas on "Conditions for the minimum length of a cam" revised
• Category and SIL corrected for "Safe parking axis"
• PFH, SIL, PL added for encoder types CS/CM, BS/BM (motors of MS2N type)
• New chapter "HAT02 - replacing the control module for inductive loads"
• Modified cable types (RKB0061/RKB0062 replace RKB0051/RKB0052)</td></tr>
</table>

Tab. 1-1: Record of revisions

Means of representation in this documentation

To facilitate reading of this documentation, the table below contains the means of representation and notations of recurring terms.

What?	How?	For example...
Important facts to be highlighted in the body text	Boldface	With the safety function "Safe parking axis", the following monitoring functions are **deactivated**: ...
Parameter names, diagnostic message names, function designations	Quotation marks	The missing speed information can be replaced via the control bit "defined safety with parked axis" in "P-0-3231.0.4, SMO: System configuration".

Tab. 1-2: Conventions of notation

Notes and tips are highlighted in the text. A symbol tells you what kind of note or tip is used in the text:

☞ This box contains important information that should be taken into consideration.

This symbol highlights useful tips and tricks.

Signal words in accordance with ANSI Z535.6-2011 draw the reader's attention to hazards (see "Explanation of signal words and the safety alert symbol").

Structure of documentation

Concerning integrated safety technology, the descriptions of the IndraDrive systems have the following structure:

- Application Manual of the optional safety technology modules "Safe Motion" ("S3", "S4", "S5", "SB", "SD") (this documentation)
  - is used to make oneself familiar with the subject of "Integrated Safety Technology "Safe Motion"",
  - contains information on mounting and maintenance, on proper and safe operation and on the decommissioning of the integrated safety technology "Safe Motion" of IndraDrive Cs, IndraDrive Mi and IndraDrive M / IndraDrive ML / IndraDrive C with control sections of the Cxx02 type,
  - is addressed to persons who mount, operate and maintain IndraDrive Cs, IndraDrive Mi and IndraDrive M / IndraDrive ML / IndraDrive C with control sections of the Cxx02 type with integrated safety technology "Safe Motion".
- Application Manual of the optional safety technology modules "Safe Torque Off" ("L3", "L4")
  - is used to make oneself familiar with the subject of "Integrated Safety Technology "Safe Torque Off"",
  - contains information on mounting and maintenance, on proper and safe operation and on the decommissioning of the integrated safety technology "Safe Torque Off" of IndraDrive Cs, IndraDrive Mi, IndraDrive M / IndraDrive ML / IndraDrive C with control sections of the Cxx02 type,
  - is addressed to persons who mount, operate and maintain IndraDrive Cs, IndraDrive Mi, IndraDrive M / IndraDrive ML / IndraDrive C with control sections of the Cxx02 type with integrated safety technology "Safe Torque Off".
- Project Planning Manuals

  Assist with electrical design and installation of the drive system, as well as its components
- **Parameter description** for Rexroth IndraDrive with the firmware versions MPx-1n and above, and PSB

  Apart from the specific safety technology parameters, all other drive parameters are documented in the Parameter Description
- **Description of diagnostic messages** for Rexroth IndraDrive with the firmware versions MPx-1n and above, and PSB

  Apart from the specific diagnostic messages of safety technology, all other diagnostic messages are documented in the Description of Diagnostic Messages (also called "Troubleshooting Guide").

For an overview of reference documentations, please refer to: "Reference documentations"

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

We need the following information to handle your feedback:

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

1.3 Reference documentations

1.3.1 Drive systems, system components

Drive systems, system components

Title Rexroth IndraDrive …	Kind of documentation	Document typecode[1)] DOK-INDRV*-…	Material number R911…
…Cs Drive Systems with HCS01	Project Planning Manual	HCS01******-PRxx-EN-P	322210
…Mi Drive Systems with KCU02 KSM02, KMS02/03, KMV03	Project Planning Manual	KCU02+KSM02-PRxx-EN-P	335703
Drive Systems with HMV01/02 HMS01/02, HMD01, HCS02/03	Project Planning Manual	SYSTEM*****-PRxx-EN-P	309636
Supply Units, Power Sections HMV, HMS, HMD, HCS02, HCS03	Project Planning Manual	HMV-S-D+HCS-PRxx-EN-P	318790
ML, Drive Systems with HMU05	Project Planning Manual	Hxx05******-PRxx-EN-P	344279
Drive Controllers Control Sections CSB01, CSH01, CDB01	Project Planning Manual	CSH********-PRxx-EN-P	295012
Control Sections CSE02, CSB02, CDB02, CSH02	Project Planning Manual	Cxx02******-PRxx-EN-P	338962
Additional Components and Accessories	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)

Tab. 1-3: Documentations – Drive systems, system components

1.3.2 Motors

Title Rexroth IndraDyn …	Type of documentation	Document typecode[1)] DOK-MOTOR*-…	Material number R911…
A Asynchronous Motors MAD / MAF	Project Planning Manual	MAD/MAF****-PRxx-EN-P	295781
H Synchronous Kit Spindle Motors	Project Planning Manual	MBS-H******-PRxx-EN-P	297895
L Synchronous Linear Motors	Project Planning Manual	MLF********-PRxx-EN-P	293635

Title Rexroth IndraDyn …	Type of documentation	Document typecode[1)] DOK-MOTOR*-…	Material number R911…
L Ironless Linear Motors MCL	Project Planning Manual	MCL********-PRxx-EN-P	330592
S Synchronous Motors MKE	Project Planning Manual	MKE*GEN2***-PRxx-EN-P	297663
S Synchronous Motors MSK	Project Planning Manual	MSK********-PRxx-EN-P	296289
S Synchronous Motors MSM	Data Sheet	MSM********-DAxx-EN-P	329338
S Synchronous Motors MS2N	Project Planning Manual	MS2N*******-PRxx-EN-P	347583
T Synchronous Torque Motors	Project Planning Manual	MBT********-PRxx-EN-P	298798

1) In the document typecodes, "xx" is a placeholder for the current edition of the documentation (e.g.: PR01 is the first edition of a Project Planning Manual)

Tab. 1-4: Documentations – motors

1.3.3 Gearboxes

Title	Kind of documentation	Document typecode[1)]	Material number
Rexroth GTP Planetary Gearboxes	Project Planning Manual	DOK-GEAR**-GTP********-PRxx-EN-P	R911267495
Rexroth GTM Planetary Gearboxes	Project Planning Manual	DOK-GEAR**-GTM********-PRxx-EN-P	R911297321
Rexroth GTE Planetary Gearboxes	Project Planning Manual	DOK-GEAR**-GTE********-PRxx-EN-P	R911308842

1) In the document typecodes, "xx" is a wild card for the current edition of the documentation (example: RE02 is the second edition of a Reference Book)

Tab. 1-5: Documentations – Gearboxes

1.3.4 Cables

Title	Kind of documentation	Document typecode[1)] DOK-CONNEC-…	Material number R911…
Rexroth Connection Cables IndraDrive and IndraDyn	Selection Data	CABLE*INDRV-CAxx-EN-P	322949

1) In the document typecodes, "xx" is a wild card for the current edition of the documentation (example: CA02 is the second edition of the documentation "Selection Data")

Tab. 1-6: Documentations – Cables

1.3.5 Firmware

Title Rexroth IndraDrive ...	Type of documentation	Document typecode[1)] DOK-INDRV*-…	Material number R911…
MPx-20 Functions	Application Manual	MP*-20VRS**-APxx-EN-P	345608
MPx-20 Version Notes	Release Notes	MP*-20VRS**-RNxx-EN-P	345606

Title Rexroth IndraDrive ...	Type of documentation	Document typecode[1)] DOK-INDRV*-…	Material number R911…
Power Supply Basic PSB-20 Functions	Application Manual	PSB-20VRS**-APxx-EN-P	345610
Power Supply Basic PSB-19 Functions	Application Manual	PSB-19VRS**-APxx-EN-P	345602
MPx-18 Functions	Application Manual	MP*-18VRS**-APxx-EN-P	338673
MPx-18 Version Notes	Release Notes	MP*-18VRS**-RNxx-EN-P	338658
MPx-17 Functions	Application Manual	MP*-17VRS**-APxx-EN-P	331236
MPx-17 Version Notes	Release Notes	MP*-17VRS**-RNxx-EN-P	331588
MPx-16 Functions	Application Manual	MP*-16VRS**-APxx-EN-P	326767
MPx-16 Version Notes	Release Notes	MP*-16VRS**-RNxx-EN-P	329272
MPx-16 to MPx-20 and PSB Parameters	Reference Book	GEN1-PARA**-RExx-EN-P	328651
MPx-16 to MPx-20 and PSB Diagnostic Messages	Reference Book	GEN1-DIAG**-RExx-EN-P	326738
Integrated Safety Technology "Safe Torque Off" (as of MPx-16)	Application Manual	SI3-**VRS**-APxx-EN-P	332634
Integrated Safety Technology "Safe Motion" (as of MPx-18)	Application Manual	SI3*SMO-VRS-APxx-EN-P	338920
Rexroth IndraMotion MLD Libraries as of MPx-17	Reference Book	MLD-SYSLIB2-RExx-EN-P	332627
Rexroth IndraMotion MLD Libraries as of MPx-18	Reference Book	MLD-SYSLIB3-RExx-EN-P	338916
Rexroth IndraMotion MLD as of MPx-17	Application Manual	MLD2-**VRS*-APxx-EN-P	334351
Rexroth IndraMotion MLD as of MPx-18	Application Manual	MLD3-**VRS*-APxx-EN-P	338914

1) In the document typecodes, "xx" is a placeholder for the current edition of the documentation (e.g.: RE02 is the second edition of a Reference Book)

Tab. 1-7: Documentations – Firmware

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.

⚠ WARNING **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 their 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 install damaged or faulty products or put them into 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 electric motors and monitor their operation.

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

☞ 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 to ensure that the motor executes the specific functions of an application.

Drive controllers of the Rexroth IndraDrive series 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:

- Handling and mounting systems
- Packaging and food machines
- Printing and paper processing machines
- 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 may 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 may 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 Rexroth IndraDrive system are **products of Category C3** (with restricted distribution) in accordance with IEC 61800-3. This Category comprises EMC limit values for line-based and radiated noise emission. Compliance with this Category (limit values) requires the appropriate measures of interference suppression to be used in the drive system (e.g., mains filters, shielding measures).

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 interference suppression.

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3 Safety instructions for electric drives and controls

3.1 Definitions of terms

Application documentation Application documentation comprises 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: Operating Instructions, Commissioning Manual, Instruction Manual, Project Planning Manual, Application Description, etc.

Component A component is a combination of elements with a specified function, which are part of a piece of equipment, device or system. Components of the electric drive and control system are, for example, supply units, drive controllers, mains choke, mains filter, motors, cables, etc.

Control system A control system comprises several interconnected control components placed on the market as a single functional unit.

Device A device is a finished product with a defined function, intended for users and placed on the market as an individual piece of merchandise.

Electrical equipment Electrical equipment encompasses all devices used to generate, convert, transmit, distribute or apply electrical energy, such as electric motors, transformers, switching devices, cables, lines, power-consuming devices, circuit board assemblies, plug-in units, control cabinets, etc.

Electric drive system An electric drive system comprises all components from mains supply to motor shaft; this includes, for example, electric motor(s), motor encoder(s), supply units and drive controllers, as well as auxiliary and additional components, such as mains filter, mains choke and the corresponding lines and cables.

Installation An installation consists of 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.

Machine A machine is the 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.

Manufacturer The manufacturer is an 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, the manufacturer must always have overall control and possess the required authority to take responsibility for the product.

Product Examples of a product: Device, component, part, system, software, firmware, among other things.

Project Planning Manual A Project Planning Manual is part of the application documentation used to support the sizing and planning of systems, machines or installations.

Qualified persons 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 electric 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,

- to be trained, instructed or authorized to switch electric circuits and devices safely on and off, to ground them and to mark them.
- to be trained or instructed to maintain and use adequate safety equipment.
- to attend a course of instruction in first aid.

User A user is 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 components of the electric 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.

3.2.2 Requirements for safe use

Read the following instructions before initial commissioning of the components of the electric 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 electric 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 components of the electric drive and control system are operated.
- Only use the components of the electric drive and control system in the manner that is defined as appropriate. See chapter "Appropriate Use".
- The ambient and operating conditions given in the available application documentation must be observed.

- Applications for functional safety are only allowed if clearly and explicitly specified in the application documentation "Integrated Safety Technology". If this is not the case, they are excluded. Functional safety is a safety concept in which measures of risk reduction for personal safety depend on electrical, electronic or programmable control systems.
- 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 manufacturers must

  – make sure that the delivered components are suited for their individual application and check the information given in this application documentation with regard to the use of the components,
  – make sure that their 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 has to comply with

- European countries: In accordance with 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!
- 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!

3.3 Instructions with regard to specific dangers

3.3.1 Protection against contact with electrical parts and housings

☞ This section concerns components of the electric 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 electric drive and control system, it is unavoidable that some parts of these components conduct dangerous voltage.

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 components of the electric 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 any electrical connection points of the components while power is turned on.
- Do not remove or plug in connectors when the component has been powered.
- Under specific conditions, electric drive systems can be operated at mains protected by residual-current-operated circuit-breakers sensitive to universal current (RCDs/RCMs).

- 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.

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 electric drive and control system to the equipment grounding conductor at the grounding points.
- Connect the equipment grounding conductor of the components of the electric 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 minimum cross section according to the table below. With an outer conductor cross section smaller than 10 mm^2 (8 AWG), the alternative connection of two equipment grounding conductors is allowed, each having the same cross section as the outer conductors.

<table>
<tr><th rowspan="2">Cross section outer conductor</th><th colspan="2">Minimum cross section equipment grounding conductor
Leakage current ≥ 3.5 mA</th></tr>
<tr><th>1 equipment grounding conductor</th><th>2 equipment grounding conductors</th></tr>
<tr><td>1.5 mm^2 (16 AWG)</td><td rowspan="5">10 mm^2 (8 AWG)</td><td>2 × 1.5 mm^2 (16 AWG)</td></tr>
<tr><td>2.5 mm^2 (14 AWG)</td><td>2 × 2.5 mm^2 (14 AWG)</td></tr>
<tr><td>4 mm^2 (12 AWG)</td><td>2 × 4 mm^2 (12 AWG)</td></tr>
<tr><td>6 mm^2 (10 AWG)</td><td>2 × 6 mm^2 (10 AWG)</td></tr>
<tr><td>10 mm^2 (8 AWG)</td><td>-</td></tr>
<tr><td>16 mm^2 (6 AWG)</td><td rowspan="3">16 mm^2 (6 AWG)</td><td>-</td></tr>
<tr><td>25 mm^2 (4 AWG)</td><td>-</td></tr>
<tr><td>35 mm^2 (2 AWG)</td><td>-</td></tr>
<tr><td>50 mm^2 (1/0 AWG)</td><td>25 mm^2 (4 AWG)</td><td>-</td></tr>
<tr><td>70 mm^2 (2/0 AWG)</td><td>35 mm^2 (2 AWG)</td><td>-</td></tr>
<tr><td>...</td><td>...</td><td>...</td></tr>
</table>

Tab. 3-1: Minimum cross section of the equipment grounding connection

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.

On components of an electric drive and control system provided by Rexroth, all connections and terminals with voltages up to 50 volts are PELV ("Protective Extra-Low Voltage") systems. It is allowed to connect devices equipped with basic 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").

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 electric 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.

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 electric 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 stopping switches in the immediate reach of the operator. Before commissioning, verify that the emergency stopping equip-

ment works. Do not operate the machine if the emergency stopping switch is not working.

- Prevent unintended start-up. Isolate the drive power connection by means of OFF switches/OFF buttons or use a safe starting lockout.
- Make sure that the drives are brought to 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 counterbalancing 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 electric drive and control system using the master switch and secure them from reconnection ("lock out") 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 components of the electric drive and control system and their supply leads. If the use of these devices cannot be avoided, check the machine or installation, at initial commissioning of the electric 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 electromagnetic and magnetic fields during operation and mounting

Electromagnetic and magnetic fields!

Health hazard for persons with active implantable medical devices (AIMD) such as pacemakers or passive metallic implants.

- Hazards for the above-mentioned groups of persons by electromagnetic and magnetic fields in the immediate vicinity of drive controllers and the associated current-carrying conductors.
- Entering these areas can pose an increased risk to the above-mentioned groups of persons. They should seek advice from their physician.
- If overcome by possible effects on above-mentioned persons during operation of drive controllers and accessories, remove the exposed persons from the vicinity of conductors and devices.

3.3.5 Protection against contact with hot parts

Hot surfaces of components of the electric 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 sufficient period of 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 in accordance with the respective safety regulations, the manufacturer of the machine or installation must take measures to avoid injuries caused by burns in the final 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

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 falling!

3.3.7 Battery safety

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

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.

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.

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 falling!

☞ 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.

3.4 Explanation of signal words and the Safety alert symbol

The Safety Instructions in the available application documentation contain specific signal words (DANGER, WARNING, CAUTION or NOTICE) and, where required, a safety alert symbol (in accordance with ANSI Z535.6-2011).

The signal word is meant to draw the reader's attention to the safety instruction and identifies the hazard severity.

The safety alert symbol (a triangle with an exclamation point), which precedes the signal words DANGER, WARNING and CAUTION, is used to alert the reader to personal injury hazards.

⚠ DANGER

In case of non-compliance with this safety instruction, death or serious injury **will** occur.

⚠ WARNING

In case of non-compliance with this safety instruction, death or serious injury **could** occur.

⚠ CAUTION

In case of non-compliance with this safety instruction, minor or moderate injury could occur.

NOTICE

In case of non-compliance with this safety instruction, property damage could occur.

4 System overview

4.1 Introduction

4.1.1 Motivation and objectives

Overview

The operational safety of machines and installations depends largely upon the extent of dangerous movements generated by the machine.

In normal operation (also called productive operation or automatic operation), protective equipment prevents humans from accessing danger zones and keeps parts / materials from being thrown outward.

In the special mode (also called manual mode or setting-up mode), it is often necessary for persons to access danger zones when the entire installation has not been de-energized. In such situations machine operators must be protected by mechanisms internal to the drive and the control unit.

The integrated Rexroth safety technology provides the user the requirements, on the control unit and drive side, for realizing functions of personal and machine protection with a minimum of planning and installation work required. Compared to conventional safety technology, the integrated safety technology considerably increases the functionality and availability of your machine. Integrated safety technology is characterized by the following features:

- Complies with valid standards
- Increased system performance
- Reduced system costs
- Easy understanding of complex subjects
- Improved diagnostics
- Simplified certification
- Easy commissioning
- Independent of control units

Comparison with conventional safety technology

A drive and control system with integrated safety technology differs from systems with conventional safety technology by the fact that the safety functions are directly integrated in the intelligent drives in the form hardware and software. This increases the functionality in all operation modes with a maximum of safety (short reaction times).

The following components of conventional safety technology are not included in drive and control systems with integrated safety technology:

- Motor zero-speed relay for monitoring safe standstill
- Speed monitor for monitoring safely-reduced velocities
- Power contactors between controllers and motors
- Limit switches or position cams for detection of range

Using the integrated safety technology increases the available personnel and machine safety, because the total reaction time of the system in the case of an error event, for example, is considerably reduced with regard to comparable systems with conventional safety technology.

With the optional modules "Sx", the safety signals are preferably transmitted via the safety bus, i.e. without additional hardware. At present, "CIP Safety on sercos" is supported as safety bus.

The discrete wiring of the safe input signals can only be carried out for the optional module "S4" and "S5" via the safety zone module "HSZ01"; the wiring can be carried out in redundant form or via a safe wiring with fault exclusion. The wiring type basically depends on the safety level to be achieved.

4.1.2 Conceptual overview

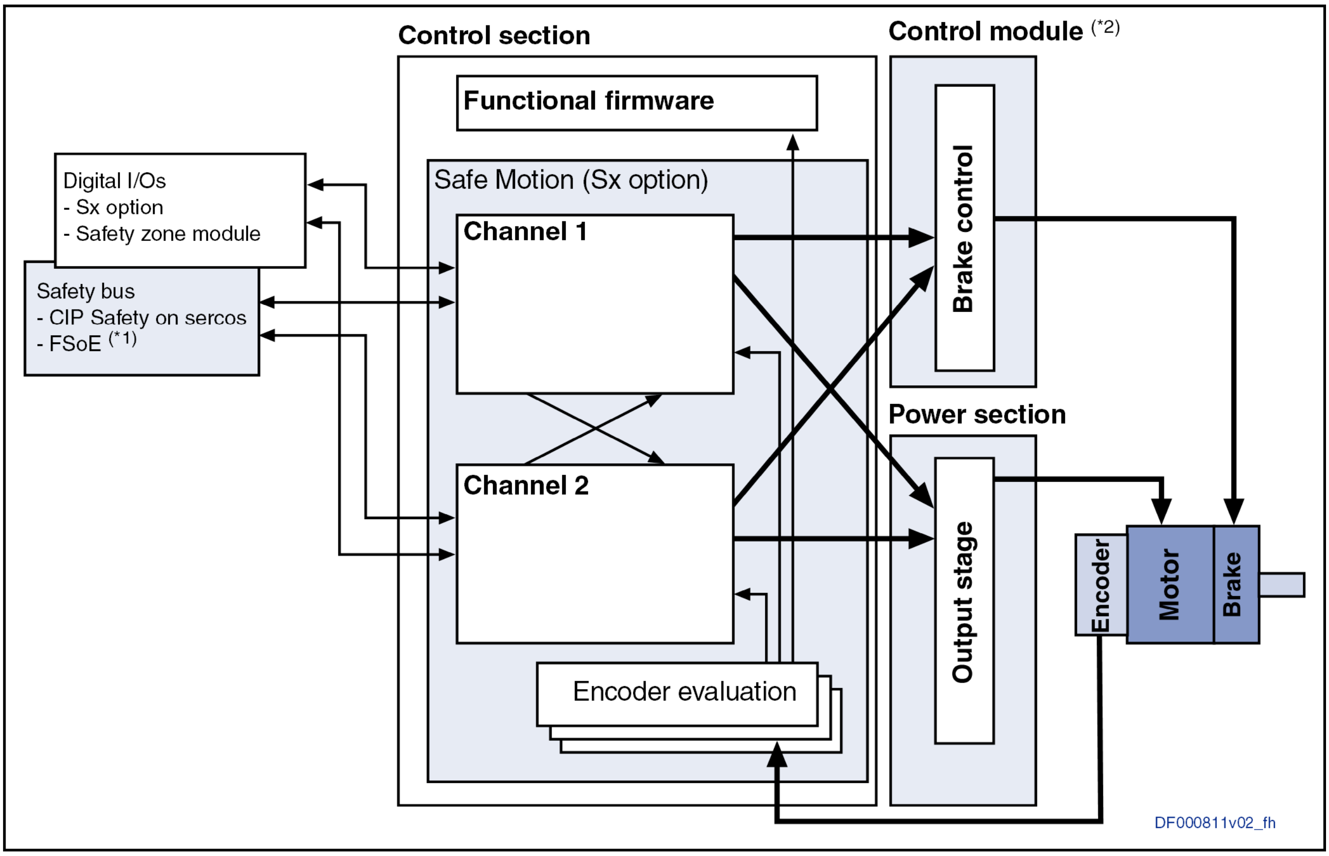
An IndraDrive system consists of the components power section, control section (incl. firmware) and motor, and the possibly required additional components.

The integrated safety technology is implemented based on the interaction of the hardware and firmware components.

☞ The figure below shows the **schematic diagram of IndraDrive controllers** with integrated safety technology "Safe Motion".

The special feature of the IndraDrive Mi system with the motor-integrated servo drive KSM02 is that the drive controller and the motor are one unit.

The **Safe Brake Control** ["(SBC)"] can be used in drive systems of the IndraDrive Cs, IndraDrive Mi (KMS03), IndraDrive M, IndraDrive C, IndraDrive ML drive families.



*1 Available in MPx-20 and above
*2 with IndraDrive Cs and KMS03 integrated into the device; for all other drive families, the external control unit "HAT02" is required

Fig. 4-1: Schematic diagram IndraDrive with integrated safety technology "SMO (Safe Motion)"

4.2 Product presentation

4.2.1 What is "integrated safety technology (Safe Motion)"?

IndraDrive Cs

The control sections of the IndraDrive Cs range can be equipped with the optional modules "S4", "S5" and "SB".

Using the mentioned optional modules, IndraDrive Cs is equipped with integrated safety technology which provides the user with universally parameterizable safe motion monitoring or standstill monitoring.

The **encoder-dependent** safety functions are applicable for personal protection at machines according to ISO 13849-1 Category 3, PL d and IEC 62061 SIL 2; the safety functions **independent of an encoder** are applicable for personal protection at machines according to ISO 13849-1 Category 4, PL e and IEC 62061 SIL 3.

Using the optional expansion package "SIL3-MOTION" or "SIL3-PLUS", the **encoder-dependent** safety functions are also applicable for personal protection at machines according to IEC 62061 SIL 3.

IndraDrive Mi

The IndraDrive Mi systems with the motor-integrated servo drive KSM02 and the near motor servo drive KMS02 can be equipped with the optional module "S3" [Safe Motion (without SBC)].

Using the optional module "S3", IndraDrive Mi is equipped with integrated safety technology which provides the user with universally parameterizable safe motion monitoring or standstill monitoring.

The IndraDrive Mi drive systems with the motor-integrated servo drive KSM02 and the near motor servo drives KMS02 / KMS03 can be equipped with the optional module "SD" [Safe Motion (with SBC)].

The **encoder-dependent** safety functions are applicable for personal protection at machines according to ISO 13849-1 Category 3, PL d and IEC 62061 SIL 2; the safety functions **independent of an encoder** are applicable for personal protection at machines according to ISO 13849-1 Category 4, PL e and IEC 62061 SIL 3.

Using the optional expansion package "SIL3-MOTION" or "SIL3-PLUS", the **encoder-dependent** safety functions are also applicable for personal protection at machines according to IEC 62061 SIL 3.

Using the KCU02.**2** drive connection box, the safety functions are applicable for personal protection at machines according to ISO 13849-1 Category 3, PL d and IEC 62061 SIL 3.

Using the KCU02.**3** drive connection box, the safety functions are applicable for personal protection at machines according to ISO 13849-1 Category 4, PL e and IEC 62061 SIL 3.

☞ For using the integrated safety technology "S3"/"SD", at least the design "2" or higher of the KCU02 drive connection box has to be used.

IndraDrive ML / IndraDrive M / IndraDrive C

The Cxx02 control sections of the IndraDrive ML / IndraDrive M / IndraDrive C ranges can be equipped with the optional modules "S4", "S5" and "SB".

Using the mentioned optional modules, IndraDrive ML / IndraDrive M / IndraDrive C are equipped with integrated safety technology which provides the user with universally parameterizable safe motion monitoring or standstill monitoring.

The **encoder-dependent** safety functions are applicable for personal protection at machines according to ISO 13849-1 Category 3, PL d and IEC 62061 SIL 2; the safety functions **independent of an encoder** are applicable for personal protection at machines according to ISO 13849-1 Category 4, PL e and IEC 62061 SIL 3.

Using the optional expansion package "SIL3-MOTION" or "SIL3-PLUS", the **encoder-dependent** safety functions are also applicable for personal protection at machines according to IEC 62061 SIL 3.

Selecting the function

The safety functions can be alternatively selected, either

- centrally via 24 V inputs of a safety zone module (HSZ01) [1)] or
- the safe channel in sercos (CIP safety on sercos) or
- the safe channel in EtherCat (FailSafe over EtherCat) or
- centrally via 24 V inputs of a safety zone module (HSZ01) **and** "CIP safety on sercos" (parallel selection of the same safety function is possible) [1)]

[1)] not possible with IndraDrive Mi

Certification

The safety technology was certified by TÜV Rheinland ®; the NRTL listing by TÜV Rheinland of North America is in preparation.

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 unit and the supply modules. It is available as a functional characteristic of the standard drive system. The following requirements can be implemented in the machine or in the installation:

- Measures in accordance with 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 ISO 13849-1 Category 4, PL e and IEC 62061 SIL 3, as required in EN 1010-1 (printing and paper converting machines), ISO 23125 (turning machines) and EN 12417 (machining centres).
- Control functions in the case of an error according to IEC 60204-1 ("homogeneous redundancy").

4.2.2 Integrated safety technology as IndraDrive platform solution

Characteristics of IndraDrive Cs

The following type code shows the different characteristics of IndraDrive Cs:

Short type designation	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	20	1	2	3	4	5	6	7	8	9	30	1	2	3	4	5	6	7	8	9	40
Example:	H	C	S	0	1	.	1	E	-	W	0	0	1	3	-	A	-	0	2	-	E	-	S	3	-	E	C	-	N	N	-	N	N	-	N	N	-	F	W	
	①			②			③	④		⑤	⑥					⑦		⑧			⑨		⑩			⑪			⑫			⑬			⑭			⑮		

①	**Product:** HCS = HCS
②	**Series:** 01 = 01

Short type designation	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	20	1	2	3	4	5	6	7	8	9	30	1	2	3	4	5	6	7	8	9	40
Example:	H	C	S	0	1	.	1	E	-	W	0	0	1	3	-	A	-	0	2	-	E	-	S	3	-	E	C	-	N	N	-	N	N	-	N	N	-	F	W	
	①			②			③	④		⑤	⑥					⑦		⑧			⑨		⑩			⑪			⑫			⑬			⑭			⑮		

③	**Design:** 1 = 1
④	**Power supply unit:** E = Feeding
⑤	**Cooling type:** W = Air, internal
⑥	**Maximum current** 1)**:** 0003 = 3 A 0005 = 5 A 0006 = 6 A 0008 = 8 A 0009 = 9 A 0013 = 13 A 0018 = 18 A 0028 = 28 A 0054 = 54 A
⑦	**Degree of protection:** A = IP20
⑧	**Mains connection voltage** 1)**:** 02 = 3 × AC 110 … 230 V 03 = 3 × AC 200 … 500 V
⑨	**Control section design** 2)**:** A = ADVANCED B = BASIC E = ECONOMY
⑩	**Communication** 2)**:** S3 = sercos 3 / EtherCAT CC = sercos 3 master (cross communication) ET = Multi-Ethernet
⑪	**Interface 1:** EC = Multi-encoder interface

Short type designation	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	20	1	2	3	4	5	6	7	8	9	30	1	2	3	4	5	6	7	8	9	40
Example:	H	C	S	0	1	.	1	E	-	W	0	0	1	3	-	A	-	0	2	-	E	-	S	3	-	E	C	-	N	N	-	N	N	-	N	N	-	F	W	
	①			②			③	④		⑤	⑥					⑦		⑧			⑨		⑩			⑪			⑫			⑬			⑭			⑮		

⑫	**Interface 2 2)**: CN = CANopen DA = Digital/analog I/O extension EC = Multi-encoder interface EP = Engineering port EM = Encoder emulation ET = Multi-Ethernet NN = Not equipped PB = PROFIBUS
⑬	**Interface 3 2) 3)**: L3 = STO (Safe Torque Off) L4 = STO (Safe Torque Off) and SBC NN = Not equipped S4 = Safe Motion S5 = Safe Motion SB = Safe Motion Bus
⑭	**Other design:** NN = None
⑮	**Firmware:** FW = With control panel, firmware has to be ordered separately NW = Without control panel, without firmware

1) See table "Possible combinations of maximum current and mains connection voltage"
2) See table "Possible combinations of options"
3) The L3, S4, S5 and SB interfaces guarantee both the function and the certification

Tab. 4-1: Type code HCS01

Possible combinations of maximum current and mains connection voltage:

Mains connection voltage [V]	Maximum current [A]								
	3	5	6	8	9	13	18	28	54
3 × AC 110 … 230	✓	–	✓	–	✓	✓	✓	–	–
3 × AC 200 … 500	–	✓	–	✓	–	–	✓	✓	✓

Tab. 4-2: Possible combinations of maximum current and mains connection voltage

Possible combinations of options:

Control section design	Communication	Interface 2								Interface 3					
		CN	DA	EC	EM	EP	ET	NN	PB	L3	L4	NN	S4	S5	SB
A	CC	✓	–	✓	✓	–	✓	✓	✓	✓	✓	✓	✓	✓	✓
		–	✓	–	–	–	–	–	–	–	–	✓	–	–	–
	ET	–	–	✓	✓	–	–	✓	–	✓	✓	✓	✓	✓	✓
		–	✓	–	–	–	–	–	–	–	–	✓	–	–	–
B	ET	✓	–	✓	✓	–	–	✓	✓	✓	✓	✓	✓	✓	✓
		–	✓	–	–	–	–	–	–	–	–	✓	–	–	–
		–	–	–	–	✓	–	–	–	✓	✓	✓	–	–	–
E	S3	–	–	–	–	✓	–	✓	–	✓	✓	✓	–	–	–

Tab. 4-3: Possible combinations of options

☞ To employ the integrated safety technology "Safe Motion" "S4", it is necessary to use at least the following firmware version or higher in the drive:

- IndraDrive Cs (HCS01.1): as of MPx-18V08

To employ the integrated safety technology "Safe Motion" "S5" and "SB", it is necessary to use at least the following firmware version or higher in the drive:

- IndraDrive Cs (HCS01.1): as of MPx-20V04

Characteristics of IndraDrive Mi

The following type codes show the devices of the "IndraDrive Mi" range and their properties:

Short type designation	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	20	1	2	3	4	5	6	7	8	9	30	1	2	3	4	5	6	7	8	9	40
Example:	K	C	U	0	2	.	2	N	-	E	T	-	E	T	*	-	0	2	5	-	N	N	-	N	-	N	N	-	N	W										
	①			②			③	④		⑤			⑥				⑦				⑧			⑨		⑩			⑪											

①	**Product:** KCU = KCU
②	**Series:** 02 = 2
③	**Design:** 2 = 2
④	**Configuration option:** N = Fixed configuration
⑤	**Master communication (input):** ET = Multi-Ethernet
⑥	**Master communication (output):** ET* = Multi-Ethernet

										1										2										3										4
Short type designation	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0
Example:	K	C	U	0	2	.	2	N	-	E	T	-	E	T	*	-	0	2	5	-	N	N	-	N	-	N	N	-	N	W										
	①			②			③	④		⑤			⑥				⑦				⑧			⑨		⑩			⑪											

⑦	**DC fuse:** 025 = Nominal current: 25 A
⑧	**Interface:** NN = None
⑨	**Control panel:** N = Without
⑩	**Other design:** NN = None
⑪	**Firmware:** NW = Without firmware

Tab. 4-4: Type code KCU02.2

☞ To employ the integrated safety technology "Safe Motion (without SBC)" (S3), it is necessary to use at least the design "2" or higher of the drive connection box KCU02.

										1										2										3										4
Short type designation	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0
Example:	K	M	S	0	2	.	1	B	-	A	0	1	8	-	P	-	D	7	-	E	T	-	E	N	H	-	L	3	-	T	O	-	F	W						
	①			②			③	④		⑤	⑥				⑦		⑧			⑨			⑩				⑪			⑫			⑬							

①	**Product:** KMS = KMS
②	**Series:** 02 = 2
③	**Design:** 1 = 1
④	**Performance:** B = Basic
⑤	**Cooling type:** A = Natural convection (exterior heat sink)
⑥	**Maximum current:** 018 = 18 A
⑦	**Degree of protection:** P = IP65
⑧	**Nominal DC bus voltage:** D7 = DC 750 V

Short type designation	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Example:	K	M	S	0	2	.	1	B	-	A	0	1	8	-	P	-	D	7	-	E	T	-	E	N	H	-	L	3	-	T	O	-	F	W						
	①			②			③	④		⑤	⑥				⑦		⑧			⑨			⑩				⑪			⑫			⑬							

⑨	**Master communication:** ET = Multi-Ethernet
⑩	**Encoder interface:** ENH = Encoder Hiperface NNN = Without
⑪	**Safety option:** L3 = Safe Torque Off (STO) S3 = Safe Motion (without SBC) [1)] SD = Safe Motion (with SBC) [1)] NN = Without
⑫	**Other design:** NN = Without TO = Multi-Ethernet output coupling (2 × M12) ES = External master communication Multi-Ethernet (2 × M12)
⑬	**Firmware:** FW = Firmware has to be ordered as a separate subposition

1) Only if encoder interface = ENH

Tab. 4-5: Type code KMS02

Short type designation	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Example:	K	M	S	0	3	.	1	B	-	A	0	3	6	-	P	-	D	7	-	E	T	-	E	N	D	-	L	3	-	T	O	-	F	W						
	①			②			③	④		⑤	⑥				⑦		⑧			⑨			⑩				⑪			⑫			⑬							

①	**Product:** KMS = KMS
②	**Series:** 03 = 3
③	**Design:** 1 = 1
④	**Performance:** B = Basic
⑤	**Cooling type:** A = Natural convection (exterior heat sink) B = Thermal interface
⑥	**Maximum current:** 036 = 36 A

System overview

Short type designation	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	20	1	2	3	4	5	6	7	8	9	30	1	2	3	4	5	6	7	8	9	40
Example:	K	M	S	0	3	.	1	B	-	A	0	3	6	-	P	-	D	7	-	E	T	-	E	N	D	-	L	3	-	T	O	-	F	W						
	①			②			③	④		⑤	⑥				⑦		⑧			⑨			⑩				⑪			⑫			⑬							

⑦	**Degree of protection:** P = IP65
⑧	**Nominal DC bus voltage:** D7 = DC 750 V
⑨	**Master communication:** ET = Multi-Ethernet
⑩	**Encoder interface:** END = Encoder Hiperface® and digital encoder
⑪	**Safety option:** L3 = Safe Torque Off (STO) SD = Safe Motion (with SBC) 1) NN = Without
⑫	**Other design:** ES = External master communication Multi-Ethernet (2 × M12) NN = Without TO = Multi-Ethernet output coupling (2 × M12)
⑬	**Firmware:** FW = Firmware has to be ordered as a separate subposition

1) Only if encoder interface = END

Tab. 4-6: Type code KMS03

Short type designation	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	20	1	2	3	4	5	6	7	8	9	30	1	2	3	4	5	6	7	8	9	40
Example:	K	S	M	0	2	.	1	B	-	0	6	1	C	-	3	5	N	-	M	1	-	H	P	0	-	E	T	-	N	N	-	D	7	-	N	N	-	F	W	
	①			②			③	④		⑤			⑥		⑦		⑧		⑨			⑩	⑪	⑫		⑬			⑭			⑮			⑯			⑰		

①	**Product:** KSM = KSM
②	**Series:** 02 = 2
③	**Design:** 1 = 1
④	**Performance:** B = Basic

Short type designation	1	2	3	4	5	6	7	8	9	1 0	1	2	3	4	5	6	7	8	9	2 0	1	2	3	4	5	6	7	8	9	3 0	1	2	3	4	5	6	7	8	9	4 0
Example:	K	S	M	0	2	.	1	B	-	0	6	1	C	-	3	5	N	-	M	1	-	H	P	0	-	E	T	-	N	N	-	D	7	-	N	N	-	F	W	
	①			②			③	④		⑤			⑥		⑦		⑧		⑨			⑩	⑪	⑫		⑬			⑭			⑮			⑯			⑰		

⑤	**Size:** 041 = Size 041 061 = Size 061 071 = Size 071 076 = Size 076
⑥	**Length:** C = Length C
⑦	**Winding:** 24 = Winding 24 35 = Winding 35 42 = Winding 42 61 = Winding 61
⑧	**Cooling type:** N = Natural convection
⑨	**Encoder:** S1 = Optical encoder, Hiperface single-turn, 128 signal periods S3 = Capacitive encoder, Hiperface single-turn, 16 signal periods M1 = Optical encoder, Hiperface multi-turn absolute, 128 signal periods M3 = Capacitive encoder, Hiperface multi-turn absolute, 16 signal periods
⑩	**Electrical connection:** H = Connector, hybrid
⑪	**Shaft:** G = Plain shaft with shaft sealing ring P = Shaft with keyway according to DIN 6885-1 with shaft sealing ring
⑫	**Holding brake:** 0 = Without holding brake 2 = Holding brake, DC 24 V, electrically releasing
⑬	**Master communication:** ET = Multi-Ethernet
⑭	**Safety option:** L3 = Safe Torque Off (STO) NN = Without safety technology S3 = Safe Motion (without SBC) SD = Safe Motion (with SBC)
⑮	**Supply voltage:** D7 = DC 750 V

Short type designation	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	20	1	2	3	4	5	6	7	8	9	30	1	2	3	4	5	6	7	8	9	40
Example:	K	S	M	0	2	.	1	B	-	0	6	1	C	-	3	5	N	-	M	1	-	H	P	0	-	E	T	-	N	N	-	D	7	-	N	N	-	F	W	
	①			②			③	④		⑤			⑥		⑦		⑧		⑨			⑩	⑪	⑫		⑬			⑭			⑮			⑯			⑰		

⑯	**Other design:** AE = ATEX version, external master communication Multi-Ethernet (2 × M12) AN = ATEX version AT = ATEX version, Multi-Ethernet output coupling (2 × M12) ES = External master communication Multi-Ethernet (2 × M12) NN = None TO = Multi-Ethernet output coupling (2 × M12)
⑰	**Firmware:** FW = Firmware has to be ordered as a separate subposition

Tab. 4-7: KSM02 type code

To employ the integrated safety technology "Safe Motion (without SBC)" (S3), it is necessary to use at least the following firmware version or higher in the drive:

- IndraDrive Mi (KSM02.x): as of MPB-18V08
- IndraDrive Mi (KMS02.x): as of MPB-18V08

To employ the integrated safety technology "Safe Motion (with SBC)" (SD), it is necessary to use at least the following firmware version or higher in the drive:

- IndraDrive Mi (KSM02.x): as of MPB-20V04
- IndraDrive Mi (KMS02.x/KMS03.x): as of MPB-20V04

Characteristics of IndraDrive M / IndraDrive C

The following type codes show the different characteristics of the control sections of IndraDrive C / IndraDrive M:

Short type designation	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	20	1	2	3	4	5	6	7	8	9	30	1	2	3	4	5	6	7	8	9	40
Example:	C	S	B	0	2	.	1	B	-	E	T	-	E	C	-	P	B	-	L	3	-	E	C	-	N	N	-	F	W											
	①			②			③	④		⑤			⑥			⑦			⑧			⑨			⑩			⑪												

①	**Product:** CSB = Single-axis control section BASIC
②	**Series:** 02 = 02
③	**Design:** 1 = 1
④	**Interface equipment:** A = Basic scope B = Extended scope

										1										2										3										4
Short type designation	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0
Example:	C	S	B	0	2	.	1	B	-	E	T	-	E	C	-	P	B	-	L	3	-	E	C	-	N	N	-	F	W											
	①			②			③	④		⑤			⑥			⑦			⑧			⑨			⑩			⑪											

⑤	**Communication:** ET = Multi-Ethernet
⑥	**Interface 1:** EC = Multi-encoder interface
⑦	**Interface 2:** NN = Not equipped PB = PROFIBUS CN = CANopen EC = Multi-encoder interface EM = Encoder emulation EP = Engineering port
⑧	**Interface 3 (safety technology)** 2): NN = Not equipped L3 = STO (Safe Torque Off) S4 = Safe Motion 2) S5 = Safe Motion 2) SB = Safe Motion Bus 2)
⑨	**Interface 4:** NN = Not equipped EC = Multi-encoder interface 3) EM = Encoder emulation 4) DA = Digital/analog I/O extension 2)
⑩	**Other design:** NN = None
⑪	**Firmware:** AW = With Advanced control panel, firmware has to be ordered separately FW = With Standard control panel, firmware has to be ordered separately NW = Without control panel, without firmware

1) The L3, S4, S5 and SB interfaces guarantee both the function and the certification
2) Only if interface equipment = B
3) Only if interface equipment = B and interface 2 = PB, CN or EP
4) Only if interface equipment = B and interface 2 = PB, CN, EP or EC

Tab. 4-8: CSB02.1 type code

System overview

Short type designation	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	20	1	2	3	4	5	6	7	8	9	30	1	2	3	4	5	6	7	8	9	40
Example:	C	S	H	0	2	.	1	B	-	C	C	-	E	C	-	E	T	-	N	N	-	D	A	-	N	N	-	F	W											
	①			②			③	④		⑤			⑥			⑦			⑧			⑨			⑩			⑪											

①	**Product:** CSH = Single-axis control section ADVANCED
②	**Series:** 02 = 02
③	**Design:** 1 = 1
④	**Interface equipment:** B = Extended scope
⑤	**Communication:** CC = sercos III master ET = Multi-Ethernet
⑥	**Interface 1:** EC = Multi-encoder interface
⑦	**Interface 2:** NN = Not equipped ET = Multi-Ethernet [1)] PB = PROFIBUS [1)] CN = CANopen [1)] EC = Multi-encoder interface EM = Encoder emulation
⑧	**Interface 3 (safety technology) [2)]:** NN = Not equipped L3 = STO (Safe Torque Off) S4 = Safe Motion S5 = Safe Motion SB = Safe Motion Bus
⑨	**Interface 4:** NN = Not equipped EC = Multi-encoder interface [3)] EM = Encoder emulation [3)] DA = Digital/analog I/O extension
⑩	**Other design:** NN = None
⑪	**Firmware:** FW = Firmware must be ordered as a separate subposition

1) Only if communication = CC

2) The L3, S4, S5 and SB interfaces guarantee both the function and the certification

3) Only if interface 2 = ET, PB, CN or EC

Tab. 4-9: CSH02.1 type code

Short type designation	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	20	1	2	3	4	5	6	7	8	9	30	1	2	3	4	5	6	7	8	9	40
Example:	C	D	B	0	2	.	1	B	-	E	T	-	E	C	-	E	C	-	E	M	-	L	3	-	L	3	-	E	M	-	N	N	-	F	W					
	①			②			③	④		⑤			⑥			⑦			⑧			⑨			⑩			⑪			⑫			⑬					

①	**Product:** CDB = Double-axis control section BASIC
②	**Series:** 02 = 02
③	**Design:** 1 = 1
④	**Interface equipment:** B = Extended scope
⑤	**Communication:** ET = Multi-Ethernet
⑥	**Interface 1 (axis 1):** EC = Multi-encoder interface
⑦	**Interface 2 (axis 2):** EC = Multi-encoder interface
⑧	**Interface 3:** NN = Not equipped PB = PROFIBUS EC = Multi-encoder interface EM = Encoder emulation
⑨	**Interface 4 (safety technology axis 1) [1]:** NN = Not equipped L3 = STO (Safe Torque Off) S4 = Safe Motion S5 = Safe Motion SB = Safe Motion Bus
⑩	**Interface 5 (safety technology axis 2) [1]:** NN = Not equipped [2] L3 = STO (Safe Torque Off) [3] S4 = Safe Motion [4] S5 = Safe Motion [5] SB = Safe Motion Bus [6]

Short type designation									1										2										3										4
	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0
Example:	C	D	B	0	2	.	1	B	-	E	T	-	E	C	-	E	C	-	E	M	-	L	3	-	L	3	-	E	M	-	N	N	-	F	W					
	①			②			③	④		⑤			⑥			⑦			⑧			⑨			⑩			⑪			⑫			⑬						

⑪	**Interface 6:** NN = Not equipped EC = Multi-encoder interface 7) EM = Encoder emulation 8) DA = Digital/analog I/O extension
⑫	**Other design:** NN = None
⑬	**Firmware:** AW = With Advanced control panel, firmware has to be ordered separately FW = With Standard control panel, firmware has to be ordered separately

1) The L3, S4, S5 and SB interfaces guarantee both the function and the certification
2) Only if interface 4 = NN
3) Only if interface 4 = L3
4) Only if interface 4 = S4
5) Only if interface 4 = S5
6) Only if interface 4 = SB
7) Only if interface 3 = PB or EC
8) Only if interface 3 = PB, EC or EM

Tab. 4-10: CDB02 type code

☞ To employ the integrated safety technology "Safe Motion" "S4", it is necessary to use at least the following firmware version or higher in the drive:

- IndraDrive C (control sections Cxx02.x): as of MPx-18V08
- IndraDrive M (control sections Cxx02.x): as of MPx-18V08

To employ the integrated safety technology "Safe Motion" "S5" and "Safe Motion Bus" "SB", it is necessary to use at least the following firmware version or higher in the drive:

- IndraDrive C (control sections Cxx02.x): as of MPx-20V04
- IndraDrive M (control sections Cxx02.x): as of MPx-20V04

Characteristics of IndraDrive ML

The following type codes show the different characteristics of the control sections of IndraDrive ML:

Short type designation	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Example:	C	S	B	0	2	.	5	B	-	E	T	-	E	C	-	P	B	-	L	3	-	E	C	-	N	N	-	F	W											
	①			②			③	④		⑤			⑥			⑦			⑧			⑨			⑩			⑪												

①	**Product:** CSB = Single-axis control section BASIC
②	**Series:** 02 = 02
③	**Design:** 5 = For Hxx05
④	**Interface equipment:** B = Extended scope
⑤	**Communication:** ET = Multi-Ethernet
⑥	**Interface 1:** EC = Multi-encoder interface
⑦	**Interface 2:** NN = Not equipped PB = PROFIBUS CN = CANopen EC = Multi-encoder interface EM = Encoder emulation EP = Engineering port
⑧	**Interface 3 (safety technology)** 1): NN = Not equipped L3 = STO (Safe Torque Off) S4 = Safe Motion S5 = Safe Motion SB = Safe Motion Bus
⑨	**Interface 4:** NN = Not equipped EC = Multi-encoder interface 2) EM = Encoder emulation 3) DA = Digital/analog I/O extension
⑩	**Other design:** NN = None
⑪	**Firmware:** FW = Firmware has to be ordered as a separate subposition NW = Without control panel, without firmware

1) The L3, S4, S5 and SB interfaces guarantee both the function and the certification

2) Only if interface 2 = PB or CN
3) Only if interface 2 = PB, CN or EC

Tab. 4-11: CSB02.5 type code

Short type designation	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	20	1	2	3	4	5	6	7	8	9	30	1	2	3	4	5	6	7	8	9	40
Example:	C	S	H	0	2	.	5	B	-	C	C	-	E	C	-	E	T	-	N	N	-	D	A	-	N	N	-	F	W											
	①			②			③	④		⑤			⑥			⑦			⑧			⑨			⑩			⑪												

①	**Product:** CSH = Single-axis control section ADVANCED
②	**Series:** 02 = 02
③	**Design:** 5 = For Hxx05
④	**Interface equipment:** B = Extended scope
⑤	**Communication:** CC = sercos III master ET = Multi-Ethernet
⑥	**Interface 1:** EC = Multi-encoder interface
⑦	**Interface 2:** NN = Not equipped ET = Multi-Ethernet 1) PB = PROFIBUS 1) CN = CANopen 1) EC = Multi-encoder interface EM = Encoder emulation
⑧	**Interface 3 (safety technology) 2):** NN = Not equipped L3 = STO (Safe Torque Off) S4 = Safe Motion S5 = Safe Motion SB = Safe Motion Bus
⑨	**Interface 4:** NN = Not equipped EC = Multi-encoder interface 3) EM = Encoder emulation 3) DA = Digital/analog I/O extension

Short type designation	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	20	1	2	3	4	5	6	7	8	9	30	1	2	3	4	5	6	7	8	9	40
Example:	C	S	H	0	2	.	5	B	-	C	C	-	E	C	-	E	T	-	N	N	-	D	A	-	N	N	-	F	W											
	①			②			③	④		⑤			⑥			⑦			⑧			⑨			⑩			⑪												
⑩	**Other design:** NN = None																																							
⑪	**Firmware:** FW = Firmware must be ordered as a separate subposition NW = Without control panel, without firmware																																							

1) Only if communication = CC
2) The L3, S4, S5 and SB interfaces guarantee both the function and the certification
3) Only if interface 2 = ET, PB, CN or EC

Tab. 4-12: CSH02.5 type code

To employ the integrated safety technology "Safe Motion" (S4), it is necessary to use at least the following firmware version or higher in the drive:

- IndraDrive ML, CSB02.5 control sections: MPB-19 and above
- IndraDrive ML, control sections CSH02.5: as of MPC-19

To employ the integrated safety technology "Safe Motion" "S5" and "Safe Motion Bus" "SB", it is necessary to use at least the following firmware version or higher in the drive:

- IndraDrive ML, control sections CSB02.5: as of MPB-20
- IndraDrive ML, control sections CSH02.5: as of MPC-20

4.2.3 Supported safety technology functions

The table below shows the dependency on safety functions, SIL and on the availability with the optional safety technology modules.

System overview

Safety technology function	Available with optional safety technology module					SIL	Notes
	IndraDrive Mi		IndraDrive Cs, IndraDrive M / IndraDrive C (Cxx02 control section) and IndraDrive ML				
	S3 (KMS02 and KSM02)	SD (KSM02, KMS02 and KMS03)	S4	S5	SB		
Safety Zone Acknowledge (SZA) The safety technology function can only be used in conjunction with the safety zone module (HSZ01). Using "Safety zone acknowledge" and the safety zone module "HSZ", an acknowledgment master can monitor the safety of a safety zone and acknowledge the safety to a higher-level control unit. It is also possible for the acknowledgment master of the safety zone to directly control a safety door locking device connected to the safety zone module.	–	–	✓	✓	–	3	
Safe Door Locking (SDL) The safety technology function can only be used in conjunction with the safety zone module (HSZ01). The locking device of an interlocking guard is controlled via two channels when the safety zone acknowledge signals "Safety" and the user by means of a pushbutton requests the safety door to be unlocked. The position of the locking device is safely monitored.	–	–	✓	✓	–	3	
Safe Zone Error (SZE) The safety technology function can only be used in conjunction with the safety zone module (HSZ01). The "Safe zone error" function is a subfunction of the safety function "Safety zone acknowledge". The "Safe zone error" function allows locally present safety technology errors to be signaled by the zone nodes to all zone nodes via a safe output and to trigger individual error reactions. It is also possible for the acknowledgment master of a safety zone to signal zone errors via the safe communication to the higher-level control unit.	–	–	✓	✓	–	3	
Safe Torque Off (STO) The energy supply to the drive is interrupted in a safe way. The drive cannot generate any torque/force and, as a consequence, it cannot generate any dangerous motions, either.	✓	✓	✓	✓	✓	3	
Safe Operating Stop (SOS) With the safety function "Safe operating stop", the drive is in controlled standstill, i.e. all control functions between the electronic control unit and the drive are maintained. The dual-channel monitoring prevents the drive from carrying out dangerous movements due to errors although the energy supply is not interrupted.	✓	✓	✓	✓	✓	2 / 3*	* SIL 3 is only attained with firmware option (FWS) "SIL3-MOTION" or "SIL3-PLUS"

Safety technology function	Available with optional safety technology module					SIL	Notes
	IndraDrive Mi		IndraDrive Cs, IndraDrive M / IndraDrive C (Cxx02 control section) and IndraDrive ML				
	S3 (KMS02 and KSM02)	SD (KSM02, KMS02 and KMS03)	S4	S5	SB		
Safe Brake Control (SBC) With the safety function "Safe brake control", the motor holding brake is switched off safely (via two channels).	–	✓	✓ *	✓ *	✓ *	3	* With IndraDrive M / IndraDrive C (Cxx02 control section) and IndraDrive ML, the safety technology function can only be used in conjunction with a control module (HAT02.1).
Safe Maximum Speed (SMS) With the safety function "Safe maximum speed", dual-channel monitoring prevents the drive from exceeding the preset velocity limit value.	✓	✓	✓	✓	✓	2 / 3*	* SIL 3 is only attained with firmware option (FWS) "SIL3-MOTION" or "SIL3-PLUS"
Safe Direction (SDI) The safety function "Safe direction" ensures by dual-channel monitoring that motion is only possible in one direction.	✓	✓	✓	✓	✓	2 / 3*	* SIL 3 is only attained with firmware option (FWS) "SIL3-MOTION" or "SIL3-PLUS"
Safely Limited Speed (SLS) The safety function "Safely limited speed" monitors via two channels that the drive does not exceed a previously defined limitation of the velocity window.	✓	✓	✓	✓	✓	2 / 3*	* SIL 3 is only attained with firmware option (FWS) "SIL3-MOTION" or "SIL3-PLUS"
Safely Monitored Transient Oscillation (SLS-LT) Using a velocity window and a tolerance time, the safety function "Safely monitored transient oscillation" monitors the transient oscillation with regard to a "Safely-limited speed".	✓	✓	✓	✓	✓	2 / 3*	* SIL 3 is only attained with firmware option (FWS) "SIL3-MOTION" or "SIL3-PLUS"
Safely Limited Increment (SLI) The safety function "Safely limited increment" monitors via two channels that the drive moves only within the maximum increment.	✓	✓	✓	✓	✓	2 / 3*	* SIL 3 is only attained with firmware option (FWS) "SIL3-MOTION" or "SIL3-PLUS"
Safe Stop 1 (SS1) When the transition function "Safe stop 1 (SS1)" is activated, the drive is stopped in a safely monitored way. After the stopping process has been completed, the safety function "Safe torque off (STO)" is activated and the energy supply to the motor is safely interrupted. The motor cannot generate any torque/any force and therefore no dangerous movements.	✓	✓	✓	✓	✓	3	SS1, time-monitored
						2 / 3*	SS1, delay monitoring * SIL 3 is only attained with firmware option (FWS) "SIL3-MOTION" or "SIL3-PLUS"
Safe Stop 2 (SS2) When the transition function "Safe stop 2" is activated, the drive is stopped in a safely monitored way. After the deceleration process has been completed, the safety function "Safe operating stop" is activated and it is safely prevented that the motor deviates from the stopping position by more than a specified absolute value.	✓	✓	✓	✓	✓	2 / 3*	* SIL 3 is only attained with firmware option (FWS) "SIL3-MOTION" or "SIL3-PLUS"

Safety technology function	Available with optional safety technology module					SIL	Notes
	IndraDrive Mi		IndraDrive Cs, IndraDrive M / IndraDrive C (Cxx02 control section) and IndraDrive ML				
	S3 (KMS02 and KSM02)	SD (KSM02, KMS02 and KMS03)	S4	S5	SB		
Safely Monitored Deceleration (SMD) Given a change in the operating status or in the case of an error reaction, the safety function "Safely monitored deceleration" monitors via two channels whether the actual velocity of the drive is within a parameterized velocity envelope curve.	✓	✓	✓	✓	✓	2 / 3*	* SIL 3 is only attained with firmware option (FWS) "SIL3-MOTION" or "SIL3-PLUS"
Safely Monitored Position (SMP) The safety function "Safely monitored position" monitors whether or not the parameterized position range is exceeded in positive or negative direction.	✓	✓	✓	✓	✓	2	available in MPx-20V06 and above with firmware option (FWS) "SAFETY-PLUS" or "SIL3-PLUS"
Safely Limited Position (SLP) The safety function "Safely limited position" monitors via two channels that the drive can be decelerated within the parameterized **position limits** with the current velocity and the parameterized minimum delay.	✓	✓	✓	✓	✓	2	available in MPx-20V06 and above with firmware option (FWS) "SAFETY-PLUS" or "SIL3-PLUS"
Safely Limited End Position (SLE) The safety function "Safely limited end position" monitors via two channels that the drive can be decelerated within the parameterized **end position limit value** with the current velocity and the parameterized minimum delay.	✓	✓	✓	✓	✓	2	available in MPx-20V06 and above with firmware option (FWS) "SAFETY-PLUS" or "SIL3-PLUS"
Safe CAM (SCA) The safety function "Safe CAM" monitors via two channels whether or not the axis is within a position range defined by the switch-on und switch-off thresholds (cam range) and makes available the result via the status words.	✓	✓	✓	✓	✓	2	available in MPx-20V08 and above with firmware option (FWS) "SAFETY-PLUS" or "SIL3-PLUS"
Safe Homing Procedure With the auxiliary function "Safe homing procedure", another homing event is expected at a separate position after the functional homing procedure. The second homing event is used to validate the functional homing procedure.	✓	✓	✓	✓	✓	2	available in MPx-20V06 and above

Tab. 4-13: Functions for safe motion monitoring and safe standstill monitoring

☞ Optional safety technology modules can be neither retrofitted nor replaced "in the field"; i.e. drive controllers have to be ordered ex works with the required safety technology option.

4.2.4 Firmware options for Safe Motion

As of firmware version MPx-20VRS, the functional scope of the "Safe Motion" can be extended, if necessary, by using firmware options (FWS). The following firmware options are available:

- "SAFETY-PLUS"

- "SIL3-MOTION"
- "SIL3-PLUS"

You can only activate a maximum of one firmware option at a time.

The safety functions belonging to the individual firmware options are always available in the "Safe Motion" and active dependent on their parameterization. By activating/deactivating a firmware option, only the parameterization options of the contained functions are enabled and/or switched off in IndraWorks. I.e. by deselecting a firmware option, the related safety functions are not deactivated, they still take effect!

The basic function of "Safe Motion" is available state without any enabling. Using the optional firmware options, however, requires licensing.

☞ The desired scope of "Safe Motion" functions should preferably be defined when the program is ordered. This guarantees that the required firmware options have been enabled when the program is delivered. In individual cases, it is possible to enable options subsequently (additional licensing) or to reduce the activated scope of functions. This procedure is described in section ""Firmware option enable" on page 51".

The individual firmware options extend the basic function of "Safe Motion" by the following scope of functions:

Firmware option "SAFETY-PLUS"

"Safe Motion" can be enhanced by the following safety functions using the "SAFETY-PLUS" firmware option:

- Safely Monitored Position (SMP)
- Safely Limited Position (SLP)
- Safely Limited End Position (SLE)
- Safe CAM (SCA)
- Safe homing procedure

Firmware option "SIL3-MOTION"

By means of the "SIL3-MOTION" firmware option, up to SIL3 according to IEC 62061 and category 4, PL e according to ISO 13849-1 can be achieved for encoder-dependent safety functions. One prerequisite is that a SIL3- or category 4, PL e--enabled encoder (e.g. resolver) is used. With safety functions requiring a safe absolute position (SMP, SLP, SLE, SCA), it must also be available in SIL3 or category4, PL e.

Firmware option "SIL3-PLUS"

The firmware option "SIL3-PLUS" combines the functionalities of the firmware options "SAFETY-PLUS" and "SIL3-MOTION" in one firmware option.

Firmware option enable

Firmware options for the "Safe Motion" must be configured in "P-0-3203, SMO: Optional firmware packages". Any change in the firmware option selection will take effect immediately, it is not necessary to restart the axis.

☞ Firmware options for the "Safe Motion" ordered ex works are stored in "P-0-0660.0.1, Configurable factory default values". They will still remain active upon loading of the default values of "Safe Motion".

☞ Non-licensed firmware options must not be used. Enabling firmware options which are not 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 Rexroth will expire.

Firmware options can be enabled subsequently using IndraWorks. To do so, open the "Safe Motion Firmware Option Package" dialog. The dialog can be called in the functional tree of the axis via the context menu of the "Safe Motion" node. There, the firmware option can be directly selected.

Subsequent changes in the firmware options in IndraWorks are reset by the command "C0720 SMO: Load defaults procedure command"; then, only the firmware options ordered upon delivery of the axis will be active again.

Notes on commissioning

To commission several axes with different firmware options, we recommend creating a basic parameter set without configured firmware options and to transmit it to the axis. Afterwards, the firmware options required for the axes can be activated.

4.3 Safety-relevant standards and regulations

4.3.1 General information

Standard documents and sheets are subject to copyright protection and Bosch Rexroth must not pass them on. If required, contact the authorized sales agencies; in Germany directly contact Beuth Verlag GmbH (http://www.beuth.de).

See below for a short overview of the relevant standards for the use of safety-related control units. The overview does not claim completeness; besides, only the safety-relevant standards and regulations for functional safety are taken into consideration.

4.3.2 Standards relevant to components

Product group	Standard	Title
Electric drives	IEC 61800-5-2	Adjustable speed electrical power drive systems, Part 5-2: Safety requirements - Functional
Complex controls	IEC 61508-1 to IEC 61508-7	Functional safety of electrical/electronic/programmable electronic safety-related systems
Electrical equipment for measurement, control and laboratory use	IEC 61326-3-1	Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 3-1: Immunity requirements for safety-related systems and for equipment intended to perform safety-related functions (functional safety) - General industrial applications
Industrial communication networks - Fieldbus specifications	EN 61158	Industrial communication networks - Fieldbus specifications
Industrial communication networks - Profiles	EN 61784-1 to EN 61784-3	Industrial communication networks - Profiles
Industrial communication networks - Profiles	IEC 62685	Industrial communication networks - Profiles - Assessment guideline for safety devices using IEC 61784-3 functional safe communication profiles

Tab. 4-14: Standards relevant to components

4.3.3 Standards relevant to machinery

Standard	Title
ISO 12100	Safety of machinery - General principles for design - Risk assessment and risk reduction
IEC 60204-1	Safety of machinery - Electrical equipment of machines - Part 1: General requirements
IEC 62061	Safety of machinery - Functional safety of safety-related electrical, electronic and programmable electronic control systems
ISO 13849-1 ISO 13849-2	Safety of machinery - Safety-related parts of control systems Part 1: General principles for design Part 2: Validation
ISO 13850	Safety of machinery - Emergency stop - Principles for design
EN 1037	Safety of machinery - Prevention of unexpected start-up
ISO 13855	Safety of machinery - The positioning of protective equipment in respect of approach speed of parts of the human body
ISO 14119	Safety of machinery - Interlocking devices associated with guards - Principles for design and selection
ISO 11161	Safety of machinery - Integrated manufacturing systems - Basic requirements
ISO 10218-1 ISO 10218-2	Robots and robotic devices - Safety requirements for industrial robots Part 1: Robots Part 2: Robot system and integration
EN 1010-1	Safety of machinery - Safety requirements for the design and construction of printing and paper converting machines, Part 1: Common requirements
EN 848-3	Safety of woodworking machines - One side moulding machines with rotating tools, Part 3: Numerically controlled (NC) boring and routing machines
EN 415-1 to EN 415-8	Safety of packaging machines Part 1 to part 8
EN 201	Plastics and rubber machines - Injection moulding machines - Safety requirements
ISO 23125	Machine tools - Safety - Turning machines
EN 12417	Machine tools - Safety - Machining centres
EN 13218	Machine tools - Safety - Stationary grinding machines

Tab. 4-15: Standards relevant to machinery

4.3.4 EC Directives

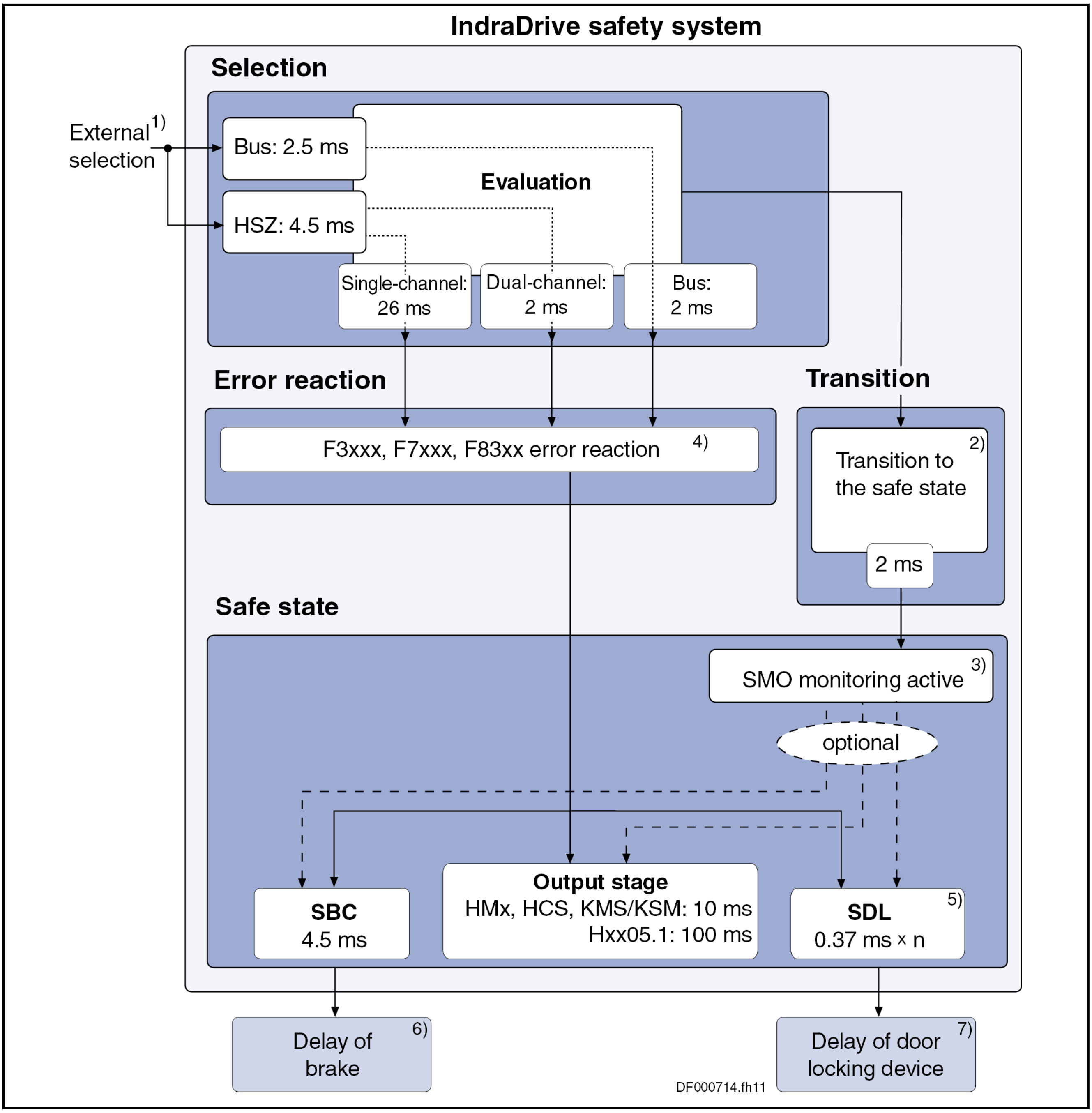
Description	Title
Directive 2006/42/EC	Machinery Directive
Directive 2006/95/EC	Low-Voltage Directive
Directive 2004/108/EC	EMC Directive

Tab. 4-16: EC Directives

4.4 Performance

4.4.1 Time response and reaction times

The figure below illustrates the time response of "Safe Motion". The figure can be used to determine the hardware-dependent and configuration-dependent total reaction time for individual applications.



1) (External component) Selection of a safety function or of a special mode

2) See chapter "Transition functions"

3) See chapter "Safety functions"

4) See chapter "Error reaction / escalation strategy"

5) "n"=number of zone nodes (a maximum of 35 zone nodes including zone master)

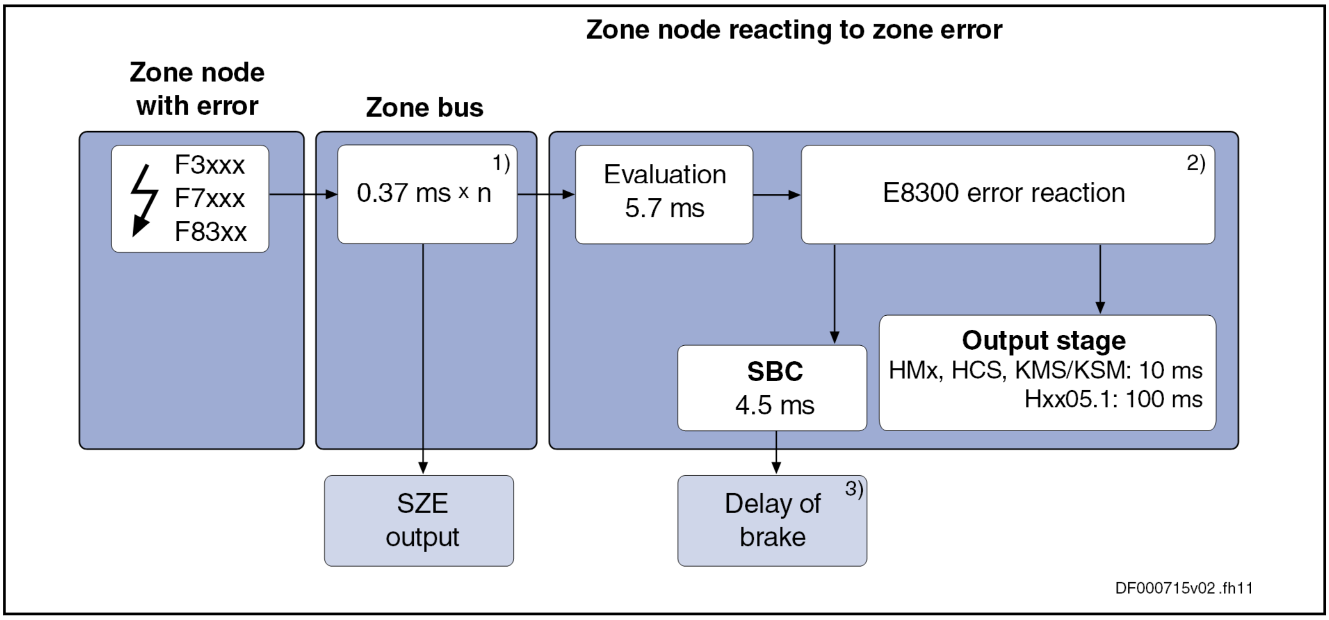
6) (External component) Use the delay of the brake here, see manufacturer's specification

7) (External component) Use the delay of the door locking device here, see manufacturer's specification

Fig. 4-2: Safe Motion: Time response and reaction times

4.4.2 Reaction time of "Safe zone error" (SZE)

The reaction time of the zone nodes to errors signaled via SZE can be determined from the figure below:



1) "n"=number of zone nodes (a maximum of 35 zone nodes including zone master)

2) See chapter "Error reaction / escalation strategy"

3) (External component) Use the delay of the brake here, see manufacturer's specification

Fig. 4-3: Safe Motion: Reaction time of "Safe zone error" (SZE)

4.5 Safety characteristics of the safety system

4.5.1 Introduction

For using the optional safety technology module "Safe Motion", the "IndraDrive" drive systems have been certified according to IEC 61508, IEC EN 61800-5-2, IEC EN 62061 and ISO EN 13849-1.

The risk evaluation and risk reduction of a machine require evaluating the safety functions of the individual components. The interaction of the components has to be taken into account, too. Therefor, it is necessary to determine the total PFH value for the machine or the machine part (e.g., a safety zone). The total PFH value allows assessing whether the required "Safety Integrity Levels" (SIL) or "Performance Levels" (PL) have been complied with. The paragraph below describes for the optional safety technology modules "Safe Motion" how the PFH value can be determined for a drive system and how additional components have to be integrated.

4.5.2 Optional safety technology modules "Sx"

Drives equipped with the optional safety technology module "Safe Motion" comply with the following "Safety Integrity Level" (SIL) or Performance Level (PL):

- SIL3 according to EN 61508, IEC EN 62061 and IEC 61800-5-2
  - for all safety functions working independently of the measuring system

  - for all safety functions working dependently of the measuring system, in conjunction with the optional package "SIL3-MOTION" or "SIL3-PLUS" (as of MPx-20)
- SIL2 according to EN 61508, IEC EN 62061 and IEC 61800-5-2
  - for all safety functions
- Category 4, PL e according to EN ISO 13849-1
  - for all safety functions working independently of the measuring system
  - for all safety functions working dependently of the measuring system, in conjunction with the optional package "SIL3-MOTION" or "SIL3-PLUS" (as of MPx-20)
- Category 3, PL d according to EN ISO 13849-1
  - for all safety functions

For the IndraDrive Mi system and depending on the design of the drive connection box used, there are the following "Safety Integrity Levels" (SIL) or "Performance Levels" (PL) for safety functions working independently of the measuring system:

- KCU02.2 / KCU02.3 / KMV03.1: SIL3 according to EN 61508, IEC EN 62061 and IEC 61800-5-2
- KCU02.2: Category 3, PL e according to EN ISO 13849-1
- KCU02.3 / KMV03.1:Category 4, PL e according to EN ISO 13849-1

Depending on the axis safety functions used and the device range used, there are the following safety characteristics:

Description	IndraDrive Cs HCS01.1	IndraDrive C/M Cxx02.1	IndraDrive Mi		IndraDrive ML Hxx05.1 N[4)]	IndraDrive ML Hxx05.1 P[5)]
			KMS02/ KSM02[3)]	KMS03		
PFH_{Sx} option (no SBC function)[1), 2)]	1×10^{-9} 1/h	1×10^{-9} 1/h	1×10^{-9} 1/h	1.8×10^{-9} 1/h	1.5×10^{-9} 1/h	(1.5×10^{-9} 1/h) + (N-1) × 0.4×10^{-9} 1/h [N = 1, 2, 4, 8 (number of "HMU" devices)]
$PFH_{SBC\ function}$[1), 2)]	1×10^{-9} 1/h	external actuator, see ""HAT02" control module"	1×10^{-9} 1/h	0.7×10^{-9} 1/h	external actuator, see ""HAT02" control module"	
Mission Time	175,200 h (20 years)					
$MTTF_{d/channel}$[1)]	> 90 years					
DC_{avg}	> 95 %					

1) The specified safety characteristics refer to an average ambient temperature of 40 °C (see also "Ambient and operating conditions" in the Project Planning Manuals).

2) PFH value of an axis with "Safe Motion", additional components not taken into account (e.g., encoder, brake, safety zone module). To determine the actual PFH value, see chapter "Calculating the PFH component of an axis".

3) For the brake and encoder data of KSM02, please see "chapter "Rexroth motors" on page 290"

4) Parallel operation is not possible

5) Parallel operation is possible

For the IndraDrive Mi system with KMS02/KSM02/KMS03, the PFH value of the drive connection box/the distributed supply unit has to be taken into account within the safety zone in addition to the PFH values of the axis:

- KCU02.2/KCU02.3: <1.5×10^{-9} 1/h
- KMV03.1: <2.0×10^{-9} 1/h (2 % of SIL3)

"Mission Time" and "Proof Test" interval

- The "Mission Time" of all components used has to be observed and complied with. After the "Mission Time" of a component has elapsed, the component has to be discarded or replaced. It is not allowed to continue operating the component!
- After the component was discarded ("Mission Time" has elapsed), it has to be ensured that the component cannot be reused (e.g., by disabling it).
- If a component (with valid "Mission Time") is decommissioned, the "Mission Time" has to be recorded and continued when the component is commissioned again.
- There is no specified "Proof Test" for the IndraDrive system. Therefore, the "Mission Time" cannot be reset by a "Proof Test".

4.5.3 "HSZ01" safety zone module

The safety zone module complies with the following "Safety Integrity Levels" (SIL) and Performance Levels (PL):

- SIL2 according to EN 61508, IEC EN 62061 and IEC 61800-5-2, with single-channel wiring and selection with fault exclusion
- Category 3, PL d according to EN ISO 13849-1, with single-channel wiring and selection with fault exclusion
- SIL3 according to EN 61508, IEC EN 62061 and IEC 61800-5-2, with dual-channel selection
- Category 4, PL e according to EN ISO 13849-1, with dual-channel selection

Depending on the selection, there are the following safety characteristics:

Description	Single-channel selection (with fault exclusion): SIL2 / PL d	Dual-channel selection: SIL3 / PL e
PFH[1)]	1×10^{-9} 1/h	1×10^{-9} 1/h
Mission Time	175,200 h (20 years)	175,200 h (20 years)
$MTTF_{d/channel}$[1)]	> 90 years	> 90 years
DC_{avg}	> 95 %	> 95 %

1) The specified safety characteristics refer to an average ambient temperature of 40°C (see also "Ambient and operating conditions" in the Project Planning Manual of the additional components).

"Mission Time" and "Proof Test" interval

- The "Mission Time" of all components used has to be observed and complied with. After the "Mission Time" of a component has elapsed, the component has to be discarded or replaced. It is not allowed to continue operating the component!
- After the component was discarded ("Mission Time" has elapsed), it has to be ensured that the component cannot be reused (e.g., by disabling it).
- If a component (with valid "Mission Time") is decommissioned, the "Mission Time" has to be recorded and continued when the component is commissioned again.
- There is no specified "Proof Test" for the IndraDrive system. Therefore, the "Mission Time" cannot be reset by a "Proof Test".

In the case of single-channel selection with fault exclusion, the accidental deactivation of the safety function by short circuits with other potentials must be excluded. See EN 61800-5-2 table D.1. Due to the isolated inputs and possible potential shifts of the 24 V systems, the contact of the selection channel with ground might cause a selection.

If it is possible from a technical point of view, the dual-channel selection should be preferred to the single-channel selection with fault exclusion.

4.5.4 Control module for inductive loads "HAT02"

The "HAT02" control module for inductive loads complies with the following "Safety Integrity Levels" (SIL) and Performance Levels (PL):

- SIL3 according to EN 61508, IEC EN 62061 and IEC 61800-5-2
- Category 4, PL e according to EN ISO 13849-1

There are the following safety characteristics:

Description	HAT02.1-002
PFH[1)]	1×10^{-9} 1/h
Mission Time	175,200 h (20 years)
$MTTF_{d/channel}$[1)]	> 90 years

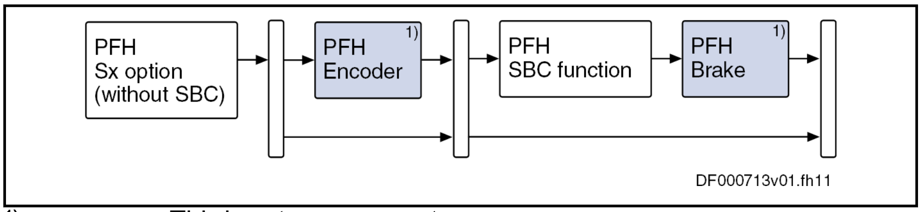
1) The specified safety characteristics refer to an average ambient temperature of 40°C (see also "Ambient and operating conditions" in the Project Planning Manual of the additional components).

"Mission Time" and "Proof Test" interval

- The "Mission Time" of all components used has to be observed and complied with. After the "Mission Time" of a component has elapsed, the component has to be discarded or replaced. It is not allowed to continue operating the component!
- After the component was discarded ("Mission Time" has elapsed), it has to be ensured that the component cannot be reused (e.g., by disabling it).
- If a component (with valid "Mission Time") is decommissioned, the "Mission Time" has to be recorded and continued when the component is commissioned again.
- There is no specified "Proof Test" for the IndraDrive system. Therefore, the "Mission Time" cannot be reset by a "Proof Test".

4.5.5 Calculating the PFH component of an axis

To determine the required total PFH value of an axis, the PFH values of the individual components relevant to the safety function and of the required third-party components have to be used for calculation. The figure below illustrates all the components relevant to the calculation:



1) Third-party component

Fig. 4-4: Safe Motion: Determining the PFH for an axis

To calculate the PFH value of an axis, a valid PFH value has to be available for all components which have an influence on the safety function (if necessary, procure the PFH value from the component manufacturer).

$PFH_{axis} = PFH_{Sx\ option} + PFH_{encoder} + PFH_{SBC\ function} + PFH_{brake}$

Tab. 4-17: Safe Motion: Formula to calculate PFH for an axis

The following conditions/restrictions apply to the general use of the formula for PFH calculation for an axis:

Variable	Value	Description
$PFH_{Sx\ option}$	See "Optional safety technology modules "Sx""	This value is **independent** of the safety functions used and thereby independent of the safety level to be achieved.
[1]$DC_{Encoder}$	**analog encoders:** 90% **digital encoders:** See manufacturer's specification (when using Rexroth motors, see "Required motors and measuring systems"	The diagnostic coverage attained by the monitoring functions in the drive.
[1]$PFH_{Encoder}$	See manufacturer's specification (when using Rexroth motors, see "Required motors and measuring systems")	Use the value of the encoder connected to X4 (resp. X4.1 or X4.2 or X104), if safety functions requiring an encoder are used. Otherwise, enter "0" for this variable.
$PFH_{SBC\ function}$	See "Optional safety technology modules "Sx""	Enter "0" for this variable, if the safety function "SBC" is not used.
[2]PFH_{Brake}	See manufacturer's specification (when using Rexroth motors, see "Required motors and measuring systems")	Use the value of the connected brake, if the safety function "SBC" is used. If the safety function "SBC" is not used, enter "0" for this variable.

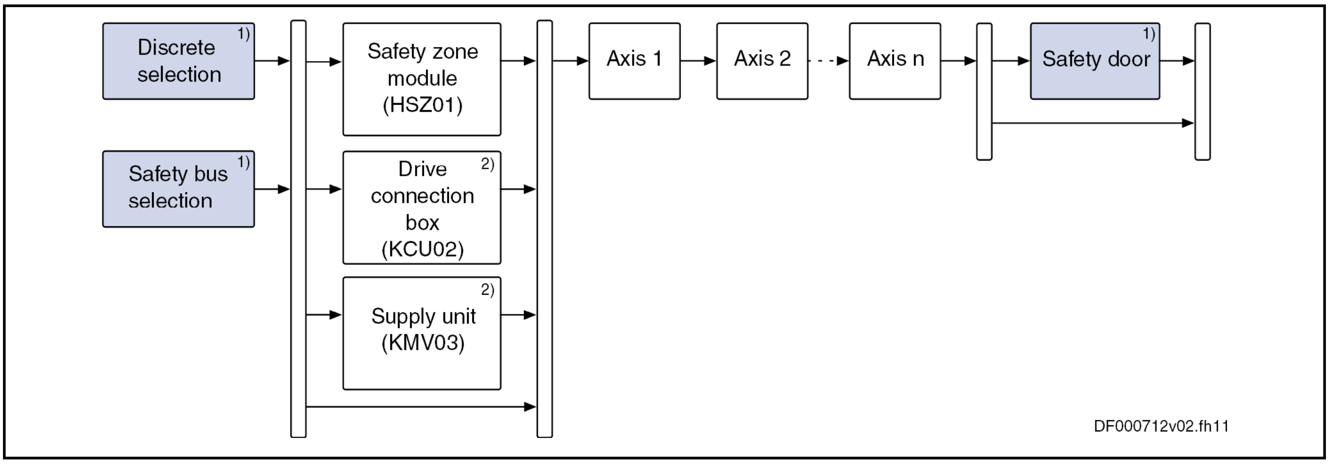
1) $PFH=(1-DC)/MTTF_D$

2) $PFH=\lambda_D$

Tab. 4-18: Variable description to calculate PFH for an axis

4.5.6 Calculating the total PFH value of a safety zone

To determine the required total PFH value of an axis or a safety zone, the PFH values of the individual axes and of the required third-party components have to be used for calculation. The figure below illustrates all the components relevant to the calculation:



1) Third-party component

2) Only for IndraDrive Mi with optional safety technology module

Fig. 4-5: Safe Motion: Determining the PFH for a safety zone

To calculate the PFH value of a safety zone, a valid PFH value has to be available for all components which have an influence on the safety function (if necessary, procure the PFH value from the component manufacturer).

$PFH_{safety\ zone} = PFH_{selection}$ 1), 2), 3) $+ PFH_{KCU02}$ 4) $+ PFH_{KMV03}$ 4) $+ PFH_{axis\_1} + PFH_{axis\_2} + \ldots + PFH_{axis\_n} + PFH_{safety\ door}$
1) exclusive selection via the safety bus: $PFH_{selection} = PFH_{selection\_safety\_bus}$
2) exclusive selection via HSZ01: $PFH_{selection} = PFH_{selection\_discrete} + PFH_{HSZ01}$
3) selection via HSZ01 and safety bus: $PFH_{selection}$ = the greater value of ($PFH_{selection\_discrete} + PFH_{HSZ01}$) and ($PFH_{selection\_safety\_bus}$)
4) only for safety zone with at least one IndraDrive Mi with optional safety technology module

Tab. 4-19: Safe Motion: Formula to calculate PFH for a safety zone

The following conditions/restrictions apply to the general use of the formula for PFH calculation for a safety zone:

Variable	Value	Description
$PFH_{selection\_discrete}$	See manufacturer's specification	Enter the sum of the individual PFH values of the switches or safety devices involved in the selection. In this case, there is no distinction made as to which safety functions are selected in the drive.
PFH_{HSZ01}	1×10^{-9} 1/h	PFH value of the safety zone module.
$PFH_{selection\_safety\_bus}$	See manufacturer's specification	Enter the sum of the individual PFH values of the switches or safety devices involved in the selection, that are transmitted to the axes via the safety bus. In addition enter the PFH values for the external signal processing and transmission up to the axes.
PFH_{KCU02}	**KCU02.2:** 1.5×10^{-9} 1/h **KCU02.3:** 1.5×10^{-9} 1/h	Use the value of the drive connection box "KCU" here. Enter "0" for this value, if • no IndraDrive Mi with optional safety technology module has been included in the safety zone, or • a "KMV" distributed supply unit is used
$PFH_{KMV03.1}$	2.0×10^{-9} 1/h	Use the value of the distributed supply unit here. Enter "0" for this value, if • no IndraDrive Mi with optional safety technology module has been included in the safety zone, or • a "KCU" drive connection box is used
PFH_{axis_x}	See chapter "Calculating the PFH component of an axis"	This value depends on the parameterized safety functions and must be calculated for each axis of the safety zone.
$DC_{safety\ door}$	99 %	The diagnostic coverage attained by the monitoring functions in the zone master (drive).
$PFH_{safety\ door}$ 1)	See manufacturer's specification	Enter "0" for this variable, if the safety technology master does not directly control a safety door. All other receivers of acknowledgment do not need to be considered for the IndraDrive safety system, and have to be taken into account where appropriate in the machine design.

1) $PFH=(1-DC)/MTTF_D$

Tab. 4-20: Variable description to calculate PFH for a safety zone

5 Functional principle

5.1 Dynamization

The dynamization is to detect static error states in the safety-relevant circuits. Dynamization takes place automatically in the background without having an effect on the safety function or the standard drive functions.

A safety function at the safety zone module (HSZ01) is alternatively selected via an N/C-N/C combination (in the case of dual-channel selection) or via an N/C contact (in the case of single-channel selection), i.e. two or one "0" signals at the inputs are evaluated when the safety functions are selected. Therefore, the dynamization of the external selection channels can only take place in the deselected state.

Dynamization in the case of selection via an active safety unit

When the safety functions are selected via an active safety unit, the dynamization pulses of the OSSD outputs of the active safety unit are evaluated and monitored; therefore, other dynamization signals are not required.

An active safety unit is a safety switching device which selects the safe function via OSSD outputs. The active safety unit tests its outputs on its own.

The "OSSD" (Output Signal Switching Device) is that part of a safe selection unit which has been connected to the machine control and which goes to the OFF state, when the safe selection unit triggers during the intended operation.

The active safety unit must detect the following errors via its OSSD outputs:

- Short circuit of one or both selection signals with 24 V
- Short circuit of one or both selection signals with 0 V
- Short circuit between the selection signals

In order that all other relevant errors can be detected by the safety zone module (HSZ01), the dynamization pulses of the OSSD outputs must comply with the following limit values:

Limit value	Explanation
t_{PLmax} = 1 ms	Maximum low time of the test pulse
t_{PLmin} = 0 ms	Minimum low time of the test pulse
t_{Vmax}[1] = 1 s	Maximum delay of the selection signals for selection or deselection
$t_{Dmin} = t_{PH} / t_P$ = 90 %	Minimum sampling ratio of the selection signals
$t_{Dmax} = t_{PH} / t_P$ = 100 %	Maximum sampling ratio of the selection signals
t_{Bounce} = 400 ms	Maximum bounce time for a selection or deselection
φ[1] = -	Phase shift of the test pulses on both channels: no requirement

1) Only applies to dual-channel selection

Tab. 5-1: Limit values of the dynamization pulses of the OSSD outputs

Functional principle

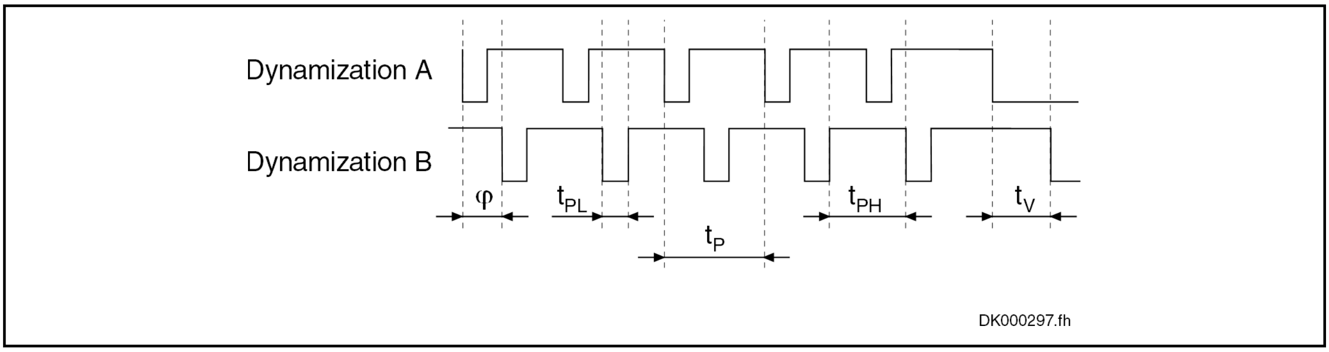


Fig. 5-1: Example of dynamized selection signals

In schematic form the figure below illustrates the interconnection of an active safety unit and a safety zone module (HSZ01):

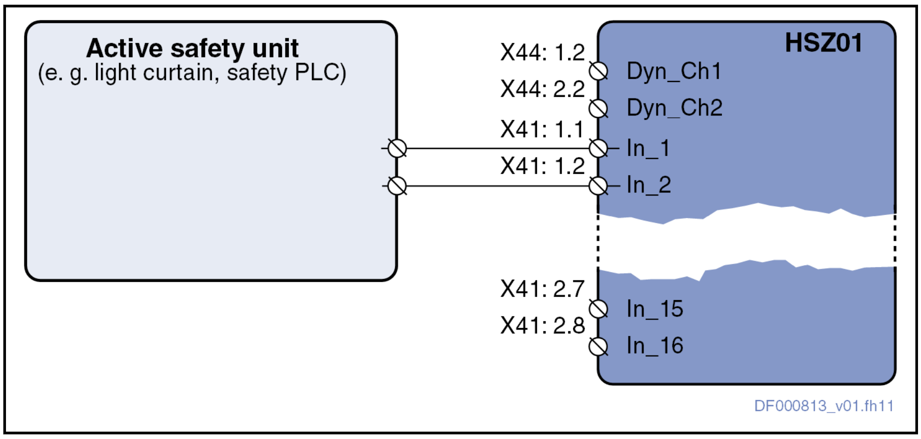


Fig. 5-2: Dynamization in the case of selection via an active safety unit

When choosing the safety unit, the maximum current consumption of the selection inputs used has to be taken into account.

Dynamization in the case of selection via passive safety units

When the safety functions are selected via a passive safety unit, the dynamization pulses are generated by the safety zone module (HSZ01) and made available via the outputs "channel 1 dynamization output" and "channel 2 dynamization output". These two outputs allow supplying the isolated selection contacts of the passive safety unit.

A passive safety unit is a safety switching device with which the safe function is selected via isolated contacts.

When the safety functions at the safety zone module (HSZ01) are selected via a passive safety unit, the safety zone module checks the wiring of the selection.

In schematic form the figure below illustrates the interconnection of a passive safety unit and several drives with a safety zone module (HSZ01):

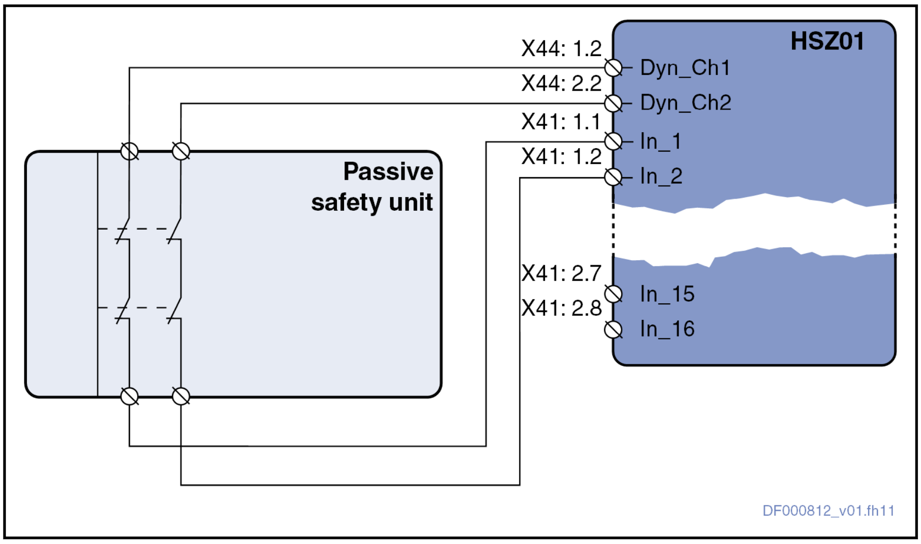


Fig. 5-3: Dynamization in the case of selection via a passive safety unit

When the safety zone module (HSZ01) and drives with optional safety technology module are selected by the same passive safety unit, the dynamization signals of the safety zone module must be used; only this ensures the verification and error detection in the wiring.

5.2 Encoder evaluation

The "safe encoder evaluation" evaluates the connected encoder system and makes its results (velocity feedback value and position feedback value) available to the safety functions.

With the "Safe Motion", a safe encoder is always analyzed at interface X4 and/or with double-axis devices at interface X4.1 (axis 1) and X4.2 (axis 2) and with IndraDrive Mi at interface X104.

Before the integrated safety technology is commissioned, make sure the following requirements have been complied with:

- The safe encoder fulfills the requirement to be used with "Safe Motion" (see chapter "Prerequisites for using integrated safety technology").
- The safe encoder has been connected at the allowed interface.
- The wiring of the safe encoder and the assignment of the encoder connector have been correctly implemented.
- The safe encoder may only be supplied via the encoder interface of the drive.

Encoder evaluation overview

The encoder evaluation depends on the operating status:

- In the "operating mode" (OM), the encoder evaluation is active and signals errors.
- In the "parameter mode" (PM), the encoder evaluation is active and does not signal any errors.
- In the "SMO configuration mode" (SCM), the encoder evaluation is not active and does not signal any errors.

Parameter "P-0-3256, SMO: Encoder evaluation status" displays the current status of the encoder analysis, encoder errors, encoder warning, ...

Functional principle

Pertinent parameters

The following parameters are made available for configuring the physical encoder:

- P-0-3230.0.1, SMO: Password
- P-0-3242.1.1, SMO: Phys. encoder type
- P-0-3242.1.2, SMO: Phys. encoder properties
- P-0-3242.1.3, SMO: Phys. encoder resolution (analog)
- P-0-3242.1.4, SMO: Phys. encoder resolution (digital)
- P-0-3252.1.2, SMO: Mounting position
- P-0-3252.1.3, SMO: Gearbox input revolutions
- P-0-3252.1.4, SMO: Gearbox output revolutions
- P-0-3254, C8400 SMO: Command Apply encoder configuration
- P-0-3255, SMO: Velocity threshold for safe standstill
- P-0-3256, SMO: Encoder evaluation status
- P-0-3257, SMO: Position feedback value
- P-0-3258, SMO: Velocity feedback value

Pertinent diagnostic messages

- C8200 SMO: Command Exit configuration mode
- C8214 SMO: Incorrect configuration
- C8215 SMO: Incorrect encoder/scaling configuration
- C8400 SMO: Command Apply encoder configuration
- C8401 SMO: Impossible to apply encoder type
- C8402 SMO: Impossible to apply encoder configuration
- C8403 SMO: Parameter for applying encoder configuration invalid
- F8359 SMO: Encoder evaluation error

Encoder type

The "encoder type" (P-0-3242.1.1) describes the type of encoder with regard to the signal shape and, if necessary, the communication interface (EnDat etc.). "Safe Motion" can evaluate the following encoder types:

- analog encoders with sine signals ($1V_{pp}$, 5V or 12V supply)
- analog encoders with sine signals and HIPERFACE interface ($1V_{pp}$, 12V supply)
- analog encoders with sine signals and EnDat2.1 interface ($1V_{pp}$, 5V or 12V supply)
- as of MPx20V08: analog resolvers (10 V supply and 8 kHz excitation frequency)
- as of MPx20V08: digital encoders with ACURO®link interface (only rotational encoders)

☞ The partly available digital position data of the analog encoder are not evaluated by "Safe Motion".

With the "Safe Motion", a safe encoder is always analyzed at interface X4 and/or with double-axis devices at interface X4.1 (axis 1) and X4.2 (axis 2) and with IndraDrive Mi at interface X104.

With P-0-3242.1.1="0", the "safe encoder evaluation" can be deactivated. When the safe encoder evaluation has been deactivated, only those safety functions of "Safe Motion" are available that do not require safe encoder evaluation [e.g. STO, SBC, SS1 (time-prioritized)].

Encoder properties

In order that "Safe Motion" can correctly evaluate the transmitted position and velocity information of a safe encoder, the following encoder properties are required in addition to the encoder type:

- Type of construction of the encoder (linear or rotary) (P-0-3242.1.2)
- Rotational direction of the encoder (not inverted or inverted) (P-0-3242.1.2)
- Encoder resolution (P-0-3242.1.3 and/or P-0-3242.1.4) in division periods per motor revolution (DP/rev) for rotary encoders or mm per line count (mm/line count) for linear encoders

Mounting position of the safe encoder

"Safe Motion" supports the motor-side, as well as the load-side mounting of the safe encoder. When choosing the mounting position, observe that the encoder must be mounted in such a way that dangerous movements can be monitored. To correctly evaluate the safe encoder in "Safe Motion", the mounting position of the encoder must be configured via "P-0-3252.1.2, SMO: Mounting position".

According to the safety-related application, it is sometimes impossible to connect the safe encoder directly. Therefore, "Safe Motion" provides the possibility to evaluate a safe encoder connected via a gearbox. The gear ratio of the gearbox results from the relation between the encoder-side gearbox input revolutions (P-0-3252.1.3) and the load- or motor-side gearbox output revolutions (P-0-3252.1.4). With a gear ratio of 1:1, the gearbox is switched off.

The wrong parameterization of the mounting position and of the encoder gearbox causes incorrect position and velocity values. Make sure the physical mounting position of the encoder has been parameterized correctly.

The figures below illustrate the possible mounting positions of the safe encoder:

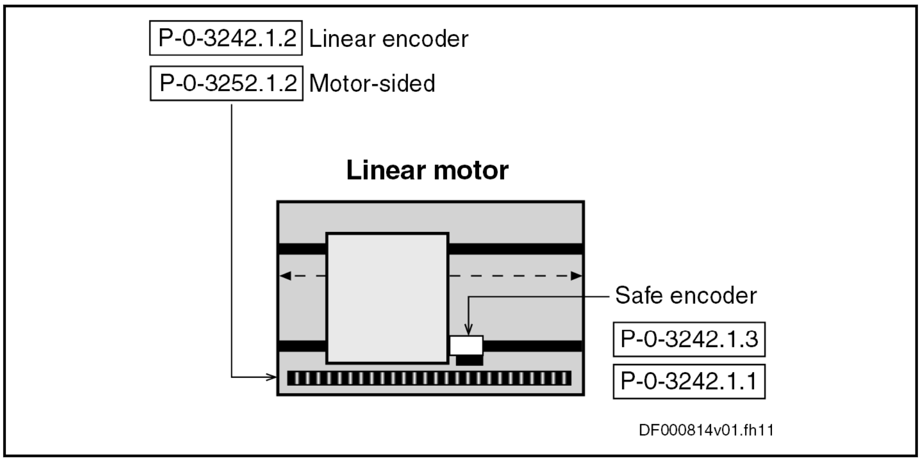


Fig. 5-4: Mounting position of safe encoder, linear motor

With linear motors, the position reference of the position data and the mounting position are to be configured as follows:

- **either** "Position reference of the position data"="motor shaft" and "mounting position"="motor side" **or**
- "Position reference of the position data"="load" and "mounting position"="load side"

The encoder gears (P-0-3252.1.3, P-0-3252.1.4 as well as P-0-3521.1.3, P-0-3521.1.4) are to be configured to "1:1".

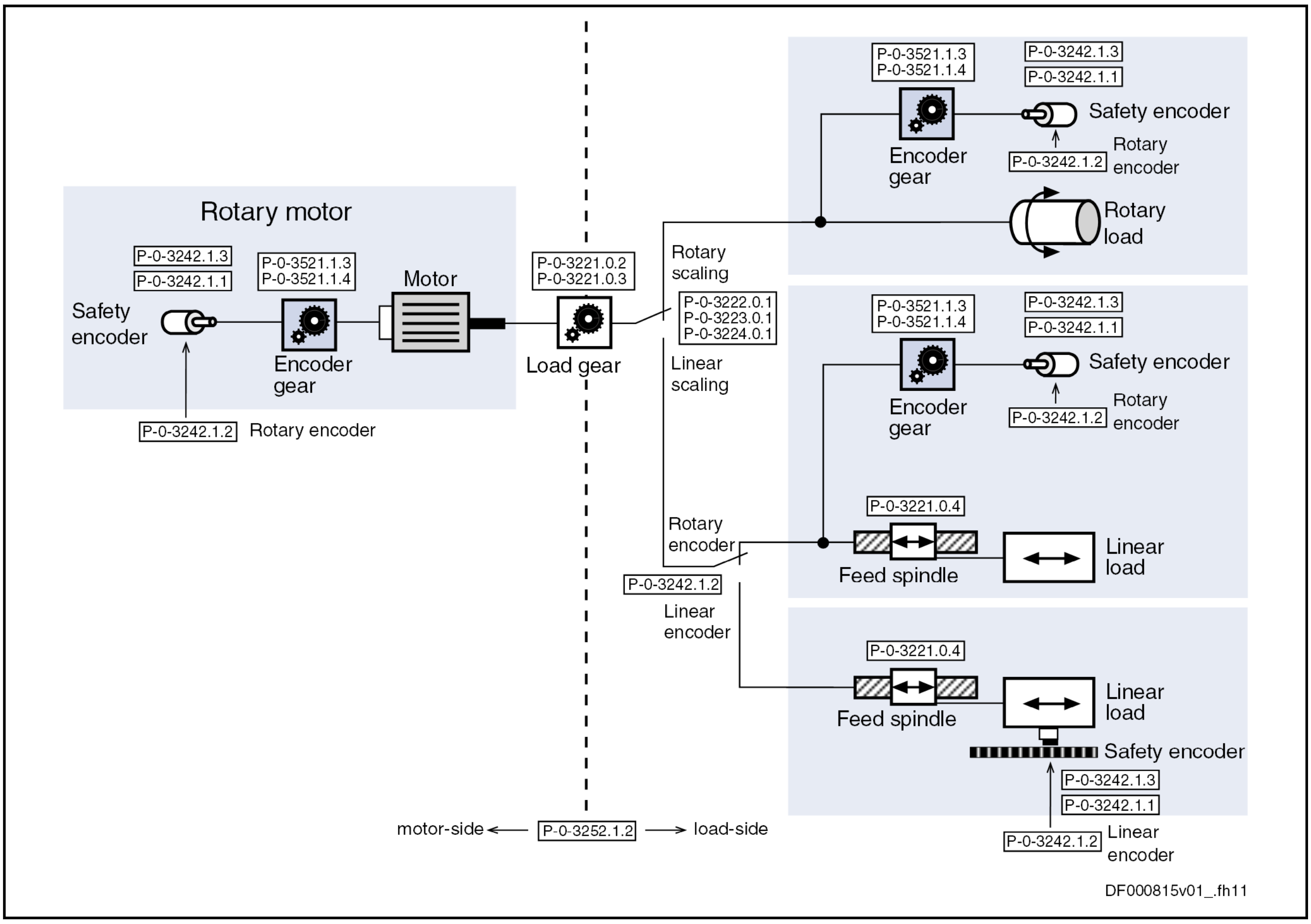


Fig. 5-5: Mounting position of safe encoder, rotary motor

Velocity threshold for safe standstill

The velocity resolution of "Safe Motion" depends on the resolution of the measuring system or of the "measurement noise". Thus, the velocity feedback value never is constantly "0", not even in the case of encoder standstill, but displays small velocities around the zero point ("encoder noise"). In order that "Safe Motion" safely detects axis standstill, it is necessary to parameterize the velocity threshold below which "Safe Motion" is to detect standstill (P-0-3256, bit 6="1") in "P-0-3255, SMO: Velocity threshold for safe standstill".

- The safely generated scaling-related **position feedback value** is made available in P-0-3257.
- The safely generated scaling-related **velocity feedback value** is made available in P-0-3258.
- The safely generated **direction of motion** is provided in P-0-3256, bit 11.

Notes on commissioning

It is recommended to configure and commission the encoder which is analyzed in "Safe Motion" in the functional part of the drive first. This ensures that all functions necessary for the operation of the encoder (e.g. encoder supply voltage, terminating resistors for the encoder signals, etc.) are activated.

Via the command "C8400 SMO: Command Apply encoder configuration", the settings of the encoder of interface X4 (or X4.1, X4.2, X104) can be applied from the standard firmware to "Safe Motion".

Not all encoders are approved for "safe encoder evaluation"; therefore, only the data of approved encoder types are applied. The command "C8400" can only be executed in the configuration mode (SCM) with the safety technology password (P-0-3230.0.1) having been set.

After the encoder configuration has been successfully applied, the SMO encoder parameters must be verified.

If the encoder configuration cannot be applied, one of the following command errors will be generated - depending on the error cause-:

- C8401 SMO: Impossible to apply encoder type
- C8402 SMO: Impossible to apply encoder configuration
- C8403 SMO: Parameter for applying encoder configuration invalid

The parameterization of the safe encoder evaluation is subject to a fixed order, because there are dependencies between the parameters:

1. First of all, the encoder has to be parameterized in the standard firmware in order to activate the voltage supply at the encoder interface.
2. Afterwards, the physical data of the safe encoder must be parameterized (P-0-3242.1.1, P-0-3242.1.2 and P-0-3242.1.3 and/or P-0-3242.1.4); the "encoder property" determines the unit of the "encoder resolution" (e.g. linear encoder: resolution in mm/line count).
3. Finally, the encoder mechanics must be defined (P-0-3252.1.2, P-0-3252.1.3 and P-0-3252.1.4).

The complete function is only achieved by parameterizing the entire mechanics and the scaling.

As of MPx20V08, monitoring of the safe encoder can be deactivated for the normal operation. It should, however, only be switched off if in normal operation, the encoder monitoring would response based on the process.

The effects of switching off the Safe encoder monitoring for the normal operation have to be considered in the risk analysis for the machine!

The Safe encoder monitoring for the normal operation can only be deactivated under the following conditions:

- the safety technology encoder is a sine/cosine encoder

- no global safety functions (SMS, SLE, SCA) have been configured
- no safety functions for the normal operation (SDI, SLE) have been configured
- the auxiliary function "Safe homing procedure" has not been configured

The Safe encoder monitoring can be deactivated using parameter "P-0-3242.1.2, SMO: Phys. encoder properties".

☞ The deactivation of the Safe encoder monitoring will only effect the "Safe Motion". The encoder monitoring functions of the functional part of the drive will still remain active.

5.3 Scaling system

5.3.1 Brief description

The scaling defines the input format of a parameter; i.e. the relation between the input value and the physical unit is established.

☞ An operating data (numerical value) can only be evaluated as a physical value, when the numerical 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.

For "Safe Motion" there are independent scaling and mechanics parameters that can be selected independently of the scaling parameters of the standard firmware. These independent safety technology scaling parameters are processed, stored and verified in accordance with the requirements on safety-related systems.

For example, for applications with switchable gearboxes and load-side scaling of the standard drive, it might be useful to select differing scaling settings for "Safe Motion". In this case, "Safe Motion" can be configured with "data reference to motor shaft"; it is then independent of the gearbox and the scaling of the standard drive.

Pertinent parameters

- P-0-3220, C8000 SMO: Command Apply scaling
- P-0-3221.0.1, SMO: Polarity
- P-0-3221.0.2, SMO: Input revolutions of load gearbox
- P-0-3221.0.3, SMO: Output revolutions of load gearbox
- P-0-3221.0.4, SMO: Feed constant
- P-0-3221.0.6, SMO: Modulo value
- P-0-3221.0.7, SMO: Maximum travel range
- P-0-3222.0.1, SMO: Position data scaling type
- P-0-3222.0.2, SMO: Linear position data scaling exponent
- P-0-3222.0.3, SMO: Rotational position resolution
- P-0-3223.0.1, SMO: Velocity data scaling type
- P-0-3223.0.2, SMO: Velocity data scaling exponent
- P-0-3224.0.1, SMO: Acceleration data scaling type
- P-0-3224.0.2, SMO: Acceleration data scaling exponent
- P-0-3224.0.3, SMO: Ramp reference velocity for acceleration data
- P-0-3230.0.1, SMO: Password

Pertinent diagnostic messages

- C8000 SMO: Command Apply scaling
- C8001 SMO: Invalid scaling parameters ->S-0-0423
- C8002 SMO: Not allowed to apply scaling
- C8200 SMO: Command Exit configuration mode
- C8214 SMO: Incorrect configuration
- C8215 SMO: Incorrect encoder/scaling configuration

5.3.2 Functional description

The scaling of "Safe Motion" is independent of the standard scaling of the drive; the scaling settings can be different.

There are two options for setting the scaling:

- Preferred scaling: **Predefined** settings for "unit", "time unit" and "exponent".
- Parameter scaling: Settings to be defined **by the user** for "unit", "time unit" and "exponent".

"Unit" and "time unit" are physical values. The "exponent" defines the number of decimal places of the scaled values.

There are no scaling parameters for times, 2 fixed scalings were defined:

- Time in milliseconds: Decimal places "0", unit "ms", display format "decimal, unsigned", data length "4 bytes"
- Time in seconds: Decimal places "3", unit "s", display format "decimal, unsigned", data length "4 bytes"

Position scaling

The scaling type of the **position data** for "Safe Motion" can be set in P-0-3222.0.1. The position values are set in "degrees" for rotary scaling and in "mm" or "inch" for linear scaling. The data reference can be at the motor shaft or at the load. **The incremental scaling, as in the standard firmware, is not supported.**

Example:

Position scaling

With preferred scaling, the format is as follows:

- Rotary: 0.0001 degrees
- Linear, metric: 0.0001 mm
- Linear, inch: 0.000001 inch

With parameter scaling, the number of decimal places of the scaled position values can be defined with the following parameters:

- Linear scaling: "P-0-3222.0.2, SMO: Linear position data scaling exponent"
- Rotary scaling: "P-0-3222.0.3, SMO: Rotational position resolution"

Velocity scaling

The scaling type of the **velocity data** for "Safe Motion" can be set in P-0-3223.0.1. The velocity values are set in rpm, rev/s for rotary scaling and in mm/min, mm/s, inch/min, inch/s for linear scaling. The data reference can be at the motor shaft or at the load. **The incremental scaling, as in the standard firmware, is not supported.**

Example:

Velocity scaling

With preferred scaling, the format is as follows:

- Rotary: 0.0001 rpm or 0.000001 rev/s
- Linear, metric: 0.001 mm/min or mm/s
- Linear, inch: 0.00001 inch/min or inch/s

With parameter scaling, the number of decimal places of the scaled velocity values can be defined by means of P-0-3223.0.2.

Acceleration scaling

The scaling type of the **acceleration data** for "Safe Motion" can be set in P-0-3224.0.1. The acceleration values are set in rad/s^2 for rotary scaling, in mm/s^2, inch/s^2 for linear scaling and in s for "ramp time".

With the "ramp time" scaling type, the scaling can be defined by means of "P-0-3224.0.3, SMO: Ramp reference velocity for acceleration data".

The data reference can be at the motor shaft or at the load. **The incremental scaling, as in the standard firmware, is not supported.**

Example:

Acceleration scaling

With preferred scaling, the format is as follows:

- Rotary: 0.001 rad/s^2
- Linear, metric: 0.001 mm/s^2
- Linear, inch: 0.00001 inch/s^2
- Ramp time, s: 0.001 s

With parameter scaling, the number of decimal places of the scaled acceleration values can be defined by means of P-0-3224.0.2.

Jerk scaling

The **Jerk data** scaling type for the "Safe Motion" is derived from the acceleration scaling. It does not have own scaling parameters. In this connection, the jerk scaling accepts the measurement unit and the exponent of the acceleration scaling. The time unit changes from s^2 to s^3.

Example:

Jerk scaling

With preferred scaling, the format is as follows:

- Rotary: 0.001 rad/s^3
- Linear, metric: 0.001 mm/s^3
- Linear, inch: 0.00001 inch/s^3

Modulo scaling

For the position data format, it is possible to choose between two formats via the respective bit of "P-0-3222.0.1, SMO: Position data scaling type":

- Absolute format
- Modulo format

Switching the format of the position data from the absolute to the modulo format does not have any effect on the monitoring functions of "Safe Motion". The switching only serves to display the position values in the same format as in the standard firmware. For this purpose, the corresponding modulo value van be entered in the parameter P-0-3221.0.6.

☞ To achieve the synchronization of the position feedback values of the standard firmware and of "Safe Motion", the standard firmware must be referenced to the position feedback value of "Safe Motion" (P-0-3257). There is **no** automatic adjustment!

Data reference

The data reference (position: P-0-3222.0.1, velocity: P-0-3223.0.1, acceleration: P-0-3224.0.1) defines whether the data refer to the motor shaft or to the load. The scaling (P-0-3222.0.1) defines in which format (unit) the data is displayed. Not all setting variants for scaling and data reference are supported. The setting of the data reference is restricted by the encoder used and its mounting position as well as the desired presentation of the data:

physical encoder type (P-0-3242.1.1)	Mounting position (P-0-3252.1.2)	Data reference (P-0-3222.0.1)	Scaling type (P-0-3222.0.1)	Configuration
Encoder	mounted on motor side	with respect to motor shaft	Rotary	✓
			Linear	–
		at the load	Rotary	✓
			Linear	✓
	mounted on the load side	with respect to motor shaft	Rotary	–
			Linear	–
		at the load	Rotary	✓
			Linear	✓
Linear encoders	mounted on motor side	with respect to motor shaft	Rotary	–
			Linear	✓
		at the load	Rotary	–
			Linear	–
	mounted on the load side	with respect to motor shaft	Rotary	–
			Linear	–
		at the load	Rotary	–
			Linear	✓

Tab. 5-2: Mechanics scaling configuration of "Safe Motion"

☞ The data reference (motor or load) must be the same for SMO scaling types position, velocity and acceleration

When switching over from the configuration mode (SCM) into the parameterization mode (PM), the configuration is checked for admissibility. In case of an inadmissible configuration, the command error "C8215 SMO: Incorrect encoder/scaling configuration is generated."

Polarity

The polarity of the position, velocity and acceleration data can be adjusted by means of P-0-3221.0.1. Depending on the mounting situation, this allows determining the appropriate polarity of the respective data for the machine axis.

The polarity can only be set consistently for all scaling types (position, velocity, acceleration).

Functional principle

Mechanics

With the mechanics elements "load gearbox" and "feed constant", the mechanical transfer elements between motor and the point where the load takes effect can be represented in the drive.

Via the load gearbox, gear ratios or reduction gear ratios between the motor shaft and the load can be represented. The ratio is parameterized via the parameters "P-0-3221.0.2, SMO: Input revolutions of load gearbox" (motor side) and "P-0-3221.0.3, SMO: Output revolutions of load gearbox" (load side).

If a linear load is driven by a rotary motor, the corresponding gear ratio must be written by the feed constant (mm/rev). The feed constant can be parameterized via the parameter "P-0-3221.0.4, SMO: Feed constant".

The parameter "P-0-3221.0.7, SMO: Maximum travel range" defines the maximum mechanical travel distance of the machine. Depending on this parameter, the internal resolution is set in "Safe Motion", which influences the monitoring precision. To achieve the highest possible precision, the parameter should be set to the smallest possible value for the application.

☞ During the commissioning procedure, the user must check that the mechanical elements have been correctly parameterized; the wrong parameterization causes incorrect position and velocity values.

5.3.3 Notes on commissioning

Automatically applying the scaling

As the scaling of "Safe Motion" and of the standard drive are to be the same, the standard scaling parameters can be applied from the drive to "Safe Motion" to simplify the commissioning procedure.

To apply the standard scaling parameters to the scaling parameters of "Safe Motion", start the command "P-0-3220, C8000 SMO: Command Apply scaling".

Requirements for applying the scaling:

- The standard scaling parameters to be applied must be valid (data status), otherwise the procedure for applying the standard scaling parameters to the scaling parameters of "Safe Motion" is aborted and the command error "C8001 SMO: Invalid scaling parameters ->S-0-0423" is generated.
- The drive must be in the SMO configuration mode (SCM) and the safety technology password must have been set (P-0-3230.0.1), otherwise the procedure for applying the standard scaling parameters to the scaling parameters of "Safe Motion" is aborted and the command error "C8002 SMO: Not allowed to apply scaling" is generated.

Validation check when exiting the configuration

The command C8200 SMO: Command Exit configuration mode (P-0-3231.0.2) controls the switching from the SMO configuration mode (SCM) to the parameterization mode (PM). For the scaling, a validation check comparing the scaling types is performed, otherwise switching is aborted and the command error "C8214 SMO: Incorrect configuration" is generated.

5.4 Diagnostic system

5.4.1 Introduction

The general diagnostic system of IndraDrive is explained in detail in the Functional Description of the firmware where you can read more about it, if required (see also index entry "Diagnostic system").

The following parameters are used in conjunction with the diagnostic system:

- S-0-0095, Diagnostic message

- S-0-0375, Diagnostic numbers list
- S-0-0390, Diagnostic message number
- P-0-0478, Logbook event
- P-0-0479, Logbook time stamp

Axis or device configuration

A drive controller consists of several components (power section, control section, firmware,...); each of them has its own identifier in the form of a parameter (see also Functional Description of firmware "Device configuration").

Identifiers useful for the purpose of diagnostics and service are stored in the following parameters:

- S-0-0140, Controller type
- S-0-0141, Motor type
- S-0-0142, Application type
- P-0-1518, Module code of control section
- P-0-1519, Module code of power section
- P-0-1520, Control section type
- S-0-0030, Manufacturer version
- P-0-3200, SMO: Manufacturer version

5.4.2 Firmware codes

The parameter "P-0-3200, SMO: Manufacturer version" contains the designation of the safety technology firmware version. Via the parameter "S-0-0030, Manufacturer version", the designation of the standard firmware version can be read.

5.4.3 Status messages

Status parameters of "Safe Motion"

"Safe Motion" makes available several parameters to the standard firmware via which the states of "Safe Motion" can be read. By means of these status parameters, the individual status signals can be freely programmed to existing real-time bits of the master communication or hardware I/Os or I/O extensions.

☞ These pieces of status information are not allowed for the safety-relevant evaluation!

- P-0-3231, SMO: Operating status: Makes available binary status signals for online monitoring of the "safety technology operating status" of "Safe Motion".
- P-0-3237, SMO: Status word: Makes available binary status signals for online monitoring of the "safety technology status" of "Safe Motion".
- P-0-3238, SMO: Active velocity threshold: Displays the currently active monitoring limit of the velocity.
- P-0-3261, SMO: State machine control word: Makes available binary control signals for displaying the selected safety functions via digital hardware inputs (local safe inputs) or via a Safety bus communication of the drive.
- P-0-3262, SMO: Selected operating status: Makes available binary status signals for displaying the selected safety technology operating status.

Functional principle

- P-0-3266, SMO: Safety zone status word: Makes available binary status signals for online monitoring which the zone node gives to the zone bus. These pieces of information are generated from the status of the zone node and the transmitted zone telegram from the previous zone node.

Status dialogs in IndraWorks

For diagnostic purposes, the state of "Safe Motion" can be displayed in IndraWorks via the corresponding diagnostic dialogs. The dialogs can be called in the function tree of the axis under the "Safe Motion" main branch and the "Diagnostics" subbranch. The following dialogs are available:

- "Safe Motion" shows information on the status and diagnostic messages of "Safe Motion"

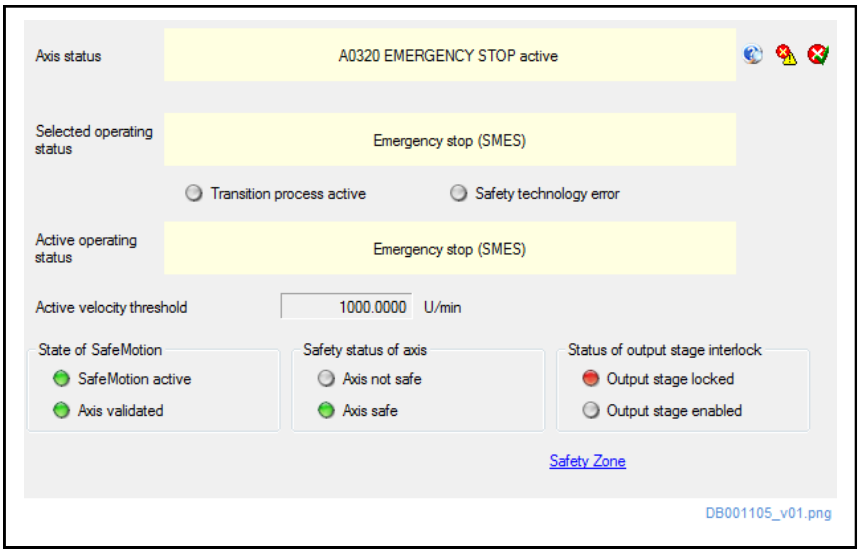


Fig. 5-6: "Safe Motion" status dialog

- "Safety bus communication" shows information on the status and diagnostic messages of the safety bus communication

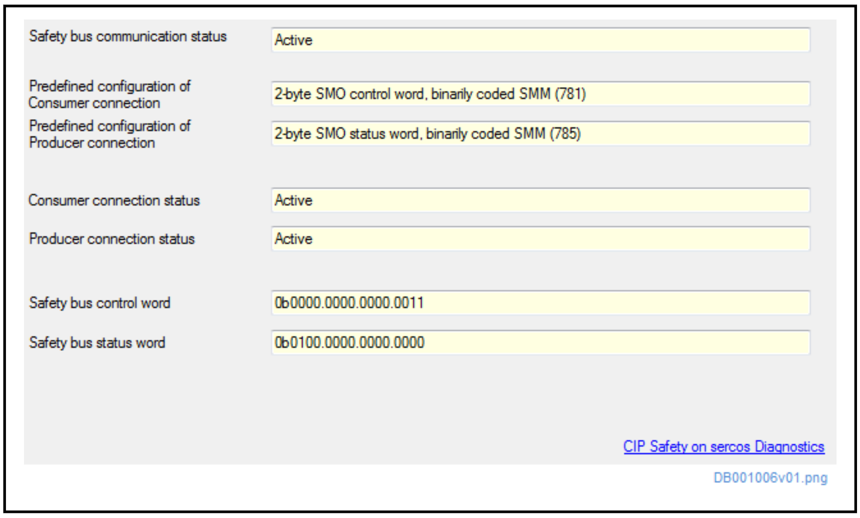


Fig. 5-7: "Safety bus communication" status dialog

- "Inputs and outputs" shows information on the status of the input and output signals of the local interface and of the safety zone module

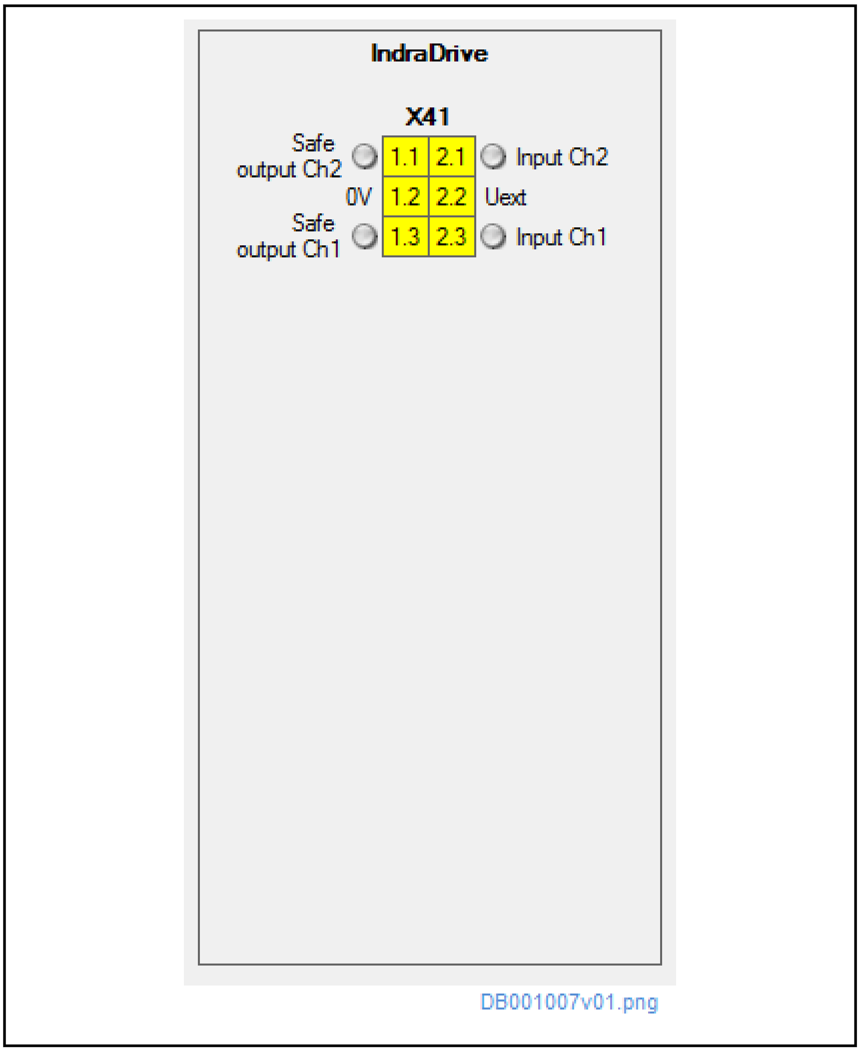


Fig. 5-8: "Inputs and outputs" status dialog

- "Safety zone and safe door locking" shows information on the status of the safety zone and of safe door locking (for the zone master only)
- "Safe brake control" shows information on the status of the safe brake control

5.4.4 Error reaction / escalation strategy

"Safe Motion" has two operating states, "normal operation" and "special mode". In both operating states, an error or a warning is generated if a monitoring function is triggered.

The error messages of "Safe Motion" can be divided into the following classes:

Diagnostic message number	Error class
F3xxx	Non-fatal safety technology error
F7xxx	Safety technology error
F83xx	Fatal safety technology error

The warning messages of "Safe Motion" can be divided into the following classes:

Functional principle

Diagnostic message number	Warning class
E3xxx	Safety technology warnings **without** drive reaction
E83xx	Safety technology warnings **with** drive reaction, configurable

Warning messages of the "E83xx" class produce the same reactions and monitoring functions in the drive as the errors of the "F3xxx" class. Therefore, all error reactions of the "F3xxx errors" described in this documentation also apply to the "E83xx warnings".

Behavior in the error state

If an error state is detected, "Safe Motion" generates an error or a warning and triggers the drive reaction configured for the error or warning class (P-0-3263.0.1, SMO: Configuration of stopping process).

It is the objective of the error reaction to stop the axis. This stopping process is monitored by "Safe Motion". If the error reaction does not occur as expected, an error of the next higher error class is generated, in extreme cases causing torque disable (see "Escalation strategy of Safe Motion").

After an error reaction has been completed, the safety function "Safe Torque Off" (STO) is active. If it has been configured, the safety function SBC becomes active with STO; i.e. the connected brake has been safely switched off.

In the status word of "Safe Motion" (P-0-3231, SMO: Operating status), the "safety technology error" status bit is set to "0" in the case of error. The safety status of the axis is maintained during the transition process, i.e. depending on the operating status (normal operation or special mode) of the axis at the time the safety technology error occurs, safety is acknowledged or not during the transition process. Safety is acknowledged once the transition is complete. However, **No safety** is always acknowledged in the following cases:

Axis becomes "torque-free" during the error reaction	As long as the axis is "coasting", the safety status is set to "Axis not safe". As soon as "Safe Motion" has detected axis standstill, the safety status of the axis is permanently set to "Axis safe".
Error in safety technology encoder evaluation	"Safe Motion" can no longer ensure dual-channel safety. A coasting spindle, for example, cannot be detected. The safety status is permanently set to "Axis not safe".
Error in brake control	"Safe Motion" can no longer ensure dual-channel safety. The brake possibly cannot be applied any more. The safety status is permanently set to "Axis not safe".
Error in local acknowledgment output	The safety status is permanently set to "Axis not safe".
SMO system error (F8304) Fatal system errors (F9xxx) ("Safe Motion" does not generate any fatal system errors, but reacts to fatal system errors of the standard firmware.)	"Safe Motion" establishes the safe state "Safety Default"; this state comprises: • Output stage is locked (drive torque has been disabled) • Digital local outputs have been set to "0" • Brake output is deactivated; electrically releasing brake is applied! The safety status is permanently set to "Axis not safe".

Configuring the error reaction

The following error reactions can be configured in "P-0-3263.0.1, SMO: Configuration of stopping process" for the individual error classes of safety technology. The error reactions configured in P-0-3263.0.1 have to match the error reactions of the standard firmware (see "P-0-0117, Activation of control unit reaction on error" and "P-0-0119, Best possible deceleration"). Differing configurations are detected by the transition command error "C0214 SMO: Incorrect configuration". The following error reactions can be configured:

Reaction	F3xxx / E83xx (P-0-3263.0.1 bit 3-0, bit 16)	F7xxx (P-0-3263.0.1 bit 7-4)	F83xx (not configurable)	Drive behavior / deceleration	Reference to standard parameters
NC/MLD reaction on error	✓	–	–	The error reaction is executed by the NC / MLD, i.e. NC / MLD decelerates the drive. "Safe Motion" monitors that the reaction is completed within the parameterized tolerance time for the error reaction (P-0-3263.0.6). The monitoring functions and monitoring thresholds from the last safety technology operating status remain active.	P-0-0117, bit 0="1" or P-0-0117, bit 1="1"
Return motion*1)	✓	–	–	The drive is moved and decelerated by selecting a relative process block (P-0-0055 to P-0-0058). "Safe Motion" monitors that the reaction is completed within the parameterized tolerance time for the error reaction (P-0-3263.0.6). The monitoring functions and monitoring thresholds from the last safety technology operating status remain active.	P-0-0119, bit 3-0="3"
Velocity command value reset with ramp and filter (quick stop)	✓	–	–	The drive is decelerated by the standard firmware using velocity command value reset with ramp (S-0-0372) and filter (S-0-0349). With **active** SMO encoder evaluation (P-0-3242.0.1), "Safe Motion" monitors the error reaction of the standard drive using the safety function "SMD". With **inactive** SMO encoder evaluation (P-0-3242.0.1), "Safe Motion" monitors that the reaction is completed within the parameterized tolerance time for the error reaction (P-0-3263.0.6).	P-0-0119, bit 3-0="2"

Functional principle

Reaction	F3xxx / E83xx (P-0-3263.0.1 bit 3-0, bit 16)	F7xxx (P-0-3263.0.1 bit 7-4)	F83xx (not configurable)	Drive behavior / deceleration	Reference to standard parameters
Velocity command value reset with ramp and filter (emergency stop)	✓	✓	–	The drive is decelerated by the standard firmware using velocity command value reset with ramp (S-0-0429) and filter (S-0-0349). With **active** SMO encoder evaluation (P-0-3242.0.1), "Safe Motion" monitors the error reaction of the standard drive using the safety function "SMD". With **inactive** SMO encoder evaluation (P-0-3242.0.1), "Safe Motion" monitors that the reaction is completed within the parameterized tolerance time for the error reaction (P-0-3263.0.6 or P-0-3263.0.7).	P-0-0119, bit 3-0="4" P-0-0119, bit 7-4="4"
Velocity command value reset (emergency stop)	✓	✓	–	The drive is decelerated taking the torque limit value (P-0-0109) into account. With **active** SMO encoder evaluation (P-0-3242.0.1), "Safe Motion" monitors the error reaction of the standard drive using the safety function "SMD". With **inactive** SMO encoder evaluation (P-0-3242.0.1), "Safe Motion" monitors that the reaction is completed within the parameterized tolerance time for the error reaction (P-0-3263.0.6 or P-0-3263.0.7).	P-0-0119, bit 3-0="0" P-0-0119, bit 7-4="0"
Torque disable	✓	✓	✓	The drive torque is disabled by the standard firmware and the drive in this case is only decelerated by the friction torque. The drive coasts to stop. If a brake is available, it is controlled. The safety technology activates the safety function "STO" and - if configured/available - the safety function "SBC".	P-0-0119, bit 3-0="1" P-0-0119, bit 7-4="1"
*1): MPx20V10 and above					

The error reactions of the error classes can be combined as follows:

<table>
<tr><th>F3xxx or E83xx</th><th>F7xxx</th><th>F83xx</th></tr>
<tr><td rowspan="3">NC/MLD reaction</td><td>Velocity command value reset with ramp and filter (emergency stop)</td><td rowspan="12">Torque disable*2)</td></tr>
<tr><td>Velocity command value reset (emergency stop)</td></tr>
<tr><td>Torque disable</td></tr>
<tr><td rowspan="2">Return motion*1)</td><td>Velocity command value reset with ramp and filter (emergency stop)</td></tr>
<tr><td>Velocity command value reset (emergency stop)</td></tr>
<tr><td rowspan="2">Velocity command value reset with ramp and filter (quick stop)</td><td>Velocity command value reset with ramp and filter (emergency stop)</td></tr>
<tr><td>Velocity command value reset (emergency stop)</td></tr>
<tr><td rowspan="2">Velocity command value reset with ramp and filter (emergency stop)</td><td>Velocity command value reset with ramp and filter (emergency stop)</td></tr>
<tr><td>Velocity command value reset (emergency stop)</td></tr>
<tr><td>Velocity command value reset (emergency stop)</td><td>Velocity command value reset (emergency stop)</td></tr>
<tr><td>Torque disable*2)</td><td>Torque disable*2)</td></tr>
<tr><td colspan="3">*1): MPx20V10 and above
*2): Brake is controlled, if available</td></tr>
</table>

NC reaction on error

To avoid damage to the machine, it may be required that the master (e.g. NC) retains control of the travel profile of the axes even in the case of error and decelerates the machine axes in a coordinated way. For this case, the option "NC reaction on error" can be activated. The master is informed of an error via the drive status word (S-0-0135) so that the master can shut down the machine axes in a coordinated way and therefore avoid any damage.

As an alternative to the NC reaction, a reaction on error can also be realized for the (local) axis with "IndraMotion MLD".

> For the "NC/MLD reaction on error", it is recommended to configure the safety function "Safe maximum speed".

Error reaction times of "Safe Motion"

The generally valid maximum time from the occurrence of a safety technology error to the standstill of the axis or torque disable is calculated as follows:

"Error reaction F3 tolerance time" + "Error reaction F7 tolerance time" =

P-0-3263.0.6 + P-0-3263.0.7

The table below shows the exact calculations of the reaction times, depending on the axis configuration:

Functional principle

Configuration options (P-0-3263.0.1)		Reaction times			Assumed scenarios
F3 reaction / E83 reaction	F7 reaction	$t_{F3\ reaction}$	$t_{F7\ reaction}$	Total	
NC / MLD error reaction	Velocity command value reset with ramp and filter (emergency stop)	$t_{P\text{-}0\text{-}3263.0.6}$	$t_{P\text{-}0\text{-}3263.0.3}$ + v_x *1) / $a_{P\text{-}0\text{-}3263.0.5}$ + (3 × $a_{P\text{-}0\text{-}3263.0.5}$ / $j_{P\text{-}0\text{-}3253.0.8}$) *3) (max. $t_{P\text{-}0\text{-}3263.0.7}$)	$t_{F3\ reaction}$ + $t_{F7\ reaction}$	At the end of the F3 reaction, the axis moves with the velocity v_x *1). ⇒ F7 error For the F7 reaction, the axis needs the entire parameterized time and ramp until standstill.
	Velocity command value reset (emergency stop)		$t_{P\text{-}0\text{-}3263.0.3}$ + v_x *1) / $a_{P\text{-}0\text{-}3263.0.5}$ (max. $t_{P\text{-}0\text{-}3263.0.7}$)		
	Torque disable		Immediately	$t_{F3\ reaction}$	At the end of the F3 reaction, the axis is not yet in standstill. ⇒ F7error with torque disable.
	Velocity command value reset with inactive SMO encoder evaluation*2)		$t_{P\text{-}0\text{-}3263.0.7}$	$t_{F3\ reaction}$ + $t_{F7\ reaction}$	At the end of the F3 reaction, the axis is not yet torque-free. ⇒ F7 error For the F7 reaction, the axis needs the entire parameterized time.
Return motion*4)	Velocity command value reset with ramp and filter (emergency stop)	$t_{P\text{-}0\text{-}3263.0.3}$	$t_{P\text{-}0\text{-}3263.0.3}$ + v_x *1) / $a_{P\text{-}0\text{-}3263.0.5}$ + (3 × $a_{P\text{-}0\text{-}3263.0.5}$ / $j_{P\text{-}0\text{-}3253.0.8}$) *3) (max. $t_{P\text{-}0\text{-}3263.0.7}$)	$t_{F3\ reaction}$ + $t_{F7\ reaction}$	At the end of the reaction time of the F3 reaction, the axis moves with the velocity v_x *1) and exceeds the deceleration ramp. ⇒ F7 error For the F7 reaction, the axis needs the entire parameterized time and ramp until standstill.
	Velocity command value reset (emergency stop)		$t_{P\text{-}0\text{-}3263.0.3}$ + v_x *1) / $a_{P\text{-}0\text{-}3263.0.5}$ (max. $t_{P\text{-}0\text{-}3263.0.7}$)		
Velocity command value reset with ramp and filter (quick stop)	Velocity command value reset with ramp and filter (emergency stop)	$t_{P\text{-}0\text{-}3263.0.3}$	$t_{P\text{-}0\text{-}3263.0.3}$ + v_x *1) / $a_{P\text{-}0\text{-}3263.0.5}$ + (3 × $a_{P\text{-}0\text{-}3263.0.5}$ / $j_{P\text{-}0\text{-}3253.0.8}$) *3) (max. $t_{P\text{-}0\text{-}3263.0.7}$)	$t_{F3\ reaction}$ + $t_{F7\ reaction}$	At the end of the reaction time of the F3 reaction, the axis moves with the velocity v_x *1) and exceeds the deceleration ramp. ⇒ F7 error For the F7 reaction, the axis needs the entire parameterized time and ramp until standstill.
	Velocity command value reset (emergency stop)		$t_{P\text{-}0\text{-}3263.0.3}$ + v_x *1) / $a_{P\text{-}0\text{-}3263.0.5}$ (max. $t_{P\text{-}0\text{-}3263.0.7}$)		
Velocity command value reset with ramp and filter (emergency stop)	Velocity command value reset with ramp and filter (emergency stop)	$t_{P\text{-}0\text{-}3263.0.3}$ + v_x *1) / $a_{P\text{-}0\text{-}3263.0.5}$ + (3 × $a_{P\text{-}0\text{-}3263.0.5}$ / $j_{P\text{-}0\text{-}3253.0.8}$) *3) (max. $t_{P\text{-}0\text{-}3263.0.6}$)	Does not exist; F8 error is signaled because F3 ≙ F7 reaction	$t_{F3\ reaction}$	For the F3 reaction, the axis needs the entire parameterized time and ramp until standstill.
	Velocity command value reset (emergency stop)	$t_{P\text{-}0\text{-}3263.0.3}$	$t_{P\text{-}0\text{-}3263.0.3}$ + v_x *1) / $a_{P\text{-}0\text{-}3263.0.5}$ (max. $t_{P\text{-}0\text{-}3263.0.7}$)	$t_{F3\ reaction}$ + $t_{F7\ reaction}$	At the end of the reaction time of the F3 reaction, the axis moves with the velocity v_x *1) and exceeds the deceleration ramp. ⇒ F7 error For the F7 reaction, the axis needs the entire parameterized time and ramp until standstill.

Configuration options (P-0-3263.0.1)		Reaction times			Assumed scenarios
F3 reaction / E83 reaction	F7 reaction	$t_{F3\ reaction}$	$t_{F7\ reaction}$	Total	
Velocity command value reset (emergency stop)	Velocity command value reset (emergency stop)	$t_{P\text{-}0\text{-}3263.0.3}$ + v_x*1) / $a_{P\text{-}0\text{-}3263.0.5}$ (max. $t_{P\text{-}0\text{-}3263.0.6}$)	Does not exist; F8 error is signaled because F3 ≙ F7 reaction	$t_{F3\ reaction}$	For the F3 reaction, the axis needs the entire parameterized time and ramp until standstill.
Velocity command value reset with inactive SMO encoder evaluation*2)	Velocity command value reset with inactive SMO encoder evaluation*2)	$t_{P\text{-}0\text{-}3263.0.6}$	$t_{P\text{-}0\text{-}3263.0.7}$	$t_{F3\ reaction}$ + $t_{F7\ reaction}$	At the end of the F3 reaction, the axis is not yet torque-free. ⇒ F7 error For the F7 reaction, the axis needs the entire parameterized time.
Torque disable	Torque disable	Immediately	Immediately	=0	The axis immediately goes torque-free.

*1): v_x= Depending on the initial state, use the following data

- Normal operation **with** use of the safety function "Safe maximum speed" (SMS)
  v_x = P-0-3270.0.2
- Normal operation without safety function "Safe maximum speed" (SMS)
  v_x = maximum occurring velocity + P-0-3263.0.2 + P-0-3263.0.4
- Special mode "Safe motion" (SMMx)
  v_x = P-0-3290.x.2

*2): Inactive SMO encoder evaluation (P-0-3242.1.1 = "0"), velocity command value reset in accordance with setting in parameter "P-0-3263.0.1, SMO: Configuration of stopping process"

*3): Addend can only be used with MPx-20 and above, because the jerk ($j_{P\text{-}0\text{-}3253.0.8}$) can only be parameterized in this firmware and versions above

*4): from MPx20V10

Escalation strategy of "Safe Motion"

With "Safe Motion", the drive is decelerated in the case of error; for this purpose, an escalation strategy is run. The escalation strategy is used to make sure that the drive is decelerated in an optimum way and that wear of existing holding brakes, as well as load of the mechanical system, are minimized. According to the initial situation, deceleration in the case of error takes place on several levels. Each of the levels is monitored via two channels.

Normally, the escalation strategy is not run completely; this means that depending on the currently present error message and the resulting error reaction, the drive jumps to the corresponding escalation level. This can be one of the following levels:

- Escalation strategy, level 1: F3xxx / E83xx error reaction
- Escalation strategy, level 2: F7xxx error reaction
- Escalation strategy, level 3: F83xx error reaction

Within the first two levels of the escalation strategy, the effectiveness of the escalation level is monitored via the transition function "Safely-monitored deceleration" (SMD-E). When the trend monitoring triggers and thereby has detected that the axis cannot be decelerated in the desired time / the desired distance, the error reaction is taken to the next higher escalation level until the axis has been decelerated.

☞ Depending on the configuration, the type of monitoring of the escalation level can differ:

- F3xxx/E83xx error reaction as "NC / MLD error reaction": mere time monitoring for effectiveness of escalation level is active
- F3xxx-/E83xx error reaction as "return motion" (MPx20V10 and above): mere time monitoring for effectiveness of escalation level is active
- F3xxx/E83xx/F7xxx error reaction as "torque disable": no other escalation monitoring function active
- F83xx error reaction: no other escalation monitoring function active

If the same error reaction was configured for F3xxx errors and F7xxx errors, the transition after the 1st escalation level to the 2nd escalation level (F7xxx error reaction) does not take place, but the transition directly leads to the 3rd escalation level (F83xx error reaction). This avoids unnecessarily long reaction times.

5.5 Safe Motion state machine

5.5.1 Overview

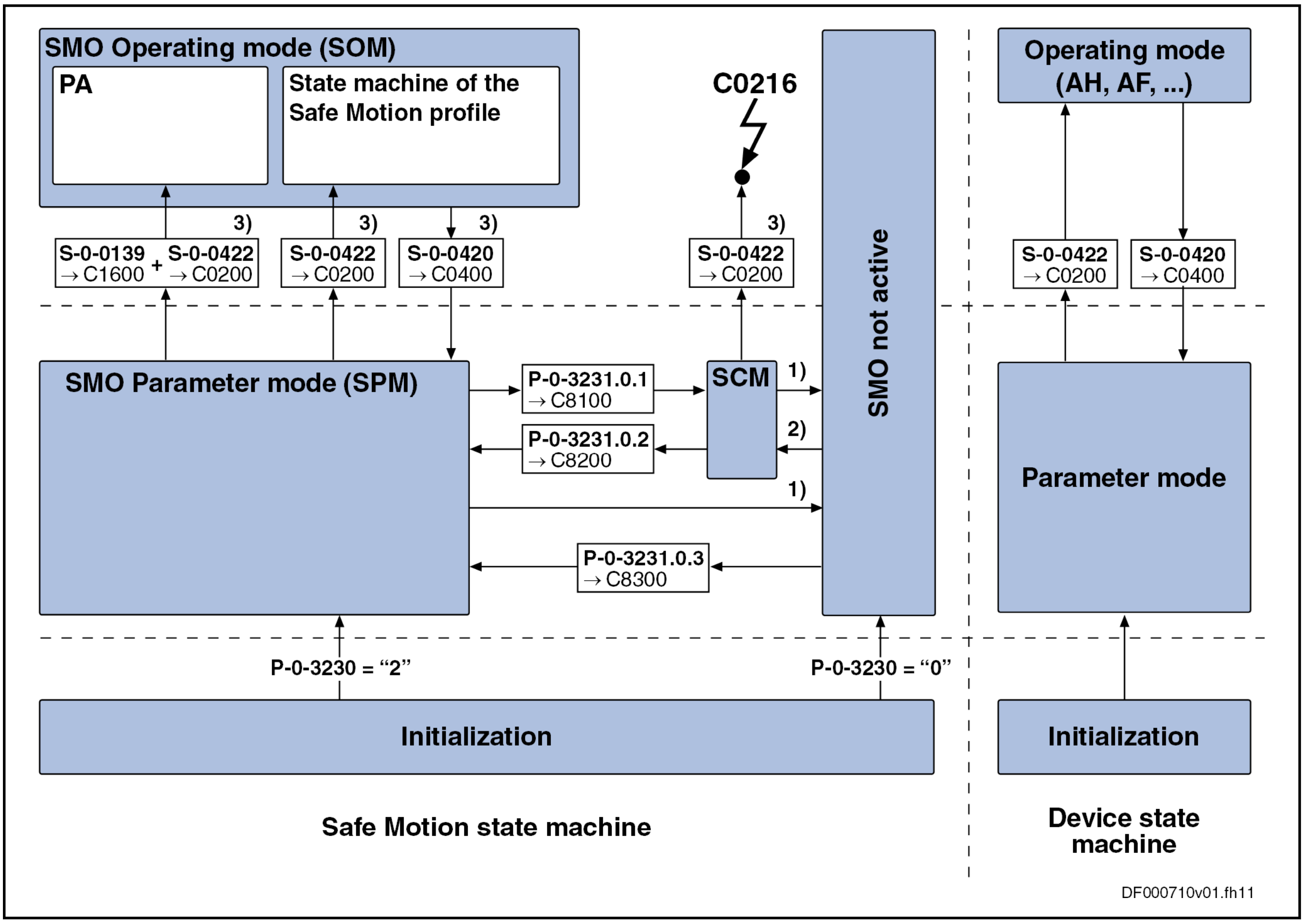
The safety technology state (e.g. special mode "Safe standstill", SMO configuration mode, safety technology error,...) represents a certain internal and external behavior of the drive with "Safe Motion". The safety technology state can be exited by defined events (e.g. drive commands, switching of operation modes). Corresponding state transitions are assigned to the events. The state transitions or the interaction of the control and status bits are called **state machine**.

☞ The parameters used to parameterize/configure the safety technology functions are write protected with "P-0-3230.0.1, SMO: Password" after safety technology has been activated, and therefore cannot be changed by unauthorized persons.

The status of the safety technology password can be seen in "P-0-3230, SMO: Password level".

For drives with "Safe Motion" we distinguish between:

- the "device state machine" (defines the device-specific states which determine the behavior of the device) and
- the "Safe Motion state machine" (defines the safety technology-specific states which determine the behavior of safety technology)



1)	Set C0750 or C0720 or password to default value
2)	Password assignment (P-0-3230.0.1)
3)	Actions of the device state machine
SCM	SMO configuration mode

Fig. 5-9: Safe Motion state machine

This chapter describes the "Safe Motion state machine" and its interaction with the "device state machine". For a detailed description of the "device state machine", see chapter "Device control and state machines" in the Functional Description of the firmware.

Pertinent parameters

The following parameters are used in conjunction with the "Safe Motion state machine":

- S-0-0139, C1600 Parking axis procedure command
- S-0-0420, C0400 Activate parameterization level procedure command
- S-0-0422, C0200 Exit parameterization level procedure command
- P-0-3201, SMO: Configuration of functional commissioning
- P-0-3230, SMO: Password level
- P-0-3230.0.1, SMO: Password
- P-0-3231, SMO: Operating status
- P-0-3231.0.1, C8100 SMO: Command Activate configuration mode
- P-0-3231.0.2, C8200 SMO: Command Exit configuration mode
- P-0-3231.0.3, C8300 SMO: Command Activate parameter image
- P-0-3231.0.4, SMO: System configuration

- P-0-3237, SMO: Status word
- P-0-4090, Configuration for loading default values

Pertinent diagnostic messages

- C0200 Exit parameterization level procedure command
- C0213 SMO: Incorrect parameterization
- C0216 SMO: SCM-OM switching not allowed
- C0400 Activate parameterization level 1 procedure command
- C0720 SMO: Load defaults procedure command
- C0750 Load defaults procedure command (factory settings)
- C1600 Parking axis command
- C8100 SMO: Command Activate configuration mode
- C8200 SMO: Command Exit configuration mode
- C8213 SMO: Incorrect parameterization
- C8300 SMO: Command Activate parameter image

5.5.2 Function

States

In the "Safe Motion state machine", we distinguish the following states:

- Initialization

  → In the "initialization" state, the safety technology is initialized and is in the safe state "Safety Default".

- SMO not active

  → In the "SMO not active" state, the safety technology of the drive is not active and is in the safe state "Safety Default". The safety technology waits for being activated by the assignment of a safety technology password (P-0-3230.0.1). As an alternative, safety technology can be activated by a parameter image being loaded and the command "C8300" being executed. In this state, only those safety technology errors are detected and signaled that require the hardware or firmware to be replaced.

  The "Safety Default" state is characterized by the following features:

  – The output stage is locked.
  – The drive does not signal safety.
  – All local safe outputs have been set to "0".
  – The brake output has been deactivated, i.e. an electrically releasing brake is applied.

☞ Even without active safety technology, it is possible to commission and operate a drive with a Safe Motion safety option. For this purpose, activate the "Functional commissioning" in the "SMO not active" state in the parameter "P-0-3201, SMO: Configuration of functional commissioning". Hereby, the output stage and brake interlock are disabled by the safety technology.

⚠ DANGER

Danger to life, risk of injury, serious injury or property damage! With functional enabling of the drive, the output stage and brake interlock are disabled by inactive Safe Motion! Protection is not provided in the danger zone.

The commissioning engineer is responsible for establishing safety by other means.

- SMO configuration mode (SCM)

  → In the "SMO configuration mode (SCM)" state, the safety technology of the drive is active and in the configuration mode.

  In this state, basic properties of safety technology can be configured and verified [e.g. the representation of parameters (scaling), the detection of the axis motion (encoder evaluation), the interfaces for selection and acknowledgment (local, safety zone module, Safety bus communication)]. The safety technology is in the safe state "Safety Default".

> ☞ All changes made to safety technology parameters must be verified before switching to SPM takes place. When the safety technology detects unverified parameters, it acknowledges the transition command with the command error "C8213 SMO: Incorrect parameterization".

> ☞ For switching to the SCM, the "device state machine" must be in the parameter mode (PM). Switching to OM is only possible after SCM has been exited, and is prevented by the command error "C0216 SMO: SCM-OM switching not allowed".

- SMO parameterization mode (SPM)

  → In the "SPM" state, the safety technology of the drive is active and is in the "Safe Torque Off" state. Furthermore, a selection evaluation takes place, the encoder evaluation is active (but encoder errors are not output) and the safety status signals "Axis safe" (if safety technology has detected axis standstill and all safety technology parameters have been verified).

  In "SPM" it is possible to configure all the safety technology functions and properties that are **not** part of the basic properties of safety technology (see SCM); this applies to the configuration of safety functions, the parameterization of monitoring thresholds and the configuration of the error reaction.

> ☞ All changes made to safety technology parameters must be verified before switching to SOM takes place. When the safety technology detects unverified parameters, it acknowledges the transition command with the command error "C0213 SMO: Incorrect parameterization".

- SMO operating mode (SOM)

  → In the "SOM" state, the safety technology in the drive is active and either in the sub-state "Parking axis" or in the "state machine of the Safe Motion profile". In SOM **changes to the configuration cannot** be made.

– **State machine of the Safe Motion profile**

  → When switching to "SOM" takes place, the "state machine of the Safe Motion profile" is called, unless the command "C1600 Parking axis command" was started. Depending on the active "Safe Motion profile", the selection is evaluated, the safety functions are activated and safety is acknowledged (see "Safe Motion profiles").

– **Parking axis (PA)**

  → When switching to "SOM" takes place, the switching to the "PA" state is carried out, if the command "C1600 Parking axis command" is active. In the "PA" state, the safety technology of the drive is active and in the "Safe Torque Off" state. There is no encoder analysis. Whether safety technology acknowledges safety when a safety function is selected, depends on the configuration ("P-0-3231.0.4, SMO: System configuration").

  (See also "Safe parking axis")

Switching

To change between the states of the Safe Motion state machine, use the following commands:

- Switching **SOM→SPM**: Is triggered by the corresponding switching of the "device state machine" (command "C0400 Activate parameterization level 1 procedure command")
- Switching **SPM→SOM**: Is triggered by the corresponding switching of the "device state machine" (command "C0200 Exit parameterization level procedure command")
- Switching **SPM→SCM**: by the command "C8100 SMO: Command Activate configuration mode"
- Switching **SPM→PA**: Is triggered by the corresponding switching of the "device state machine" (commands "C1600 Parking axis command" and "C0200 Exit parameterization level procedure command") (see "Safe parking axis")
- Switching **SPM→SMO not active**: Deactivating Safe Motion by means of command ("C0720 SMO: Load defaults procedure command" or "C0750 Load defaults procedure command (factory settings)") or changing the safety technology password (P-0-3230.0.1, SMO: Password) to the default value "INDRASAVE"
- Switching **SCM→SPM**: by the command "C8200 SMO: Command Exit configuration mode"
- Switching **SCM→SMO not active**: Deactivating Safe Motion by means of command ("C0720 SMO: Load defaults procedure command" or "C0750 Load defaults procedure command (factory settings)") or changing the safety technology password (P-0-3230.0.1, SMO: Password) to the default value "INDRASAVE"
- Switching **SMO not active→SPM**: By activating a parameter image by means of command "C8300 SMO: Command Activate parameter image" (see chapters "Replacing drive components" and "Serial commissioning")
- Switching **SMO not active→SCM**: By assigning the safety technology password (P-0-3230.0.1, SMO: Password)
- Switching **Initialization→SMO not active**: Automatically when the drive is booted up, if **no** safety technology password (P-0-3230.0.1) has been assigned yet

- Switching **Initialization→SPM**: Automatically when the drive is booted up, if a safety technology password (P-0-3230.0.1) has already been assigned

5.6 Safe Motion profiles

5.6.1 Overview

The integrated safety technology in the "Safe Motion" characteristic supports different Safe Motion profiles. The individual profiles differ with regard to the number of available safety functions and the type of selection and acknowledgment. Thus, the safety functions can be independently selected and deselected in some profiles, but in other profiles they cannot. This chapter describes the supported profiles with their profile-specific properties.

☞ Only the "Bosch Rexroth" Safe Motion profile is available up to now. It is automatically activated with "Safe Motion".

5.6.2 Safe Motion profile "Bosch Rexroth"

Brief description

The "Bosch Rexroth" Safe Motion profile is a Bosch Rexroth-specific profile. With this profile, the **safety functions cannot** be individually selected, it is only possible to select **different safety technology operating states**. Within the safety technology operating states the safety functions configured in these states become active.

In the case of a change between the individual safety technology operating states, a transition process is always started in which the command value system can be adjusted to the new monitoring limits. With drive-controlled transition, this is done automatically by the drive, and in the case of NC-controlled transition it has to be done by the control unit.

Features

The "Bosch Rexroth" Safe Motion profile has the following features:

- It is automatically activated with "Safe Motion".
- All safety functions available in Safe Motion can be used in this profile.
- Safety technology operating states can be selected.
- Direct selection of individual safety functions is not possible.
- Selection and acknowledgment are possible in discrete form via hardware inputs and via the safety bus.
- Safety functions in normal operation cannot be selected and deselected, but are always active in normal operation after configuration.
- Safety functions for Safe standstill cannot be directly selected.
- The safety functions for safe motion cannot be individually selected, but only in groups.
- The safety level to be achieved depends on the safety functions used.

  With the firmware version MPx-20 and above, and using the firmware options (FWS) "SIL3-MOTION" or "SIL3-PLUS", the safety level can be increased from SIL2 to SIL3 for some safety functions.

Pertinent parameters

The following parameters are used in conjunction with the "Bosch Rexroth" Safe Motion profile:

- P-0-3231, SMO: Operating status
- P-0-3237, SMO: Status word

Functional principle

- P-0-3261, SMO: State machine control word
- P-0-3261.0.1, SMO: State machine control word, functional
- P-0-3262, SMO: SMO: Selected operating status
- P-0-3264, SMO: Safety function selection
- P-0-3264.0.1, SMO: Safety function status
- P-0-3270.0.1, SMO: Configuration of global safety functions
- P-0-3277.0.1, SMO: Configuration of normal operation
- P-0-3285.0.1, SMO: Configuration of safe standstill
- P-0-3290.x.1, SMO: Configuration of safe motion
- P-0-3290.x.6, SMO: Maximum activation time of enabling control

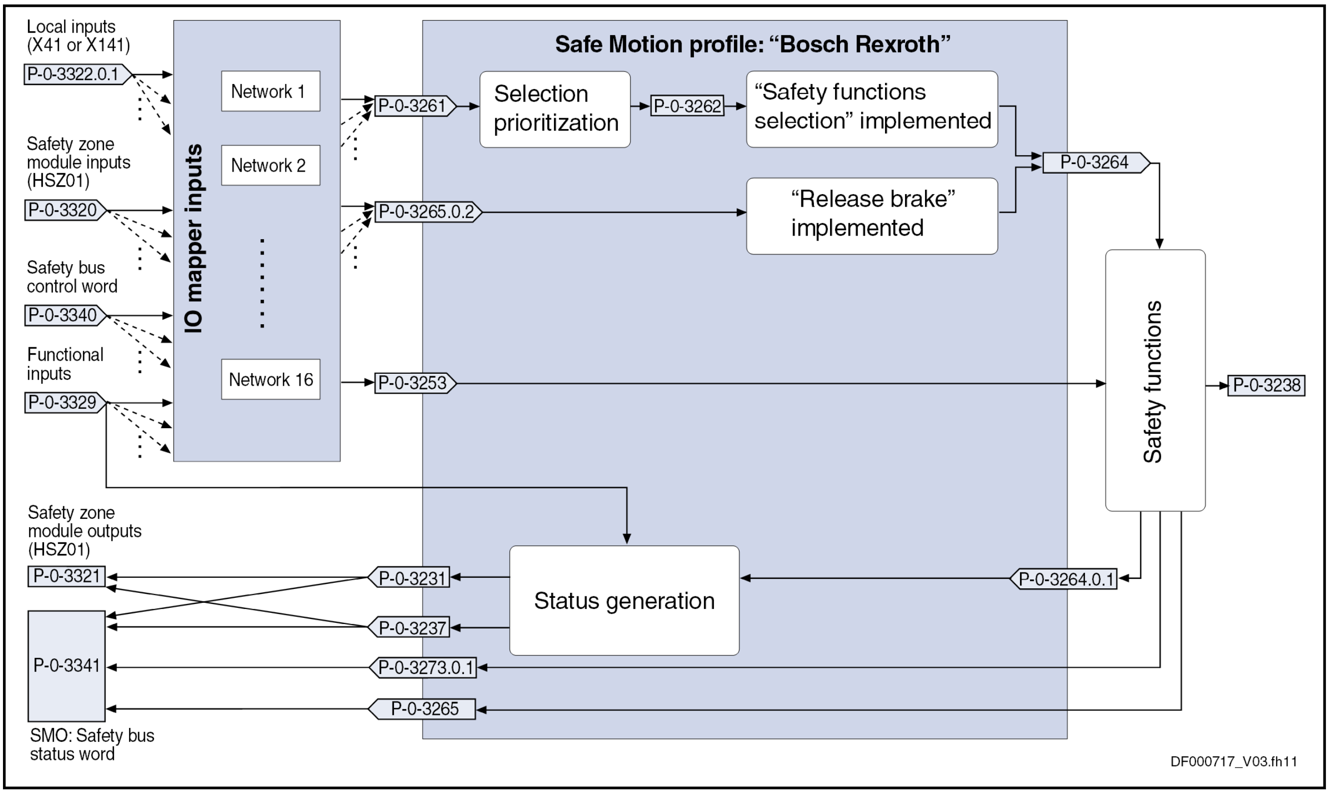
Pertinent diagnostic messages

The following diagnostic messages can be generated in conjunction with the "Bosch Rexroth" Safe Motion profile:

- A0301 Special mode Safe motion 1 active
- A0302 Special mode Safe motion 2 active
- ...
- A0316 Special mode Safe motion 16 active
- A0320 EMERGENCY STOP active
- A0321 Special mode Safe standstill active with STO
- A0322 Special mode Safe standstill active with SOS
- C0256 Safety technology configuration error
- F3141 Operating status selection validation error
- F3142 Activation time of enabling control exceeded

General information

In the "Bosch Rexroth" Safe Motion profile, the individual safety functions cannot be directly selected. The figure below shows the pertinent parameters and the basic function in conjunction with the "Bosch Rexroth" Safe Motion profile:



P-0-3320,	SMO: Safe Input Signals, safety zone module
P-0-3321,	SMO: Safe Output Signals, safety zone module
P-0-3322.0.1,	SMO: Functional input signals, local
P-0-3329,	SMO: Functional input signals, drive
P-0-3340,	SMO: Safety bus control word
P-0-3231,	SMO: Operating status
P-0-3237,	SMO: Status word
P-0-3238,	SMO: Active velocity threshold
P-0-3341,	SMO: Safety bus status word
P-0-3253,	SMO: Safe homing procedure control word
P-0-3261,	SMO: State machine control word
P-0-3262,	SMO: Selected operating status
P-0-3264,	SMO: Safety function selection
P-0-3264.0.1,	SMO: Safety function status
P-0-3265,	SMO: Status word of safe braking and holding function
P-0-3265.0.2,	SMO: Control word of safe braking and holding function
P-0-3273.0.1,	SMO: Status word, bit-coded SCA

Fig. 5-10: Control and status parameters with active "Bosch Rexroth" Safe Motion profile

Safety technology operating states

In the "Bosch Rexroth" Safe Motion profile, the individual safety functions cannot be directly selected. The safety functions are combined to form safety technology operating states. There are the following safety technology operating states:

- Normal operation (NO)
- Special mode "Safe motion" (SMM1 to SMM16)
- Special mode "Safe standstill" (SMST1 and SMST2)
- Special mode "Emergency stop" (SMES)

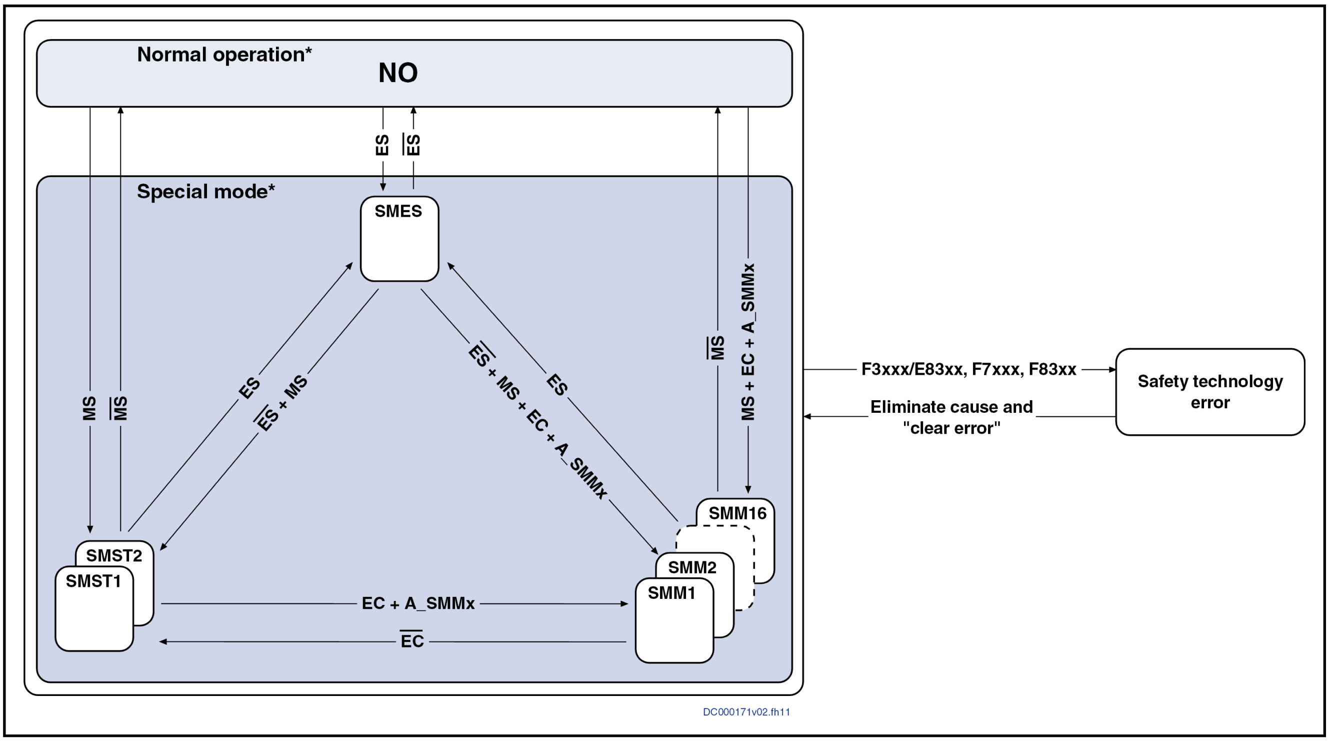
Functional principle

The safety technology operating states are selected using activation signals (P-0-3261). There are four types of activation signals:

- Mode selection signal
- Enabling control signal
- SMM signals
- Emergency stop signal

Via the "IO mapper inputs", the activation signals can be wired to discrete selection signals of the drive and of the safety zone module or mapped to the control signals of safe communication.

The state diagram below illustrates how the different safety technology operating states are selected with the activation signals:



ES	Emergency stop signal ("0" = active)
MS	Mode selection signal ("0" = active)
EC	Enabling control signal ("1" = active)
A_SMMx	SMMx signal ("1" = active)
*	Global monitoring functions active

Fig. 5-11: State diagram

Safety status

		Safety status of the axis	
		Axis safe	Axis not safe
Normal operation	Special mode transition process	–	✓
	Otherwise	–	✓
Special mode	Transition process within special mode	✓	–
	Transition process to normal operation	✓	–
	Otherwise	✓	–
Error	Transition process from special mode	✓[1]	–
	Transition process from normal operation	–	✓
	Otherwise	✓[1]	–

1) In certain cases, safety cannot be acknowledged, see ""Behavior in the error state " on page 78"

Tab. 5-3: Safety status of the axis

In IndraWorks, the safety status of the axis is displayed in the "Safe Motion" status dialog (see also index entry "Status dialog, Safe Motion").

Prioritizing the selection

The safety technology evaluates and prioritizes the selection of the safety technology operating states via the activation signals (P-0-3261). As the result of the prioritization (P-0-3262), only one safety technology operating status is activated at a time (P-0-3231). The table below shows the prioritization for the different selection combinations of the activation devices:

Activation signals				Selected safety technology operating status
Emergency stop signal (ES) (selected ≙ "0" = active)	Mode selection signal (MS) (selected ≙ "0" = active)	Enabling control signal (EC) (angewählt ≙ "1" = aktiv)	SMMx signal (A_SMM1.. A_SMM16)	
selected	selected	selected	selected	Special mode "Emergency stop" (SMES)
selected	selected	selected	-	
selected	selected	-	selected	
selected	selected	-	-	
selected	-	selected	selected	
selected	-	selected	-	
selected	-	-	selected	
selected	-	-	-	
-	selected	selected	selected[1]	Special mode "Safe motion x" (SMM1..SMM16)
-	selected	selected	-	Invalid selection [2], last operating status is maintained
-	selected	-	selected	Special mode "Safe standstill x" (SMST1 or SMST2)
-	selected	-	-	

Functional principle

Activation signals				Selected safety technology operating status
Emergency stop signal (ES) (selected ≙ "0" = active)	Mode selection signal (MS) (selected ≙ "0" = active)	Enabling control signal (EC) (angewählt ≙ "1" = aktiv)	SMMx signal (A_SMM1.. A_SMM16)	
-	-	selected	selected	Normal operation
-	-	selected	-	
-	-	-	selected	
-	-	-	-	

1) Only one SMM signal may be selected at a time to select a special mode "Safe motion".

2) One SMM signal has to be selected to select a special mode "Safe motion".

Tab. 5-4: Prioritization of the selection of safety technology operating states in "Bosch Rexroth" Safe Motion profile

Global safety functions

In the "Bosch Rexroth" Safe Motion profile, there are safety functions that are not activated via an operating status. These safety functions are called "global safety functions". They are always active in the operating mode (OM) after they have been configured. When "Safe Motion" is commissioned, the parameter P-0-3270.0.1 is used to configure the global safety functions which are to be active.

Safety functions

The following safety functions can be configured in the "global safety functions" group:

- Optional: Safe maximum speed (SMS)
- Optional: Safely-limited end position (SLE) (MPx-20 and above)
- Optional: Safe CAM (SCA) (MPx-20 and above)

Selection

The safety functions of the "global safety functions" group cannot be selected or deselected by activation signals. If they have been configured, they are always active when the axis is in the operating mode (OM). The safety functions take effect independently of the active safety technology operating status (P-0-3231).

Diagnostics

For the safety functions of the "global safety functions" group, there are no diagnostic status messages. The status (active / not active) of the individual safety functions can be read using P-0-3264.0.1.

Normal operation

The safety technology operating status "normal operation" corresponds to normal operation of the drive as a servo positioning axis, for example. In normal operation (also called "productive operation" or "automatic operation"), protective equipment prevents persons from accessing danger zones and keeps parts / materials from being thrown outwards. When "Safe Motion" is commissioned, the parameter P-0-3277.0.1 is used to configure the safety functions which are to be active in normal operation.

Safety functions

The following safety functions can be configured for normal operation (NO):

- Optional: Safe direction (SDI)
- Optional: Safely-limited end position (SLE) (MPx-20 and above)

Selection

The normal operation is always selected when the activation signals emergency stop signal (ES) **and** mode selection signal (MS) are **not** activated. When safety technology detects a valid selection of the normal operation, switching to normal operation takes place directly; there is no transition.

Diagnostics

For the safety technology operating status "normal operation", there is no diagnostic status message.

Using P-0-3262 it is possible to read out whether a selection for normal operation exists.

Using a status bit in P-0-3231, the safety technology signals whether normal operation is active or not.

Special mode "Emergency stop" (SMES)

In the "Bosch Rexroth" Safe Motion profile, the special mode "Emergency stop" (SMES) is the safety technology operating status of the highest priority. That is to say, if the special mode "Emergency stop" is selected at an axis, the axis **always** goes to the special mode "Emergency stop". This transition is independent of whether another valid selection for a special mode has been made or whether the axis already is in a special mode.

Typically, the special mode "Emergency stop" is used to implement the emergency stop function of a machine.

Safety functions

In the special mode "Emergency stop" (SMES), the following safety functions are active:

- Safe torque off (STO)
- Optional: Safe brake control (SBC)

Selection

The special mode "Emergency stop" is selected via the emergency stop signal (ES). This selection is **independent** of the selection of the mode selection signal (MS), the SMM signals (A_SMMx) and the enabling control signal (EC). That is to say the emergency stop signal always has the highest priority.

In the case of selection, the drive is not directly switched to the special mode "Emergency stop" (SMES), but the transition function "Safe stop 1" (SS1) is activated first. When the transition has been completed, the safety function Safe torque off (STO) is always executed in the special mode "Emergency stop". If configured, the safety function Safe brake control (SBC) becomes additionally active.

Diagnostics

When the axis is in the special mode "Emergency stop", it acknowledges this via the diagnostic status message "A0320 EMERGENCY STOP active".

Using P-0-3262 it is possible to read out whether a selection for emergency stop exists.

Using a status bit in P-0-3231, the safety technology signals whether the special mode "Emergency stop" is active or not.

During the transition (with transition function "SS1") to the special mode "Emergency stop", the axis still acknowledges the last active operating status via the diagnostic status message, because the monitoring functions of the operating status remain active during the transition. Using P-0-3231, bit 26, it is possible to read out whether the axis is in a transition to a new special mode or not.

Special mode "Safe standstill" (SMST)

In the "Bosch Rexroth" Safe Motion profile, the safety technology operating status special mode "Safe standstill" (SMST) is available in two characteristics: "SMST1" and "SMST2". When "Safe Motion" is commissioned, the parameter P-0-3285.0.1 is used to configure the standstill safety function which is to become active in the special mode. It is possible to configure either Safe torque off (STO) or Safe operating stop (SOS).

Functional principle

Safety functions

In the special mode "Safe standstill" (SMST), the following safety functions are active, depending on the configuration:

- SMST1: "Safe torque off" (STO)
- SMST1: optional "Safe brake control" (SBC)
- SMST2: "Safe operating stop" (SOS)

Selection

The special mode "Safe standstill" can be selected using the mode selection signal (MS). This selection only becomes active unless a simultaneous selection is present for the special mode "Emergency stop" (emergency stop signal) **or** the special mode "Safe motion" [mode selection signal (MS) and enabling control signal (EC) and an SMM signal (A_SMMx)].

In the case of selection, the drive is not directly switched to "SMST1" or "SMST2", but the transition function "Safe stop 1" (SS1) with "SMST1" configured, or the transition function "Safe stop 2" (SS2) with "SMST2" configured, is activated.

Switching from "SMES" to "SMST1" is carried out directly; i.e. the transition function "Safe stop 1" (SS1) is not activated.

When the transition has been completed, the safety function "Safe torque off" (STO) or "Safe operating stop" (SOS) is always executed in the special mode "Safe standstill" (SMST). If configured, the safety function "Safe brake control" (SBC) becomes additionally active in "SMST1".

Diagnostics

When the axis is in the special mode "Safe standstill 1" (SMST1), it acknowledges this via the diagnostic status message "A0321 Special mode Safe standstill active with STO", and in the active special mode "Safe standstill 2" (SMST2), the axis acknowledges this with the diagnostic status message "A0322 Special mode Safe standstill active with SOS".

Using P-0-3262, it is possible to read out whether a selection for Safe standstill exists.

Using a status bit in P-0-3231, the safety technology signals whether Safe standstill is active or not.

During the transition (with transition function "SS1" or "SS2") to SMST, the axis still acknowledges the last active operating status via the diagnostic status message, because the monitoring functions of the operating status remain active during the transition.

Using P-0-3231, it is possible to read out whether the axis is in a transition to a new special mode or not.

Special mode "Safe motion" (SMM)

In the "Bosch Rexroth" Safe Motion profile, the special mode "Safe motion" (SMM) consists of 16 individual safety technology operating states (SMM1 to SMM16). They can be independently configured and parameterized. During the commissioning of "Safe Motion", it is possible to configure in P-0-3290.x.1 for the respective special mode "Safe motion" (SMMx) whether it may be selected and which safety functions are to become active in the special mode.

Safety functions

In the special mode "Safe motion" (SMM1 to SMM16), the following safety functions are active, depending on the configuration:

- Safely-limited speed (SLS)
- Optional: Safely-monitored transient oscillation (SLS-LT)
- Optional: Safe direction (SDI)
- Optional: Safely-limited increment (SLI)
- Optional: Safely-monitored position (SMP) (MPx-20 and above)

- Optional: Safely-limited position (SLP) (MPx-20 and above)

Selection

A specific special mode "Safe motion" (SMMx) can be selected via the simultaneous selection of the mode selection signal (MS), the enabling control signal (EC) and an SMMx signal (A_SMMx). This selection only becomes active, unless a simultaneous selection is present for the special mode "Emergency stop" (emergency stop signal). It is not allowed to simultaneously select mutiple special modes "Safe motion".

In the case of selection, the drive is not directly switched to the SMMx, but the transition function "Safely-monitored deceleration" (SMD) is activated.

Monitoring the activation time of enabling control:

The value parameterized in "P-0-3290.x.6, SMO: Maximum activation time of enabling control" defines the maximum allowed time for activating the enabling control. The enabling control has to be deactivated after the parameterized time is over. The time is effective when the mode selector and an SMM mode selector have been activated in addition to the enabling control.

WARNING! Dangerous movements! Danger to life, risk of injury, serious injury or property damage by switching off the monitoring of the activation time! It is possible to do without the monitoring of the activation time, if it is not common practice to use an enabling control in an industrial sector and if constant motion does not represent any danger. The machine manufacturer is responsible for the monitoring of the activation time and their risk analysis has to show their responsibility. With "P-0-3290.x.6, SMO: Maximum activation time of enabling control"="0", the time monitoring of the special mode "Safe motion" is deactivated (x=1…16). Too long monitoring times cause hazards, too.

When the transition has been completed, the safety function "Safely-limited speed (SLS)" is always executed in the special mode "Safe motion". If other safety functions have been configured, they become active, too.

Diagnostics

When the axis is in the special mode "Safe motion x" (SMMx), it acknowledges this via the diagnostic status message "A03xx Special mode Safe motion xx active" (1 to 16).

Using the parameter P-0-3262, it is possible to read out whether a selection for the special mode "Safe motion" exists.

Using the status bits of P-0-3231, the safety technology signals whether a special mode "Safe motion" is presently active or not.

During the transition (using the transition function "SMD") to SMMx, the axis still acknowledges the last active operating status via the diagnostic status message, because the monitoring functions of the operating status remain active during the transition.

Using P-0-3231, it is possible to read out whether the axis is in a transition to a new special mode or not.

Notes on application

Observe the following points for handling the safety technology operating states:

- If the enabling control is activated in normal operation, the reduction of the command value input can take effect in the control unit. Switching to the special mode internally activates the monitoring functions for Safe motion after the end of the transition times.
- In the case of a direct change in the operating status from one special mode "Safe motion" to another (e.g., from SMM2 to SMM5), the monitoring time for the enabling control signal keeps running, because the enabling control signal (EC) or the mode selection signal (MS) were not

reset. If the monitoring time then is greater than the threshold parameterized in P-0-3290.x.6, the error "F3142 Activation time of enabling control exceeded" is generated.

- Before a safety function with safe absolute position monitoring is selected, the "Safe homing procedure" has to be carried out.

  The Safe homing procedure requires an input at the optional safety technology module.

6 Safety functions

6.1 Global safety functions

Configured global safety functions take effect independently of the selection and are active in normal operation and special mode.

6.1.1 Safe maximum speed (SMS)

Brief description

In the case of the safety function "Safe maximum speed", the dual-channel monitoring prevents the drive from exceeding the preset velocity limit value (P-0-3270.0.2, SMO: Safe maximum speed).

Features

The safety function "Safe maximum speed" has the following features:

- Is suited for safety-relevant applications up to Category 3, PL d according to EN ISO 13849-1 or SIL 2 IEC 62061.

  In conjunction with a suitable measuring system and the firmware option (FWS) "SIL3-MOTION" or "SIL3-PLUS", the safety level Category 4, PL e (IndraDrive Mi with KCU02.2/KCU02.3: Category 3, PL e) according to ISO 13849-1 or SIL 3 according to IEC 62061 can be achieved.
- The safety function can be used in drive systems equipped with the optional safety technology module "S3", "S4", "S5", "SB" or "SD".
- Closed-loop controlled operation is monitored with regard to the exceeding of a defined velocity limit value (cf. "P-0-3270.0.2, SMO: Safe maximum speed").
- The safety function "Safe maximum speed" is active in normal operation and in special mode.
- The safety function "Safe maximum speed" is selected via the parameter "P-0-3270.0.1, SMO: Configuration of global safety functions" when safety technology is commissioned.
- When a monitoring function is triggered, this causes an error reaction which decelerates the drive system. The corresponding error message is "F7020 Safe maximum speed exceeded".
- The state of safety function "Safe maximum speed" is displayed via parameter "P-0-3264.0.1, SMO: Safety function status".

Pertinent parameters

The following parameters are used in conjunction with the safety function "Safe maximum speed":

- P-0-3238, SMO: Active velocity threshold
- P-0-3270.0.1, SMO: Configuration of global safety functions
- P-0-3270.0.2, SMO: Safe maximum speed

Pertinent diagnostic message

The following diagnostic message can be generated in conjunction with the safety function "Safe maximum speed":

- F7020 Safe maximum speed exceeded

With the safety function "Safe maximum speed" activated, the display of the IndraDrive control panel does not show any specific message, but the standard diagnostic message (e.g., "AF") appears.

Safety function

Selecting the function

The safety function "Safe maximum speed" is selected via the parameter "P-0-3270.0.1, SMO: Configuration of global safety functions" when safety technology is commissioned. If configured, the safety function is always active, independent of the selected operating status.

Monitoring functions

In the case of the safety function "Safe maximum speed", the dual-channel monitoring prevents the drive from exceeding the preset velocity threshold (P-0-3270.0.2, SMO: Safe maximum speed).

> The currently active velocity monitoring limit of Safe Motion is displayed in "P-0-3238, SMO: Active velocity threshold". With this parameter it is possible to check in the control unit whether the velocity command values are within the allowed limits.
>
> With the auxiliary function "limitation of the positioning velocity", it is possible to monitor and, if necessary, limit the velocity command value effective in the drive to the active velocity threshold (P-0-3238).

Monitoring of the safe maximum speed (cf. P-0-3270.0.2) is active in each safety technology operating status.

If the actual velocity is outside of the limit value (P-0-3270.0.2), the fatal safety technology error "F7020 Safe maximum speed exceeded" is generated by the drive and the drive is decelerated.

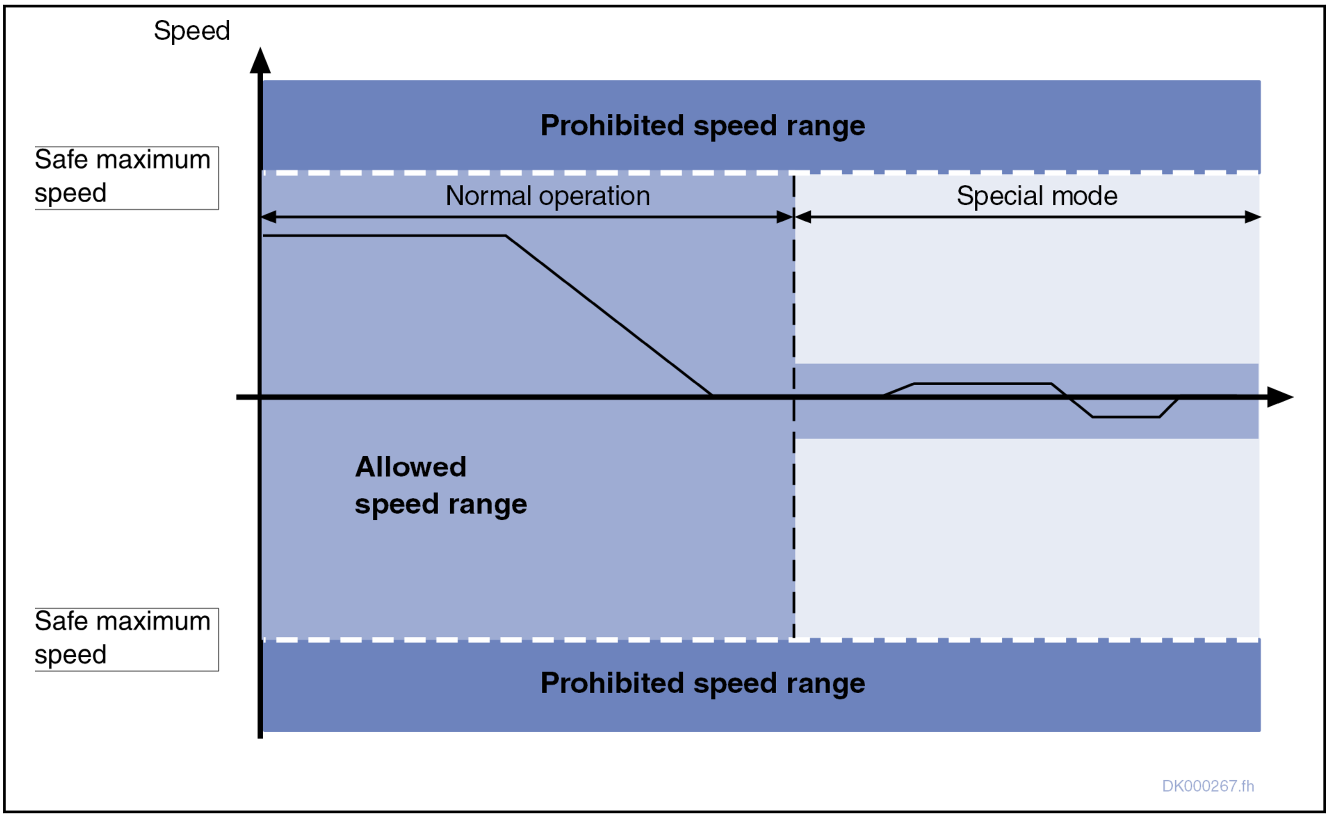


Fig. 6-1: |V_act|<P-0-3270.0.2

6.1.2 Safely-limited end position (SLE)

Brief description

The safety function "Safely-limited end position (SLE)" is one of the safe absolute position monitoring functions.

It can be configured either as a global safety function (takes effect in normal operation and special mode) or for normal operation only. Another absolute position monitoring function "Safely-limited position (SLP)" or "Safely-monitored position (SMP)" can be active in parallel.

Overview of "Safe absolute position monitoring functions"

<table>
<tr><th rowspan="2">Normal operation</th><th colspan="3">Special mode</th></tr>
<tr><th>SMES</th><th>SMST1/SMST2</th><th>SMM1...SMM16</th></tr>
<tr><td colspan="4">SLE</td></tr>
<tr><td rowspan="2">SLE</td><td colspan="2" rowspan="2"></td><td>SMP</td></tr>
<tr><td>SLP</td></tr>
</table>

In the case of the safety function "Safely-limited end position (SLE)", dual-channel monitoring prevents the drive from leaving a position range. The position range has to be set by a positive and a negative **end position limit value.**

Features

The safety function "Safely-limited end position (SLE)" has the following features:

- The safety function can be used with the firmware MPx-20 and above in drive systems equipped with the optional safety technology module "S3", "S4", "S5", "SB" or "SD"

  AND

  with the firmware option (FWS) "SAFETY-PLUS" or "SIL3-PLUS".
- Is currently suited for safety-relevant applications up to Category 3, PL d according to EN ISO 13849-1 or SIL 2 according to IEC 62061.

The auxiliary safety technology function "Safe homing procedure" is used to determine the safe absolute position, and is the prerequisite for the safety function "Safely-limited end position (SLE)". "Safe homing procedure" currently is only suited for safety-relevant applications up to Category 3, PL d according to EN ISO 13849-1 or up to SIL 2 according to IEC EN 62061, and thus limits the possible SLE SIL level to SIL 2.

With the availability of the safe absolute position in Category 4, PL e or SIL 3, the safety function can be used in conjunction with the firmware option (FWS) "SIL3-PLUS" for safety-relevant applications up to Category 4, PL e according to EN ISO 13849-1 or SIL 3 according to IEC EN 62061.

- It can be parameterized either as a global safety function (normal operation and special mode) or for normal operation only.
- Monitors the maximum allowed velocity at which the drive can still be stopped within the parameterized position limits ("P-0-3270.0.4, SMO: Safe end position limit value, positive"; "P-0-3270.0.5, SMO: Safe end position limit value, negative"), taking a parameterized deceleration and, where applicable, a jerk into account.

- When a monitoring function is triggered, this causes an error reaction which shuts down the drive system. The corresponding error messages are "F7023 SLE: Safe position limit value, positive exceeded" and "F7024 SLE: Safe position limit value, negative exceeded".
- The state of the safety function "Safely-limited end position (SLE)" (active/not active) is displayed in "P-0-3264.0.1, SMO: Safety function status", bit 25.

Pertinent parameters

The following parameters are used in conjunction with the safety function "Safely-limited end position (SLE)":

- P-0-3253.0.5, SMO: Maximum homing velocity
- P-0-3221.0.6, SMO: Modulo value
- P-0-3221.0.7, SMO: Maximum travel range
- P-0-3238, SMO: Active velocity threshold
- P-0-3238.0.1, SMO: Active position limit value, positive
- P-0-3238.0.2, SMO: Active position limit value, negative
- P-0-3253.0.1, SMO: Safe homing procedure configuration
- P-0-3257, SMO: Position feedback value
- P-0-3258, SMO: Velocity feedback value
- P-0-3263.0.1, SMO: Configuration of stopping process
- P-0-3263.0.5, SMO: SMD-E delay
- P-0-3263.0.8, SMO: SMD-E jerk
- P-0-3264, SMO: Safety function selection
- P-0-3264.0.1, SMO: Safety function status
- P-0-3264.0.2, SMO: Safety function diagnostics
- P-0-3270.0.1, SMO: Configuration of global safety functions
- P-0-3270.0.3, SMO: Standstill window for safe direction
- P-0-3270.0.4, SMO: Safe end position limit value, positive
- P-0-3270.0.5, SMO: Safe end position limit value, negative
- P-0-3277.0.1, SMO: Configuration of normal operation

Pertinent diagnostic messages

The following diagnostic messages can be generated in conjunction with the safety function:

- C0214 SMO: Incorrect configuration
- F7009 Homing velocity exceeded
- F7023 SLE: Safe position limit value, positive exceeded
- F7024 SLE: Safe position limit value, negative exceeded

Safety function

Configuration and selection

Using the safety function "Safely-limited end position" is only allowed if the Safe homing procedure has been activated in "P-0-3253.0.1, SMO: Safe homing procedure configuration" (bit 0="1").

The safety function "Safely-limited end position (SLE)" can be alternatively activated:

- as a monitoring function for normal operation only: "P-0-3277.0.1, SMO: Configuration of normal operation", bit 2="1"

- **or** as a global monitoring function in **normal operation and in special mode**: "P-0-3270.0.1, SMO: Configuration of global safety functions", bit 2="1"

> If the "Safely-limited end position (SLE)" has been parameterized in such a way that it is active in normal operation **and** globally, the drive generates the transition command error "C0214 SMO: Incorrect configuration".

The position limits for the safety function "Safely-limited end position (SLE)" have to be parameterized in "P-0-3270.0.4, SMO: Safe end position limit value, positive" and "P-0-3270.0.5, SMO: Safe end position limit value, negative". With **absolute scaling**, the position limits to be monitored have to be within "P-0-3221.0.7, SMO: Maximum travel range". With **modulo scaling**, the position limits to be monitored have to be within "P-0-3221.0.6, SMO: Modulo value".

In addition, make sure to comply with the minimum distances to the position limits of the axis.

⚠ DANGER

Lethal injury / property damage caused by operating the drive with incorrect position limit values parameterization, as the safe end positions (positive / negative) can be exceeded!

Check the required minimum distances of the parameterized position limits P-0-3270.0.4, SMO: Safe end position limit value, positive and P-0-3270.0.5, SMO: Safe end position limit value, negative.

Minimum distances to the position limits of the axis in the case of modulo scaling

P-0-3221.0.6 - P-0-3270.0.4 + P-0-3270.0.5 > 2 ms × maximum travel velocity of drive
Legend:
P-0-3221.0.6, SMO: Modulo value
P-0-3270.0.4, SMO: Safe end position limit value, positive
P-0-3270.0.5, SMO: Safe end position limit value, negative

Minimum distances to the position limits of the axis in the case of absolute scaling

(2 × P-0-3221.0.7) - P-0-3270.0.4 + P-0-3270.0.5 > 2 ms × maximum travel velocity of drive
Legend:
P-0-3221.0.7, SMO: Maximum travel range
P-0-3270.0.4, SMO: Safe end position limit value, positive
P-0-3270.0.5, SMO: Safe end position limit value, negative

☞ "P-0-3263.0.5, SMO: SMD-E delay" and "P-0-3263.0.8, SMO: SMD-E jerk" define the envelope curve of SMD-E delay monitoring and should be set in such a way that they correspond to the parameterization of the best possible deceleration of the drive in the case of F7 error. The correct parameterization ensures that the drive can come to standstill before exceeding the position limit.

☞ If the safety function "Safely-limited end position (SLE)" is used, the "torque disable" error reaction is not allowed for F7 errors.

The safety function "Safely-limited end position (SLE)" is selected with the selection of the safety technology operating status for which the safety function was parameterized.

☞ The position limits are only monitored by the safety function "Safely-limited end position" after the "Safe homing procedure" was carried out.

⚠ DANGER **Lethal injury / property damage caused by operating the drive without reference, as the safe positions (positive / negative) can be exceeded!**

As long as the drive has not been safely homed, make sure by further measures to prevent hazards caused by overrunning the end positions.

The status (active/inactive) returned by the safety function "Safely-limited end position (SLE)" is displayed in "P-0-3264.0.1, SMO: Safety function status", bit 25.

If the safety function has been selected, "P-0-3264.0.2, SMO: Safety function diagnostics" displays whether or not the position feedback value (P-0-3257) is within the positive (bit 0)/negative (bit 1) position limit.

If the safety function has **not** been selected or if safe reference is missing, bit 0 and bit 1 are set to "0" (actual position outside of position limits).

Monitoring functions

The safety function "Safely-limited end position (SLE)" monitors that the drive can be decelerated within the parameterized position limits with the current actual velocity and the parameterized braking ability.

For this purpose, the safety function in a direction-dependent way determines the braking distance available to the position limit. On the basis of the parameterized delay (P-0-3263.0.5, SMO: SMD-E delay) and the jerk (P-0-3263.0.8, SMO: SMD-E jerk), it calculates the maximum allowed velocity limit with which the drive can still come to standstill within the parameterized position limits. If the actual velocity (P-0-3258, SMO: Velocity feedback value) is greater than the maximum allowed velocity, the error "F7023 SLE: Safe position limit value, positive exceeded" or "F7024 SLE: Safe position limit value, negative exceeded" is generated in a direction-dependent way, and the drive is decelerated in accordance with the reaction parameterized for F7 errors.

"P-0-3263.0.5, SMO: SMD-E delay" and "P-0-3263.0.8, SMO: SMD-E jerk" define the envelope curve of SMD-E delay monitoring and should be set in such a way that they correspond to the parameterization of the best possible deceleration of the drive in the case of F7 error. The correct parameterization ensures that the drive can come to standstill before exceeding the position limit.

The maximum allowed velocity limit of the active safety function is displayed as an absolute value in "P-0-3238, SMO: Active velocity threshold", provided that no other safety function (e.g., SMS, SLS, SLS-LT) reduces the value in P-0-3238 even more.

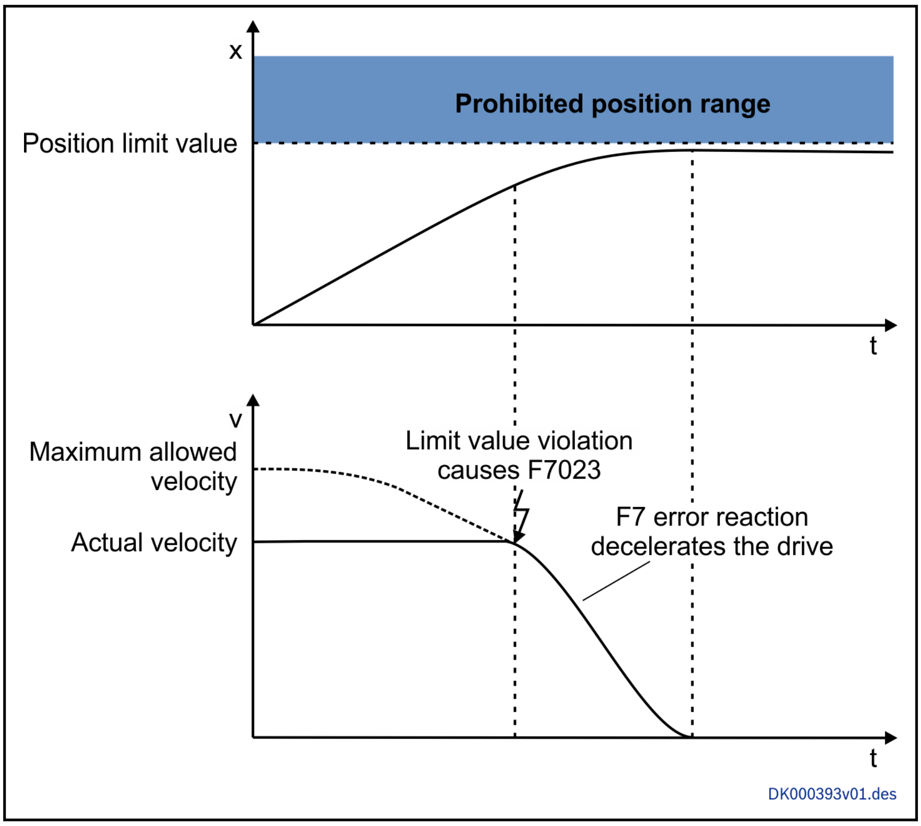


Fig. 6-2: Decelerating the drive when exceeding the maximum allowed velocity

In addition to the safety function "Safely-limited end position (SLE)", other absolute position monitoring functions "Safely-limited position (SLP)" or "Safely-monitored position (SMP)" can be active in the operation modes of the special mode "Safe motion". The currently monitored active position limits are made available via "P-0-3238.0.1, SMO: Active position limit value, positive" and "P-0-3238.0.2, SMO: Active position limit value, negative".

The drive has to have been safely homed for the safety function "Safely-limited end position". If Safe reference is not available, the position range is not monitored and the drive may be moved with no more than the velocity parameterized in P-0-3253.0.5. If this speed threshold is exceeded, the drive generates the error F7009 and is decelerated.

⚠ DANGER **Lethal injury / property damage caused by operating the drive without reference, as the safe positions (positive / negative) can be exceeded!**

As long as the drive has not been safely homed, make sure by further measures to prevent hazards caused by overrunning the end positions.

Return motion to allowed position range

If the axis is outside of the allowed position range, the error "F7023 SLE: Safe position limit value, positive exceeded" or "F7024 SLE: Safe position limit value, negative exceeded" is generated.

The error can be reset by the command "S-0-0099, C0500 Reset class 1 diagnostics". The drive can then be moved.

As long as the actual position of the drive (P-0-3257) is outside of the allowed position range, dual-channel monitoring makes sure that the drive only moves in the direction of the allowed position range with a velocity lower than "P-0-3253.0.5, SMO: Maximum homing velocity". If the velocity threshold is exceeded, the corresponding position limit value error is generated again. Movements in the opposite direction are allowed within the tolerance window defined in "P-0-3270.0.3, SMO: Standstill window for safe direction". Movements beyond will cause the error F7023 or F7024 again.

6.1.3 Safe CAM (SCA)

Brief description

With the safety function "Safe CAM (SCA)", the absolute position of the axis is monitored via two channels. The safe axis position is provided by freely definable safe position ranges (so-called cam ranges):

- for the output using safety bus communication or
- for the output using the local output of the optional safety technology module or
- as input signal for the IO mapper

Features

The safety function "Safe CAM (SCA)" has the following features:

- The safety function can be used with the firmware MPx-20V08 in drive systems equipped with the optional safety technology module "S3", "S4", "S5", "SB" or "SD"

  AND

  with the firmware option (FWS) "SAFETY-PLUS" or "SIL3-PLUS".
- Is suited for safety-relevant applications up to Category 3, PL d according to EN ISO 13849-1 or SIL 2 according to IEC 62061.

☞ The auxiliary safety technology function "Safe homing procedure" is used to determine the safe absolute position, and is the prerequisite for the safety function "Safe CAM (SCA)". "Safe homing procedure" currently is only suited for safety-relevant applications up to Category 3, PL d according to EN ISO 13849-1 or up to SIL 2 according to IEC EN 62061 and thus limits the possible SCA SIL level to SIL 2.

With the availability of the safe absolute position in Category 4, PL e or SIL 3, the safety function can be used in conjunction with the firmware option (FWS) "SIL3-PLUS" for safety-relevant applications up to Category 4, PL e according to EN ISO 13849-1 or SIL 3 according to IEC EN 62061.

- Up to 8 freely definable cam ranges (multiple cams) or (with MPx-20V12 and above) up to 31 adjacent, non-overlapping cam ranges (single cams) can be configured.
- The directionality (positive, negative, both directions) can be configured for each cam individually.
- The cam status is invertible for multiple cams.
- Time delays during the transmission of the cam status can be compensated via a parameterizable lead time (P-0-3270.0.6, SMO: Safe CAM, lead time).
- The safety function "Safe CAM (SCA)" is active in normal operation and in special mode.
- The safety function "Safe CAM (SCA)" is selected via the parameter "P-0-3264, SMO: Safety function selection" when safety technology is commissioned.
- The state of the safety function "Safe CAM (SCA)" (active/not active) is displayed in "P-0-3264.0.1, SMO: Safety function status".
- The cam status (cam activated/not activated) is displayed in the parameters "P-0-3273, SMO: Status word, binary-coded SCA" and "P-0-3273.0.1, SMO: Status word, bit-coded SCA".

Pertinent parameters

The following parameters are used in conjunction with the safety function "Safe CAM (SCA)":

- P-0-3221.0.6, SMO: Modulo value
- P-0-3221.0.7, SMO: Maximum travel range
- P-0-3255, SMO: Velocity threshold for safe standstill
- P-0-3256, SMO: Encoder evaluation status
- P-0-3257, SMO: Position feedback value
- P-0-3258, SMO: Velocity feedback value
- P-0-3264, SMO: Safety function selection
- P-0-3264.0.1, SMO: Safety function status
- P-0-3270.0.1, SMO: Configuration of global safety functions
- P-0-3270.0.3, SMO: Standstill window for safe direction
- P-0-3270.0.6, SMO: Safe CAM, lead time
- P-0-3271.0.1, SMO: Safe CAM 1
- P-0-3271.0.2, SMO: Safe CAM 2
- ...

- P-0-3271.0.31, SMO: Safe CAM 31
- P-0-3273, SMO: Status word, binary-coded SCA
- P-0-3273.0.1, SMO: Status word, bit-coded SCA

Pertinent diagnostic messages

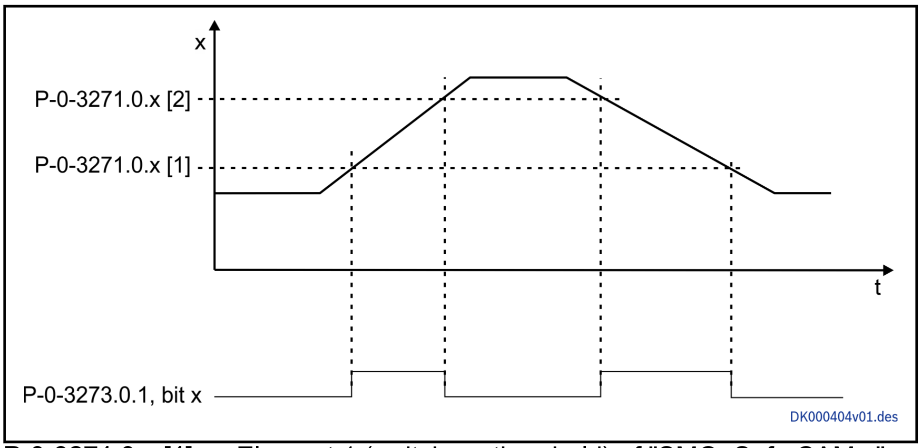
The following diagnostic messages can be generated in conjunction with the safety function:

- C0214 SMO: Incorrect configuration
- F7009 Homing velocity exceeded

Safety function

Basic function

When the safety function "Safe CAM (SCA)" is active, it is determined whether the drive is within a safe position range (so-called cam range). The cam range can be defined for each cam individually via switch-on and switch-off threshold. The result (cam status) is provided using a status word for further processing (via safety bus communication, via safe local output or as input signal for the IO mapper).



P-0-3271.0.x [1]	Element 1 (switch-on threshold) of "SMO: Safe CAM x"
P-0-3271.0.x [2]	Element 2 (switch-off threshold) of "SMO: Safe CAM x"
P-0-3273.0.1, bit x	Parameter displaying the cam status of the multiple cams in a "bit-coded" manner

Fig. 6-3: General functional principle of the safety function "Safe CAM (SCA)"

☞ Using the safety function "Safe CAM" is only allowed if the Safe homing procedure has been activated in "P-0-3253.0.1, SMO: Safe homing procedure configuration" (bit 0="1").

Configuration and selection

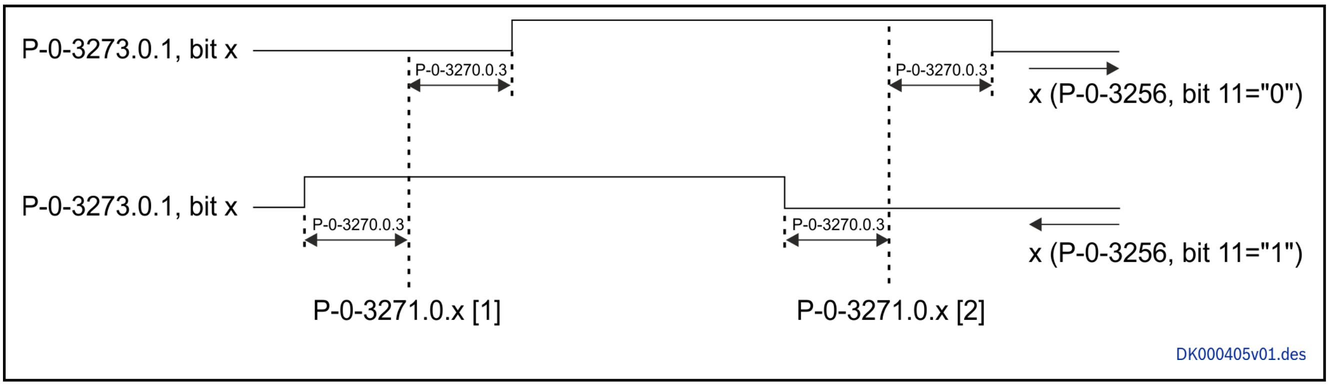
To use the safety function "Safe CAM (SCA)", it has to be configured via the parameter "P-0-3270.0.1, SMO: Configuration of global safety functions" when safety technology is commissioned. The type of cam evaluation (single or multiple cams) is to be selected here as well. The differences of the two cam types can be found in the following table:

Feature	Single cam	Multiple cams
maximum number of cams	31	8
Overlapping of the cam ranges possible	No, only adjacent allowed	Yes
Continuous arrangement of the cams	Not necessary	Not necessary
Parameterizable directionality	Yes	Yes
Cams invertible	No	Yes
Parameterizable switching hysteresis	Yes	Yes
Parameterizable lead time	Yes	Yes
Cam status transmittable via safety bus communication	Yes	Yes
Cam status evaluable as input signal for the "IO mapper inputs"	Only cams 1 to 16	Yes
Restriction for modulo scaling	With modulo scaling, single cams should not exceed the module limit	No restrictions for multiple cams in the case of modulo scaling

Tab. 6-1: Features of single and multiple cams

The cam ranges to be evaluated respectively, with the respective valid travel direction, are to be configured via the parameters "P-0-3271.0.1, SMO: Safe CAM 1" to "P-0-3271.0.8, SMO: Safe CAM 8" (for configuring multiple cams) or "P-0-3271.0.31, SMO: Safe CAM 31" (for configuring of multiple cams).

Subsequently, the switching hysteresis is to be parameterized via the parameter "P-0-3270.0.3, SMO: Standstill window for safe direction" in order to suppress the flickering of the cams (when axis is stopped at the cam limit). The switching hysteresis can only be parameterized globally for all cams. When entering the cam range, it delays the setting of the cam and when moving out, it delays the deletion of the cam.

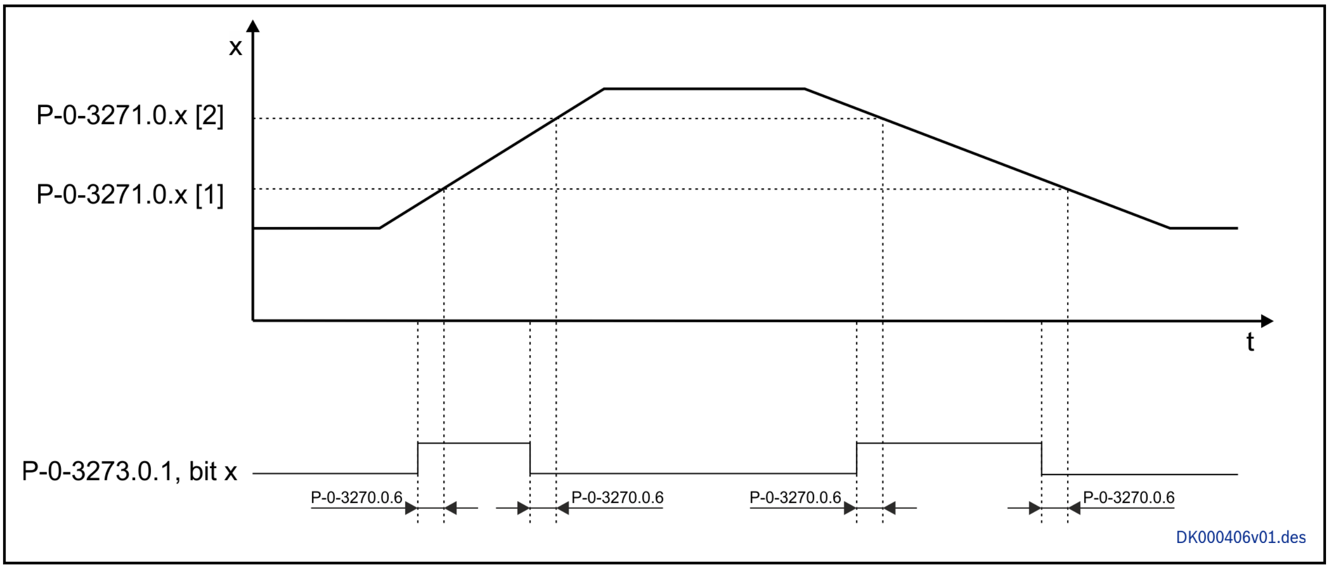


P-0-3270.0.3	SMO: Standstill window for safe direction
P-0-3271.0.x [1]	Element 1 (switch-on threshold) of "SMO: Safe CAM x"
P-0-3271.0.x [2]	Element 2 (switch-off threshold) of "SMO: Safe CAM x"
P-0-3273.0.1, bit x	Parameter displaying the cam status of the multiple cams in a "bit-coded" manner
P-0-3256	"Encoder evaluation status"; bit 11="0": direction of motion positive, bit 11="1": direction of motion negative

Fig. 6-4: Function of the switching hysteresis

To compensate for time delays when transmitting the cam status (e.g. transmission times for controlling) a lead time can be optionally parameterized in the parameter "P-0-3270.0.6, SMO: Safe CAM, lead time". This lead time takes effect for all cams. If a lead time is parameterized, a correction value is calculated from the lead time and the current actual velocity of the drive in Safe Motion, by which the switch-on and switch-off thresholds of the cams are shifted. The cam status bit of the respective cam thus switches by the lead time before reaching or leaving the cam.

☞ When using a lead time, the velocity of the drive in the range between shifted and actual switch-on and switch-off thresholds should be constant.



P-0-3270.0.6	SMO: Safe CAM, lead time
P-0-3271.0.x [1]	Element 1 (switch-on threshold) of "SMO: Safe CAM x"
P-0-3271.0.x [2]	Element 2 (switch-off threshold) of "SMO: Safe CAM x"
P-0-3273.0.1, bit x	Parameter displaying the cam status of the multiple cams in a "bit-coded" manner

Fig. 6-5: Function of the lead time

If the axis is safely homed and the safety function is configured, it is always active, independent of the selected operating status.

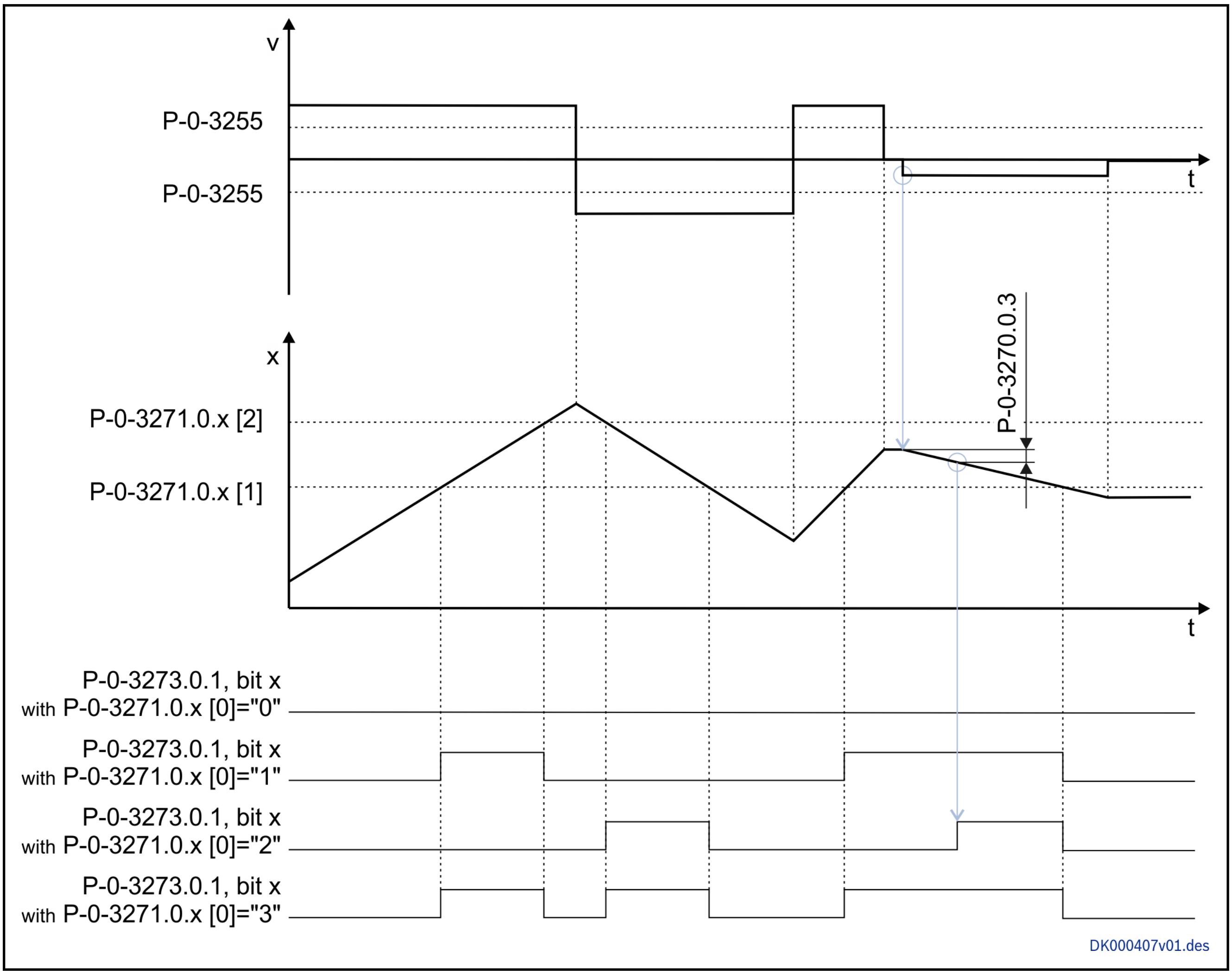
Monitoring functions

☞ The drive has to have been safely homed for the safety function "Safe CAM". If Safe reference is not available, the position range is not monitored and the drive may be moved with no more than the velocity parameterized in P-0-3253.0.5. If this speed threshold is exceeded, the drive generates the error F7009 and is decelerated.

Directionality of the cams of the moving direction:

It is to be configured for each cam in the list element 0 of the respective cam parameter (P-0-3271.0.x [0]) whether it is active and in which direction it takes effect. There are the following configuration options:

- P-0-3271.0.x [0]="0": cam not configured
- P-0-3271.0.x [0]="1": cam configured and taking effect only in positive direction
- P-0-3271.0.x [0]="2": cam configured and taking effect only in negative direction
- P-0-3271.0.x [0]="3": cam configured and taking effect in both directions



P-0-3255	SMO: Velocity threshold for safe standstill
P-0-3270.0.3	SMO: Standstill window for safe direction
P-0-3271.0.x [1]	Element 1 (switch-on threshold) of "SMO: Safe CAM x"
P-0-3271.0.x [2]	Element 2 (switch-off threshold) of "SMO: Safe CAM x"
P-0-3273.0.1, bit x	Parameter displaying the cam status of the multiple cams in a "bit-coded" manner

Fig. 6-6: Dependence of the cams on the direction

For cams taking effect into both directions, the cam status is generated depending on the axis position and taking into account the switching hysteresis and the lead time.

If only one direction has been configured for the cam (P-0-3271.0.x [0]="1" or "2"), the Safe direction is considered additionally (P-0-3256, bit 11). The type of consideration of the direction depends on the axis velocity. A distinction is made here as to whether the absolute value of the axis velocity is higher or lower than the value parameterized in "P-0-3255, SMO: Velocity threshold for safe standstill":

- Axis velocity **higher** P-0-3255:

  In this case, the Safe direction (P-0-3256, bit 11) is used directly for generating the cam status. That is to say the cam status is set in the cam range if the Safe direction is equal to the configured direction of the cam. If they differ, the cam status is deleted.

- Axis velocity **lower** P-0-3255:

  In the case of axis velocities lower P-0-3255, the Safe direction is not used for generating the cam status. As soon as the axis is within a cam range of a direction-dependent cam, the current actual position value is saved and then compared with the actual position to detect the direction.

  If the axis subsequently moves in the configured direction of the cam by the distance parameterized in "P-0-3270.0.3, SMO: Standstill window for safe direction" the cam status is set for the cam. The cam status remains set until the axis leaves the cam range (both directions) or until it moves in the opposite direction with a velocity higher than P-0-3255.

  If the axis moves in the non-configured direction of the cam by the distance parameterized in "P-0-3270.0.3, SMO: Standstill window for safe direction" the current actual position value is saved again and used for further comparison with the actual position. In this case, the cam status remains "not set".

☞ In the worst case (after prior movement in the non-configured direction), the cam status is set only after a movement of 2 × P-0-3270.0.3 in the configured direction.

Inversion of cams

For multiple cams, it is possible to invert individual cams. The inversion of a cam is carried out by exchanging the switch-on and the switch-off threshold of the respective cam. The following cases regarding the generation of the cam status can be therefore distinguished:

- Cam not inverted:

  Switch-on threshold (P-0-3271.0.x [1]) **<** switch-off threshold (P-0-3271.0.x [2])

- Cam inverted:

  Switch-on threshold (P-0-3271.0.x [1]) **>** switch-off threshold (P-0-3271.0.x [2])

Acknowledging the cam status

The cam status (cam activated/not activated) is provided via the two parameters "P-0-3273, SMO: Status word, binary-coded SCA" and "P-0-3273.0.1, SMO: Status word, bit-coded SCA" for further processing.

☞ The cam status for the single cams 17 to 31 is only available in parameter "P-0-3273, SMO: Status word, binary-coded SCA", since the parameter "P-0-3273.0.1, SMO: Status word, bit-coded SCA" can only display the first 16 cams due to the display mode (bit-coded).

☞ The drive has to have been safely homed for the safety function "Safe CAM". If Safe reference is not available, the position range is not monitored and the cam status (P-0-3273 and P-0-3273.0.1) is not generated.

Notes on commissioning

In order to avoid that a cam range is passed without it being reported in the cam status (P-0-3273 and P-0-3273.0.1), the cams cannot undercut a minimum length. The minimum length is defined by the following conditions:

Conditions for the minimum length of a cam that is independent of the direction (P-0-3271.0.x [0]="3")

|switch-off threshold - switch-on threshold| - 2 × switching hysteresis > 2 ms × max. axis velocity when passing the cam
|switch-off threshold - switch-on threshold| > 2 × switching hysteresis
[(|switch-off threshold - switch-on threshold| 2 × switching hysteresis) ÷ max. axis velocity when passing the cam] > time delays when transmitting the cam status (e.g., transmission times to safety control)

Switch-off threshold P-0-3271.0.x [2]
Switch-on threshold P-0-3271.0.x [1]
Switching hysteresis P-0-3270.0.3

Conditions for the minimum length of a direction-dependent cam (P-0-3271.0.x [0]="1" or "2")

|switch-off threshold - switch-on threshold| - 3 × switching hysteresis > 2 ms × max. axis velocity when passing the cam
|switch-off threshold - switch-on threshold| > 3 × switching hysteresis
[(|switch-off threshold - switch-on threshold| 3 × switching hysteresis) ÷ max. axis velocity when passing the cam] > time delays when transmitting the cam status (e.g., transmission times to safety control)

Switch-off threshold P-0-3271.0.x [2]
Switch-on threshold P-0-3271.0.x [1]
Switching hysteresis P-0-3270.0.3

The switching hysteresis (P-0-3270.0.3) avoids the flickering of the cam status when the axis is at standstill at the cam limit. The switching hysteresis has to be higher than the noise of the actual position value (P-0-3257) at standstill.

> The cam configuration "switch-off threshold=switch-on threshold" (P-0-3271.0.x [2] = (P-0-3271.0.x [1]) is allowed. Though the cam is active in this configuration, it is however not effective. That is to say the cam status is not set when the cam is passed.

6.2 Safety functions in normal operation

6.2.1 Safe direction (SDI)

Brief description

The safety function "Safe direction" ensures that motion is only possible in one direction.

Features

The safety function "Safe direction" has the following features:

- Is suited for safety-relevant applications up to Category 3, PL d according to EN ISO 13849-1 or up to SIL 2 according to IEC EN 62061.

  In conjunction with a suitable measuring system and the firmware option (FWS) "SIL3-MOTION" or "SIL3-PLUS", the safety level Category 4, PL e (IndraDrive Mi with KCU02.2/KCU02.3: Category 3, PL e) according to ISO 13849-1 or SIL 3 according to IEC 62061 can be achieved.
- The safety function can be used in drive systems equipped with the optional safety technology module "S3", "S4", "S5", "SB" or "SD".
- The safety function "Safe direction" is active in **normal operation**, if it has been parameterized for this mode.

  and / or

The safety function "Safe direction" is active **when the special mode "Safe motion" is selected**, if it has been parameterized for this mode.

Normal operation and special mode are parameterized separately.

- The safety function "Safe direction" can be used together with the other safety functions of the special mode "Safe motion".
- When the monitoring for the direction of motion is triggered, this causes an error reaction which decelerates the drive system. The corresponding error message is "F7031 Incorrect direction of motion".
- The safety function "Safe direction" is selected via the active "Safe Motion" profile using the parameter "P-0-3264, SMO: Safety function selection".
- The state of the safety function "Safe direction" is displayed via parameter "P-0-3264.0.1, SMO: Safety function status".

Pertinent parameters

The following parameters can be used in conjunction with the safety function "Safe direction":

- P-0-3264, SMO: Safety function selection
- P-0-3264.0.1, SMO: Safety function status
- P-0-3270.0.3, SMO: Standstill window for safe direction
- P-0-3277.0.1, SMO: Configuration of normal operation
- P-0-3290.1.1, SMO: Configuration of safe motion 1
- P-0-3290.2.1, SMO: Configuration of safe motion 2
- ...
- P-0-3290.16.1, SMO: Configuration of safe motion 16

Pertinent diagnostic messages

The following diagnostic messages can be generated in conjunction with the safety function "Safe direction":

- C0214 SMO: Incorrect configuration
- F7031 Incorrect direction of motion

With motion monitoring activated, the IndraDrive control panel shows the following display:

- In **normal operation**, no specific message appears, the standard diagnostic message (e.g. "AF") is displayed
- In the **special mode** "Safe motion", "SMM" is displayed

Safety function

Configuration and selection

To use the safety function "Safe direction", it has to be configured during the commissioning of the safety technology, for the special mode "Safe motion" via the parameters "P-0-3290.x.1, SMO: Configuration of safe motion x" (x=1..16) for the corresponding motion mode (SMM1 - SMM16); for "normal operation", it has to be configured via the parameter "P-0-3277.0.1, SMO: Configuration of normal operation".

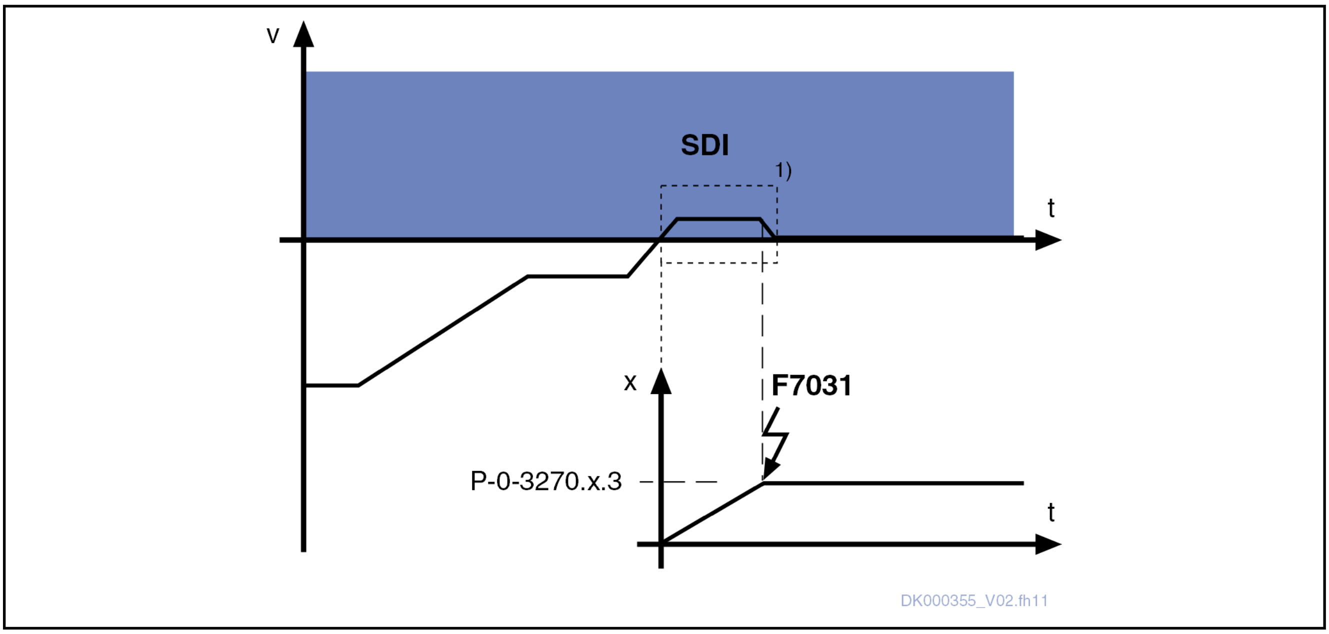
The safety function "Safe direction" is selected via the active "Safe Motion" profile using the parameter "P-0-3264, SMO: Safety function selection".

Monitoring functions

In the case of the safety function "Safe direction", dual-channel monitoring takes place to make sure that the drive only moves in the enabled direction of motion (cf. P-0-3290.x.1) or, when moving in the non-enabled direction of motion, that it does not exceed "P-0-3270.0.3, SMO: Standstill window for safe direction". Otherwise, the drive generates the error "F7031 Incorrect direction of motion" and the drive is decelerated.

The direction of motion has to be set in the corresponding control word:

- P-0-3277.0.1, SMO: Configuration of normal operation
- P-0-3290.1.1, SMO: Configuration of safe motion 1
- P-0-3290.2.1, SMO: Configuration of safe motion 2
- ...
- P-0-3290.16.1, SMO: Configuration of safe motion 16



1) Switching to the monitoring of the direction of motion. When the drive moves in the non-enabled direction of motion, the traveled distance must be smaller than P-0-3270.0.3.

Fig. 6-7: Example of "Safe direction (negative) in normal operation"

Selecting the effective limit value

The effective monitoring of the direction of motion is selected via the active "Safe Motion" profile using the parameter "P-0-3264, SMO: Safety function selection". For example, the 16 different "Safe motions" (SMM) with the corresponding directions can be selected via the SMMx signals 1 to 16 (A_SMMx, x=1..16) in the Safe Motion profile "Bosch Rexroth".

6.2.2 Safely-limited end position (SLE)

The safety function "Safely-limited end position (SLE)" is one of the safe absolute position monitoring functions. It can be configured either as a global safety function (normal operation and special mode) or for normal operation only.

Another position monitoring function "Safely-limited position (SLP)" or "Safely-monitored position (SMP)" can be active in parallel.

Overview of "Safe absolute position monitoring functions"

Normal operation	Special mode		
	SMES	SMST1/SMST2	SMM1…SMM16
SLE			
SLE			SMP
			SLP

In the case of the safety function "Safely-limited end position (SLE)", dual-channel monitoring prevents the drive from leaving a position range. The position range has to be set by a positive and a negative end position limit value.

See "Safely-limited end position (SLE)"

6.3 Safety functions in special mode "Safe standstill"

6.3.1 Safe torque off (STO)

Brief description

The energy supply to the motor is safely interrupted with the safety function "Safe Torque Off". The motor cannot generate any torque/any force and therefore no dangerous movements.

☞ Before directly selecting the safety function "Safe torque off", the drive system has to be decelerated via the command value input; there is no drive-controlled deceleration!

In the case of indirect selection via the transition function "Safe stop 1 (SS1)", the drive system is decelerated in accordance with the configuration of the transition function. Afterwards, switching to Safe torque off (STO) takes place.

⚠ DANGER **Lethal injury and/or property damage caused by unintended axis motion!**

⇒ Please observe the safety instructions in section "Notes on project planning".

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

During the time a safety function is active, power is not removed from the motor; de-energize the motor's drive before working on it.

Features

The safety function "Safe Torque Off" (STO) has the following features:

- Is suited for safety-relevant applications up to SIL 3 according to IEC 62061.
- Is suited for safety-relevant applications up to Category 4, PL e (IndraDrive Mi with KCU02.2/KCU02.3 Category 3, PL e) according to ISO 13849-1.
- Corresponds to stop category 0 according to IEC 60204-1.
- The safety function works independently of a measuring system.
- The safety function can be used in drive systems equipped with the optional safety technology module "S3", "S4", "S5", "SB" or "SD".
- The safety function "Safe torque off" is automatically activated at the end of the transition function "Safe stop 1 (SS1)"
- The energy supply to the motor is safely interrupted via two channels.
- The safety function "Safe torque off" is selected via the active "Safe Motion" profile using the parameter "P-0-3264, SMO: Safety function selection".

- The state of safety function "Safe torque off" is displayed via parameter "P-0-3264.0.1, SMO: Safety function status".
- When the safety function "Safe torque off" is active and drive enable is set, the error "F2025 Drive not ready for control" is generated.

Pertinent parameters

The following parameters are used in conjunction with the safety function "Safe Torque Off":

- P-0-3255, SMO: Velocity threshold for safe standstill
- P-0-3264, SMO: Safety function selection
- P-0-3264.0.1, SMO: Safety function status
- P-0-3285.0.1, SMO: Configuration of safe standstill

Pertinent diagnostic messages

The following diagnostic messages can be generated in conjunction with the safety function "Safe Torque Off":

- A0321 Special mode Safe standstill active with STO
- F2025 Drive not ready for control
- F8354 Error when checking interrupting circuits

With the safety function "Safe torque off" activated, the display of the IndraDrive control panel shows "SMST1".

Safety function

Configuration and selection

To use the safety function "Safe torque off", it has to be configured during the commissioning of the safety technology for the special mode "Safe standstill" via the parameter "P-0-3285.0.1, SMO: Configuration of safe standstill"; the standstill window has to be parameterized in P-0-3255, SMO: Velocity threshold for safe standstill. For the special mode "Emergency stop", only the parameter "P-0-3255, SMO: Velocity threshold for safe standstill" needs to be parameterized.

The safety function "Safe torque off" is selected via the active Safe Motion-profile using the parameter "P-0-3264, SMO: Safety function selection".

Monitoring functions

When the safety function "Safe torque off" is active and drive enable is set, the error "F2025 Drive not ready for control" is generated.

Furthermore, monitoring takes place so that the output stage is locked via two channels. When an error in the output stage interlock is detected, the drive generates the error "F8354 Error when checking interrupting circuits".

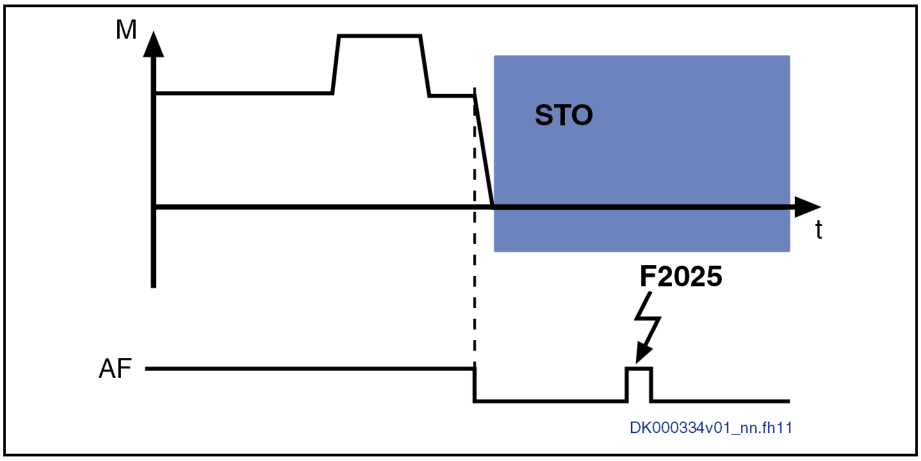


Fig. 6-8: Safety function "Safe torque off"

⚠ DANGER **Lethal injury and/or property damage caused by unintended axis motion!**

⇒ With the safety function"Safe torque off" activated, the drive does not provide any torque/force; this must be taken into account, particularly for vertical axes.

Please observe the safety instructions in section "Notes on project planning".

In addition to the monitoring functions of safety technology with the safety function "Safe torque off" activated, the standard firmware locks the execution of the following commands:

- "C1200 Commutation offset setting command"; if the command is started, the command error "C1217 Setting only possible in 'Ab'" is generated.
- "C3600 Command Motor data identification"; if the command is started, the command error "C3612 Command execution impossible" is generated.

Terminating the safety function The function "Safe torque off" can only be terminated by deselecting the safety function.

After the safety function was terminated, the working motion of the drive can only be continued after drive enable has been set.

Notes on project planning

When configuring the safety function "Safe torque off", it is absolutely necessary to observe the following safety instructions:

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

During the time a safety function is active, power is not removed from the motor; de-energize the motor's drive before working on it.

⚠ WARNING **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 counterbalance. For such axes, Bosch Rexroth recommends using the safe braking and holding system.

⚠ WARNING **Injury and/or property damage caused by deviation from standstill position!**

⇒ Even if the control of the power section has been safely locked, momentary axis motion, depending on the number of poles of the motor, can be triggered, when two errors are occurring simultaneously in the power section with the voltage DC bus being active:

- Breakdown of a power semiconductor **and**
- Breakdown of another semiconductor

In this case, two of six semiconductors are affected in such a way that the motor shaft is aligning.

Synchronous motor example: In the case of a synchronous motor with 6 pole pairs, the motion can be a maximum of 30 degrees. For a directly driven ball screw, e.g. 20 mm per revolution, this corresponds to a one-time maximum linear motion of 1.67 mm.

When an asynchronous motor is used, the short circuits in two separate circuits of the power section have almost no effect, because the exciter field breaks down when the inverter is shut down and has completely died down after approx. 1 s.

6.3.2 Safe operating stop (SOS)

Brief description

In the case of the safety function "Safe operating stop (SOS)", the drive is in controlled standstill, i.e. all control functions between the electronic control unit and the drive are maintained. The dual-channel monitoring prevents the drive from carrying out dangerous movements due to errors although the energy supply is not interrupted.

☞ Before directly selecting the safety function "Safe operating stop", the drive system must be decelerated via the command value input; drive-controlled deceleration does not take place!

In the case of indirect selection via the transition function "Safe stop 2 (SS2)", the drive system is decelerated in accordance with the configuration of the transition function. Afterwards, switching to the Safe operating stop (SOS) takes place.

⚠ DANGER **Lethal injury and/or property damage caused by unintended axis motion!**

⇒ Please observe the safety instructions in section "Notes on project planning".

Features

The safety function "Safe operating stop (SOS)" has the following features:

- Is suited for safety-relevant applications up to Category 3, PL d according to ISO 13849-1 or SIL 2 according to IEC 62061.

  In conjunction with a suitable measuring system and the firmware option (FWS) "SIL3-MOTION" or "SIL3-PLUS", the safety level Category 4, PL e (IndraDrive Mi with KCU02.2/KCU02.3: Category 3, PL e) according to ISO 13849-1 or SIL 3 according to IEC 62061 can be achieved.

- The safety function can be used in drive systems equipped with the optional safety technology module "S3", "S4", "S5", "SB" or "SD".
- The safety function "Safe operating stop (SOS)" is automatically activated at the end of the transition function "Safe stop 2 (SS2)"
- The energy supply to the motor is **not** interrupted.
- Closed-loop controlled operation in standstill is monitored (cf. "P-0-3285.0.2, SMO: Monitoring window for safe operational stop").
- When a monitoring function is triggered, this causes an error reaction which decelerates the drive system. The corresponding error message is "F7030 Position window for safe operating stop exceeded".
- The safety function "Safe operating stop (SOS)" is selected via the active "Safe Motion" profile using the parameter "P-0-3264, SMO: Safety function selection".
- The state of the safety function "Safe operating stop (SOS)" is displayed via parameter "P-0-3264.0.1, SMO: Safety function status".

Pertinent parameters

The following parameters are used in conjunction with the safety function "Safe operating stop (SOS)":

- P-0-3255, SMO: Velocity threshold for safe standstill
- P-0-3264, SMO: Safety function selection
- P-0-3264.0.1, SMO: Safety function status
- P-0-3285.0.1, SMO: Configuration of safe standstill
- P-0-3285.0.2, SMO: Monitoring window for safe operational stop

Pertinent diagnostic messages

The following diagnostic messages can be generated in conjunction with the safety function "Safe operating stop (SOS)":

- A0322 Special mode Safe standstill active with SOS
- C0214 SMO: Incorrect configuration
- F6200 Velocity command value > standstill window in SOS
- F7030 Position window for safe operating stop exceeded

With the safety function "Safe operating stop (SOS)" activated, the display of the IndraDrive control panel shows "SMST2".

Safety function

Configuration and selection

To use the safety function "Safe operating stop", it has to be configured during the commissioning of the safety technology for the special mode "Safe standstill" via the parameter "P-0-3285.0.1, SMO: Configuration of safe standstill"; the standstill window has to be parameterized in "P-0-3255, SMO: Velocity threshold for safe standstill", the monitoring window has to be parameterized in "P-0-3285.0.2, SMO: Monitoring window for safe operational stop".

The safety function "Safe operating stop" is selected via the active Safe Motion profile using the parameter "P-0-3264, SMO: Safety function selection".

Monitoring functions

With the safety function "Safe operating stop" activated, dual-channel monitoring of the actual position or the travel distance prevents the drive from carrying out dangerous movements due to errors.

☞ When the safety function "Safe operating stop (SOS)" has been selected, the control unit can reset drive enable and set it again. The monitoring of the standstill position always remains active.

Furthermore, monitoring takes place so that there are no command values preset for the drive during "Safe operating stop" which cause the drive to leave the monitoring window for the safe operating stop (P-0-3285.0.2).

If the travel distance becomes greater than the value parameterized in "P-0-3285.0.2, SMO: Monitoring window for safe operational stop", the drive generates the error "F7030 Position window for safe operating stop exceeded" and is decelerated.

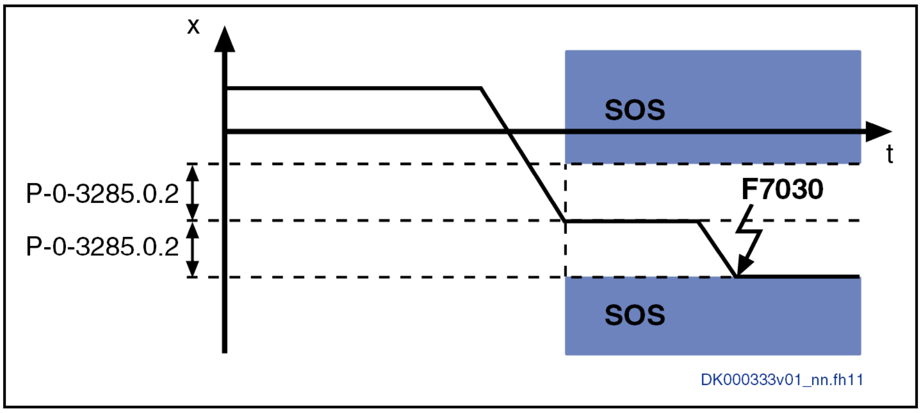


Fig. 6-9: Safety function "Safe operating stop" with monitoring of the actual position

With the safety function "Safe operating stop" activated, the standard firmware monitors, in addition to the monitoring functions of the safety technology, that there are no velocity command values greater than "S-0-0124, Standstill window" preset for the drive in the parameter "P-0-0048, Effective velocity command value". If higher velocity command values are preset, the drive generates the error "F6200 Velocity command value > standstill window in SOS" and is decelerated.

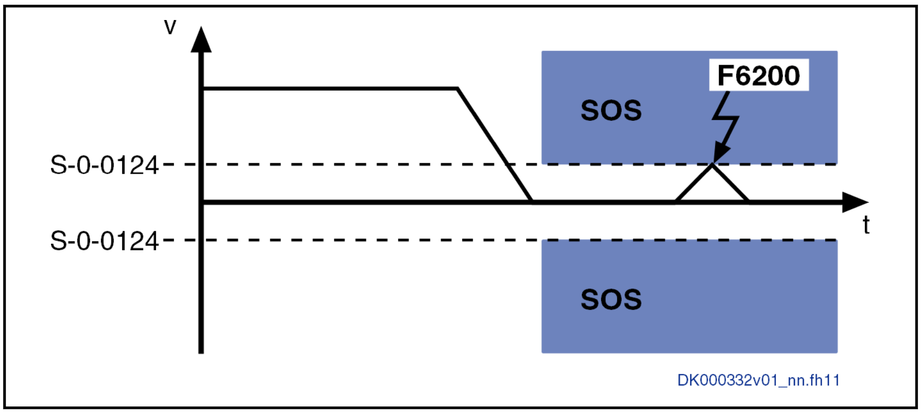


Fig. 6-10: Safety function "Safe operating stop" with monitoring of the command values

Terminating the safety function

After the Safe operating stop has been removed, e.g. by deselecting the safety function and executing the start command, the working motion of the drive can be immediately continued at the point of interruption.

The function "Safe operating stop" is deselected by selecting the safety function "Safe torque off (STO)" or by deselecting the safety function.

Notes on project planning

When using the safety function "Safe operating stop", it is absolutely necessary to observe the following safety instructions:

⚠ DANGER **Lethal injury and/or property damage caused by unintended axis motion!**

⇒ When the drive, with the safety function "Safe operating stop" activated, is in the uncontrolled state and external force influences are to be expected, any possible motion must be safely prevented by additional measures, e.g., by using a mechanical brake.

⚠ DANGER **Lethal injury and/or property damage caused by unintended axis motion!**

⇒ If external force influences are to be expected with the safety function "Safe operating stop", e.g. in case of a vertical axis, this motion must be safely prevented by additional measures, e.g. a mechanical brake or weight compensation; for such axes, Bosch Rexroth recommends using the safe braking and holding system.

⚠ WARNING **Injury and/or property damage caused by deviation from standstill position!**

⇒ When using the safety function "Safe operating stop", error situations (e.g. mains failure, controller defect) can occur in which the drive controller can no longer keep the axis in position. In this case, the axis must be kept in position by additional measures (e.g. mechanical brake). In the time between the occurrence of the error and the triggering of the "additional holding device", axis motion can occur. This has to be taken into account for the risk assessment of the installation.

For such axes, Bosch Rexroth recommends using the safe braking and holding system.

Make sure that the value parameterized in "P-0-3255, SMO: Velocity threshold for safe standstill" is sufficiently small, because during transition to the safe state, the standstill monitor ("P-0-3285.0.2, SMO: Monitoring window for safe operational stop") becomes active immediately after the velocity has fallen below this value, and the drive then must have come to standstill.

6.3.3 Safe brake control (SBC)

Brief description

The safety function "Safe brake control (SBC)" safely (via two channels) switches off an inductive load (e.g., self-applying holding brake). This allows inhibiting motions in a safety-relevant way.

☞ To simplify the terminology, "brakes" is always used in the following paragraphs. Other inductive loads can be used, too. Restrictions will be pointed out.

⚠ DANGER **Lethal injury and/or property damage caused by unintended axis motion!**

⇒ Please observe the safety instructions in section "Notes on project planning".

Features

The safety function "Safe brake control" (SBC) has the following features:

- Is suited for safety-relevant applications up to SIL 3 according to IEC 62061.
- Is suited for safety-relevant applications up to Category 4, PL e (IndraDrive Mi with KCU02.2/KCU02.3 Category 3, PL e) according to ISO 13849-1.
- The safety function works independently of a measuring system.
- The safety function can be used in drive systems equipped with the optional safety technology module "S4", "S5", "SB" or "SD".
- The safety function can be used in drive systems of the IndraDrive Cs, IndraDrive Mi (KMS03), IndraDrive M, IndraDrive C, IndraDrive ML ranges. No additional module is required for IndraDrive Cs and KMS03; the HAT02 control module is required for all other drive ranges.
- With the safety function "Safe brake control" configured, the brake is only controlled by the safety technology, i.e. the standard firmware cannot directly control the brake any more.
- If configured, the safety function "Safe brake control" is automatically activated at the end of the transition function "Safe stop 1 (SS1)".
- The energy supply to the inductive load is safely interrupted via two channels.
- Only self-holding (electrically releasing) brakes are supported (P-0-0525, bit 0="0").
- The brake is switched off if the maximum braking time of the drive (S-0-0273) is exceeded. Coasting after the maximum braking time is not supported (P-0-0525, bit 1="0").
- Online dynamization of the outputs and interrupting circuits.

⚠ **WARNING**

The safety function "Safe brake control" only checks the control of the inductive load, but not the holding or brake function! Uncontrolled axis motion in the case of insufficient holding or brake function!

The risk analysis has to show whether the holding or brake function has to be cyclically checked. If this is the case, the machine manufacturer has to develop functions to check the holding or brake function.

- The state of the safety function "Safe brake control" is displayed by the parameter "P-0-3264.0.1, SMO: Safety function status".
- The status of brake control is displayed by the parameter "P-0-3265, SMO: Status word of safe braking and holding function".

See Functional Description of firmware on how to commission the motor holding brake.

For IndraDrive C / IndraDrive M / IndraDrive ML, the safety-relevant brake control has to be effected using the HAT02 control module. Via the output for controlling the motor holding brake (X6), a brake can only be controlled functionally. If this output is used for an additional, not safety-relevant brake, it must be taken into account that the output cannot be controlled independently of the brake at the HAT02 control module.

Pertinent parameters

The following parameters are used in conjunction with the safety function "Safe brake control":

- P-0-0525, Holding brake control word
- P-0-3264.0.1, SMO: Safety function status
- P-0-3265, SMO: Status word of safe braking and holding function
- P-0-3265.0.1, SMO: Configuration of safe braking and holding function

Pertinent diagnostic messages

The following diagnostic messages can be generated in conjunction with the safety function "Safe brake control" (SBC):

- C0256 Safety technology configuration error
- C2001 Command not enabled
- F8353 SBC system error

With the safety function "Safe brake control" activated, the display of the IndraDrive control panel shows "SMST1" or "SMES". This is because Safe brake control is only activated in conjunction with the special mode "Safe standstill 1" (SMST1) or the special mode "Emergency stop" (SMES).

If IndraDrive M / IndraDrive C / IndraDrive ML are used, the brake is controlled via the external HAT02 control module. Additional diagnostics via LED is possible at the control module (see "LED H1").

Safety function

Configuration and selection

To use the safety function "Safe brake control", it has to be configured using the parameter "P-0-3265.0.1, SMO: Configuration of safe braking and holding function" when safety technology is commissioned. In addition, it is possible to configure in P-0-3265.0.1 whether it is allowed or not to "manually release the brake" with the safety function "Safe brake control" activated.

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

An error detected by evaluation leads to the system fault F8353 which causes the axis to be shut down and STO to be selected. In case of an error when closing the brake, the motor would thus have no energy available.

Take this into consideration for the safety review of the function, in particular for non-redundant holding systems.

When using the control unit HAT02.1-003, it can be configured in the P-0-3265.0.1 whether the acknowledging of the safety is carried out after evaluation of the switching state signals. To this end, the switch "S3, switching state signal evaluation" on the HAT02.1-003 is to be set to position 0 to 8.

The safety function "Safe brake control" is implicitly selected when the special mode "Safe standstill 1" (SMST1) and the special mode "Emergency stop" (SMES) are selected at the end of the transition function "SS1".

Monitoring functions

When the safety function "Safe brake control" is active, the brake is switched off via two channels. If an error in the brake switch-off is detected, the drive generates the error "F8353 SBC system error".

Furthermore, the availability of a brake is monitored using the brake current. If the drive detects that no brake has been connected, the drive generates the error "F8353 SBC system error".

In addition to the safety technology monitoring functions with "Safe brake control" configured, the standard firmware carries out the following monitoring functions:

Only an electrically releasing brake may have been configured in the parameter "P-0-0525, Holding brake control word". Otherwise, switching to the operating mode (OM) is prevented; the command error "C0256 Safety technology configuration error" is generated.

Terminating the safety function

The "Safe brake control" function can only be terminated indirectly by deselecting the special mode "Safe standstill 1" (SMST1) / "Emergency stop" (SMES).

Manually controlling (releasing) the brake

The brake can be controlled (released) with the command "C2000 Command Release motor holding brake", if the command was enabled in "P-0-0525, Holding brake control word".

If the safety function "Safe brake control" (SBC) is active (SMST1, SMES, error state), the following conditions have to habe been additionally fulfilled:

- The functionality was enabled in P-0-3265.0.1.
- With the evaluation of the safety technology encoder activated, axis standstill is safely detected (P-0-3256, SMO: Encoder evaluation status).
- The drive acknowledges safety in "P-0-3237, SMO: Status word".

To control (release) the brake, the following actions have to be taken:

1. The "release holding system" control signal (P-0-3265.0.2) has to be set via a safe input or the safety bus.
2. The command "C2000 Command Release motor holding brake" has to be started to control (to release) the brake.

⚠ WARNING **Lethal injury and/or property damage caused by unintended axis motion!**

⇒ If the brake is manually controlled via the "release holding brake" control signal, the drive is no longer able to counteract external force influences. In this state, the safety technology does not carry out any monitoring function!

If external force influences are to be expected, e.g. in the case of a vertical axis, this motion has to be safely prevented by additional measures, e.g. weight compensation.

Notes on commissioning

With the safety function "Safe brake control" configured, the brake is only controlled by the safety technology, i.e. the standard firmware cannot directly control the brake any more. This requires internal communication between the standard firmware and the safety technology. Therefore, a delay can occur between the request for brake control by the standard firmware and the execution by safety technology. This delay takes effect in addition to the times defined in the parameters "S-0-0206, Drive on delay time" and "S-0-0207, Drive off delay time" (see also Functional Description of firmware "Motor holding brake").

The control status of the brake is displayed by the parameter "P-0-3265, SMO: Status word of safe braking and holding function".

Notes on project planning

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

During the time a safety function is active, power is not removed from the motor; de-energize the motor's drive before working on it.

- When selecting the brake, it has to be taken into account that the control outputs are tested online during operation. For this purpose, the outputs are switched off for a short time (≤1 ms) and the brake is controlled. If a very fast acting brake is used, it cannot be excluded that the brake applies.
- When selecting the brake, it has to be taken into account that the control current is monitored for a fixed minimum value (see also "Allowed motor holding brakes").
- When selecting the brake, it has to be taken into account that the brake is directly operated with the 24 V supply voltage. Any supply voltage failure (e.g., overvoltage) can cause the brake to fail!

6.4 Safety functions in special mode "Safe motion SMMx"

6.4.1 Safely-limited speed (SLS)

Brief description

In the case of the safety function "Safely-limited speed", the dual-channel monitoring prevents the drive from exceeding the preset velocity limit value [P-0-3290.x.2 (x=1..16)].

⚠ DANGER **Lethal injury and/or property damage caused by unintended axis motion!**

Please observe the safety instructions in the chapter "Instructions for use".

Features

The safety function "Safely-limited speed" has the following features:

- Is suited for safety-relevant applications up to Category 3, PL d according to EN ISO 13849-1 or up to SIL 2 according to IEC EN 62061.

  In conjunction with a suitable measuring system and the firmware option (FWS) "SIL3-MOTION" or "SIL3-PLUS", the safety level Category 4, PL e (IndraDrive Mi with KCU02.2/KCU02.3: Category 3, PL e) according to ISO 13849-1 or SIL 3 according to IEC 62061 can be achieved.
- The safety function can be used in drive systems equipped with the optional safety technology module "S3", "S4", "S5", "SB" or "SD".
- Dual-channel monitoring for exceeding the velocity limit values (cf. "P-0-3290.x.2, SMO: Safely-limited speed").

  When the monitoring function is triggered, this causes an error reaction which decelerates the drive system. The corresponding error message is "F7013 Velocity threshold exceeded".
- The safety function "Safely-limited speed" is selected via the active "Safe Motion" profile using the parameter "P-0-3264, SMO: Safety function selection".

- The state of the safety function "Safely-limited speed" is displayed via parameter "P-0-3264.0.1, SMO: Safety function status".

Pertinent parameters

The following parameters are used in conjunction with the safety function "Safely-limited speed":

- P-0-3238, SMO: Active velocity threshold
- P-0-3264, SMO: Safety function selection
- P-0-3264.0.1, SMO: Safety function status
- P-0-3290.1.1, SMO: Configuration of safe motion 1
- P-0-3290.2.1, SMO: Configuration of safe motion 2
- ...
- P-0-3290.16.1, SMO: Configuration of safe motion 16
- P-0-3290.1.2, SMO: Safely-limited speed 1
- P-0-3290.2.2, SMO: Safely-limited speed 2
- ...
- P-0-3290.16.2, SMO: Safely-limited speed 16

Pertinent diagnostic messages

The following diagnostic messages can be generated in conjunction with the safety function "Safely-limited speed":

- C0214 SMO: Incorrect configuration
- F7013 Velocity threshold exceeded

With motion monitoring activated, the display of the IndraDrive control panel shows "SMM".

Safety function

Configuration and selection

The safety function "Safely-limited speed" is always active in the special mode "Safe motion". During commissioning, the effective velocity thresholds have to be parameterized via the parameters "P-0-3290.x.2, SMO: Safely-limited speed" (x=1..16).

The safety function "Safely-limited speed" is selected via the active "Safe Motion" profile using the parameter "P-0-3264, SMO: Safety function selection".

Selecting the effective limit value

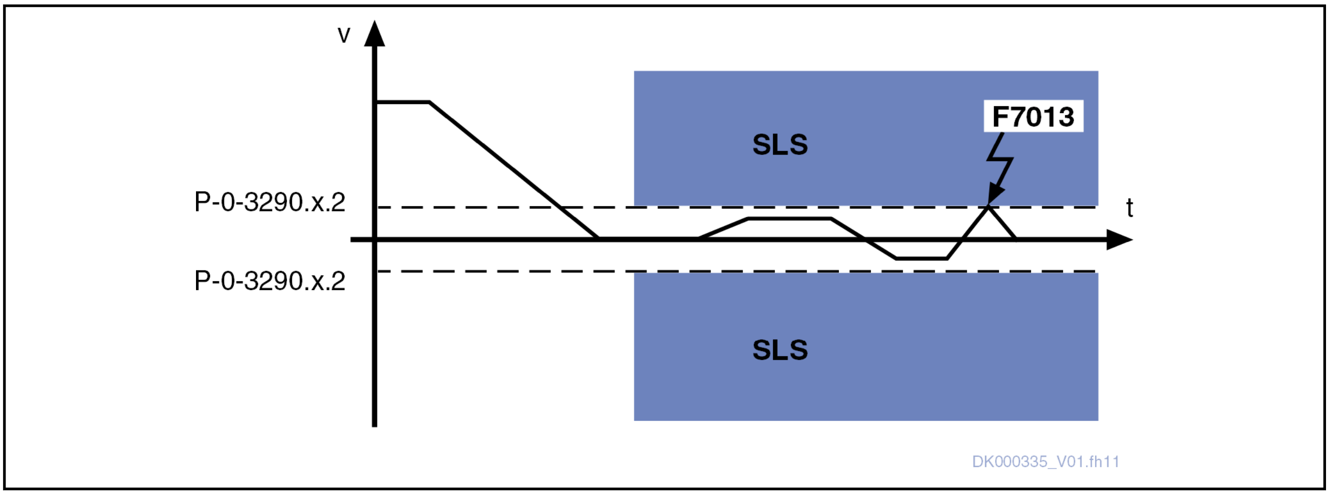
The effective threshold is selected via the active "Safe Motion" profile using the parameter "P-0-3264, SMO: Safety function selection". For example, the 16 different "Safe motions" (SMM) with the corresponding velocity limit values can be selected via the SMMx signals 1 to 16 (A_SMMx, x=1..16) in the Safe Motion profile "Bosch Rexroth".

Monitoring functions

In the case of the safety function "Safely-limited speed", dual-channel monitoring prevents the drive from exceeding the preset velocity limit values [P-0-3290.x.2 (x=1..16)].

⚠ DANGER **Lethal injury and/or property damage caused by unintended axis motion!**

Please observe the safety instructions in the chapter "Instructions for use".



F7013 Velocity threshold exceeded
P-0-3290.x.2 SMO: Safely-limited speed

Fig. 6-11: Safely-limited speed

If the actual velocity, with the safety function activated, is outside of the respective velocity limit value [P-0-3290.x.2 (x=1..16)], the drive generates the error "F7013 Velocity threshold exceeded" and the drive is decelerated.

The currently active velocity monitoring limit of Safe Motion is displayed in "P-0-3238, SMO: Active velocity threshold". With this parameter it is possible to check in the control unit whether the velocity command values are within the allowed limits.

With the auxiliary function "limitation of the positioning velocity", it is possible to monitor and, if necessary, limit the velocity command value effective in the drive to the active velocity threshold (P-0-3238).

Terminating the safety function

The safety function "Safely-limited speed" is deselected by deselecting the special mode "Safe motion".

Instructions for use

When using the safety function "Safely-limited speed", it is absolutely necessary to observe the following safety instructions:

⚠ DANGER **Lethal injury and/or property damage caused by unintended axis motion!**

⇒ If external force influences are to be expected with the safety function "Safely-limited speed", 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.

⚠ WARNING **Injury and/or property damage caused by deviation from standstill position!**

⇒ When using the safely-limited speed for axes with external force influences, error situations (e.g. mains failure, controller defect) can occur in which the drive controller can no longer keep the axis in position. In this case, the axis must be kept in position by additional measures (e.g. mechanical brake). In the time between the occurrence of the error and the triggering of the "additional holding device", axis motion can occur. This has to be taken into account for the risk assessment of the installation.

For such axes, Bosch Rexroth recommends using the safe braking and holding system.

Values for "Safely-limited speed"

In accordance with the Machinery Directive 2006/42/EC, the manufacturer of the machine must carry out a risk assessment. On the basis of the risk assessment, the values for limited speeds must be determined.

The following list contains guide values for different types of machines (excerpt from standards and working papers on safety measures for special mode). The abbreviation "SLS" means "Safely-limited speed", the abbreviation "SLI" means "Safely-limited increment".

Machining centers

- Axes: SLS=2 m/min + hold-to-run control
- Spindle: SLS=nn rpm + hold-to-run control + enabling control (choose nn in such a way that standstill is reached after 2 revolutions)

Automatic lathes

- Axes: SLS=2 m/min + hold-to-run control, SLI=6 mm + hold-to-run control
- Spindle: SLS=50 rpm (1 rps) + hold-to-run control + enabling control

Drilling and milling machines

- Axes: SLS=2 m/min + hold-to-run control
- Spindle: SLS=nn rpm + hold-to-run control + enabling control (choose nn in such a way that standstill is reached after 2 revolutions)

Robots

- SLS=15 m/min + hold-to-run control

Automated manufacturing systems

- SLS=2 m/min (15 m/min) + hold-to-run control + emergency stop

Printing and paper converting machines

- General: SLI=25 mm+ hold-to-run control - **or** - SLS=5 m/min (max. 10 m/min) + hold-to-run control
- "In particular": SLI=75 mm+ hold-to-run control - **or** - SLS=5 m/min (max. 10 m/min) + hold-to-run control

Safely-monitored transient oscillation (SLS-LT)

Brief description

To take transient oscillation processes into account, another monitoring variant - the "Safely-monitored transient oscillation" (SLS-LT) - is provided within the scope of the safety function "Safely-limited speed (SLS)".

With "Safely-monitored transient oscillation", the dual-channel monitoring prevents the drive from exceeding the preset velocity limit value [P-0-3290.x.8 (x=1..16)] for more than a preset time [P-0-3290.x.7 (x=1..16)].

⚠ DANGER **Lethal injury and/or property damage caused by unintended axis motion!**

Please observe the safety instructions in the chapter "Commissioning the safety technology".

Features

The "Safely-monitored transient oscillation" has the following features:

- Is suited for safety-relevant applications up to Category 3, PL d according to EN ISO 13849-1 or up to SIL 2 according to IEC EN 62061.
- The safety function can be used in drive systems equipped with the optional safety technology module "S3", "S4", "S5", "SB" or "SD".
- Is active when the safety function "Safely-limited speed" is selected, if it has been parameterized for this safety function.
- When the actual velocity value exceeds the velocity limit value after the tolerance time for overshooting is over, the drive switches off with the error message "F7014 Timeout safely-monitored transient oscillation".
- Dual-channel monitoring for exceeding the velocity limit values (cf. "P-0-3290.x.2, SMO: Safely-limited speed").

  When the monitoring function is triggered, this causes an error reaction which decelerates the drive system. The corresponding error message is "F7013 Velocity threshold exceeded".
- The safety function "Safely-monitored transient oscillation" is selected via the active "Safe Motion" profile using the parameter "P-0-3264, SMO: Safety function selection".
- The state of the safety function "Safely-monitored transient oscillation" is displayed via parameter "P-0-3264.0.1, SMO: Safety function status".

Pertinent parameters

The following parameters are used in conjunction with the "Safely-monitored transient oscillation":

- P-0-3238, SMO: Active velocity threshold
- P-0-3264, SMO: Safety function selection
- P-0-3264.0.1, SMO: Safety function status
- P-0-3290.1.1, SMO: Configuration of safe motion 1
- P-0-3290.2.1, SMO: Configuration of safe motion 2
- ...
- P-0-3290.16.1, SMO: Configuration of safe motion 16
- P-0-3290.1.2, SMO: Safely-limited speed 1
- P-0-3290.2.2, SMO: Safely-limited speed 2
- ...
- P-0-3290.16.2, SMO: Safely-limited speed 16
- P-0-3290.1.7, SMO: Tolerance time for overshooting 1
- P-0-3290.2.7, SMO: Tolerance time for overshooting 2
- ...
- P-0-3290.16.7, SMO: Tolerance time for overshooting 16
- P-0-3290.1.8, SMO: Safely-reduced speed 1
- P-0-3290.2.8, SMO: Safely-reduced speed 2
- ...
- P-0-3290.16.8, SMO: Safely-reduced speed 16

Pertinent diagnostic messages

The following diagnostic messages can be generated in conjunction with the "Safely-monitored transient oscillation":

- C0214 SMO: Incorrect configuration
- F7013 Velocity threshold exceeded
- F7014 Timeout in safely-monitored transient oscillation

With motion monitoring activated, the display of the IndraDrive control panel shows "SMM".

Safety function

Configuration and selection

To use the safety function "Safely-monitored transient oscillation", it has to be configured for the special mode "Safe motion" during the commissioning of the safety technology via the parameter "P-0-3290.x.1, SMO: Configuration of safe motion" (x=1..16). Furthermore, the velocity threshold has to be parameterized in "P-0-3290.x.8, SMO: Safely-reduced speed" (x=1..16), and the monitoring window has to be parameterized in "P-0-3290.x.7, SMO: Tolerance time for overshooting" (x=1..16).

The safety function "Safely-limited speed" is selected via the active "Safe Motion" profile using the parameter "P-0-3264, SMO: Safety function selection".

Selecting the effective limit value

The effective threshold is selected via the active "Safe Motion" profile using the parameter "P-0-3264, SMO: Safety function selection". For example, the 16 different "Safe motions" (SMM) with the corresponding velocity limit values can be selected via the SMMx signals 1 to 16 (A_SMMx, x=1..16) in the "Safe Motion" profile "Bosch Rexroth".

Monitoring functions

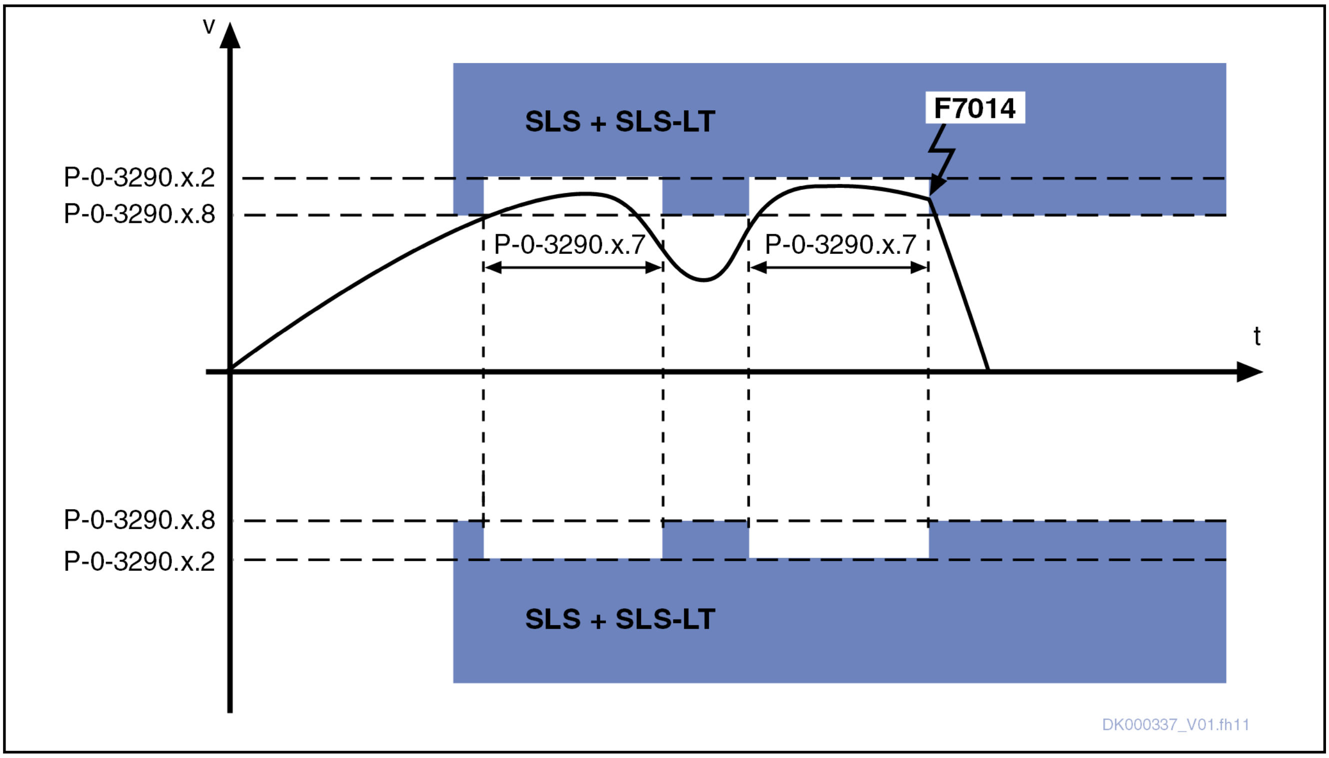
With "Safely-monitored transient oscillation", the dual-channel monitoring prevents the drive from exceeding the preset velocity limit value (P-0-3290.x.8) for more than a preset time (P-0-3290.x.7).

The velocity limit value (P-0-3290.x.8) has to be smaller than the value of the safely-limited speed (P-0-3290.x.2) parameterized in the selected special mode.

When the parameterized velocity limit value (P-0-3290.x.8) is exceeded for the first time, the parameterized time window (P-0-3290.x.7) is activated. In this window it is tolerated to exceed the parameterized velocity limit value. After the parameterized time is over, dual-channel monitoring takes place to make sure that velocity is below the parameterized velocity limit value. Otherwise, the drive generates the error "F7014 Timeout in safely-monitored transient oscillation". Afterwards, it is immediately possible to exceed the velocity limit value again. The time window will then be activated again. Retriggering during the running time window is impossible.

The currently active velocity monitoring limit of Safe Motion is displayed in "P-0-3238, SMO: Active velocity threshold". With this parameter it is possible to check in the control unit whether the velocity command values are within the allowed limits.

With the auxiliary function "limitation of the positioning velocity", it is possible to monitor and, if necessary, limit the velocity command value effective in the drive to the active velocity threshold (P-0-3238).

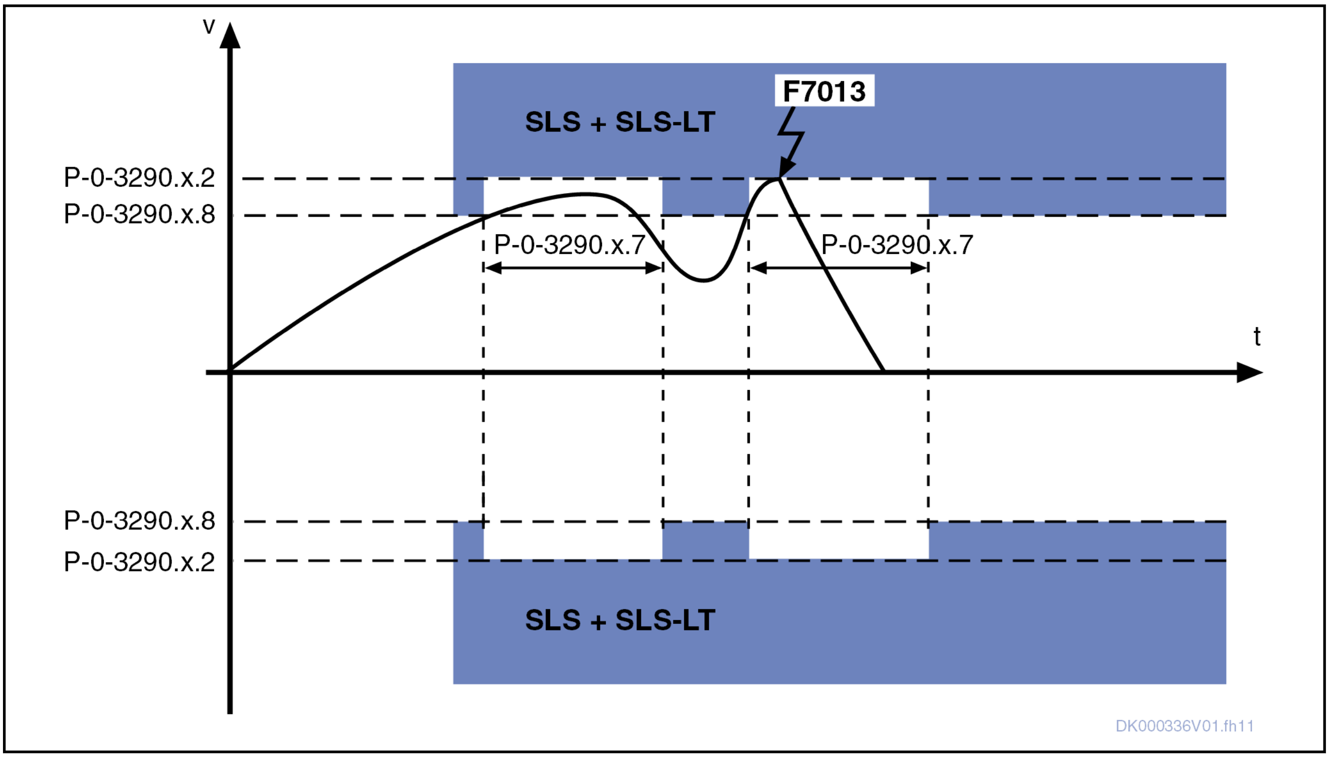


F7014 Timeout in safely-monitored transient oscillation
P-0-3290.x.2 SMO: Safely-limited speed
P-0-3290.x.7 SMO: Tolerance time for overshooting
P-0-3290.x.8 SMO: Safely-reduced speed

Fig. 6-12: Safely-monitored transient oscillation; time for "Safely-monitored transient oscillation" is exceeded

In the case of the safety function "Safely-monitored transient oscillation", the dual-channel monitoring prevents the drive from exceeding the preset velocity limit values [P-0-3290.x.2 (x=1..16)].

If the actual velocity, with the safety function activated, is outside of the respective velocity limit value [P-0-3290.x.2 (x=1..16)], the drive generates the error "F7013 Velocity threshold exceeded" and the drive is decelerated.



F7014 Velocity threshold exceeded
P-0-3290.x.2 SMO: Safely-limited speed
P-0-3290.x.7 SMO: Tolerance time for overshooting
P-0-3290.x.8 SMO: Safely-reduced speed

Fig. 6-13: Safely-monitored transient oscillation; velocity threshold is exceeded

Terminating the safety function

The safety function "Safely-monitored transient oscillation" is deselected by deselecting the special mode "Safe motion".

Instructions for use

When using the safety function "Safely-monitored transient oscillation", it is absolutely necessary to observe the following warning:

⚠ WARNING

Dangerous movements!

Danger to life, risk of injury, serious injury or property damage, because the monitoring function is switched off with a delay!

When using the safety function "Safely-monitored transient oscillation", it must be taken into account that exceeding the parameterized "Safely-limited speed" (P-0-3290.x.8) might be recognized as a regular "transient oscillation" in the case of error. In this case, the error reaction is only triggered when the "Safely-reduced speed" (P-0-3290.x.2) has been exceeded. This must be taken into account in the risk analysis of the machine.

6.4.2 Safe direction (SDI)

The safety function "Safe direction" ensures that motion is only possible in one direction.

- The safety function "Safe direction" is active in **normal operation**, if it has been parameterized for this mode.

  and / or

- The safety function "Safe direction" is active **when the special mode** "Safe motion" is selected, if it has been parameterized for this mode.

Normal operation and special mode are parameterized separately.

See "Safe direction (SDI)".

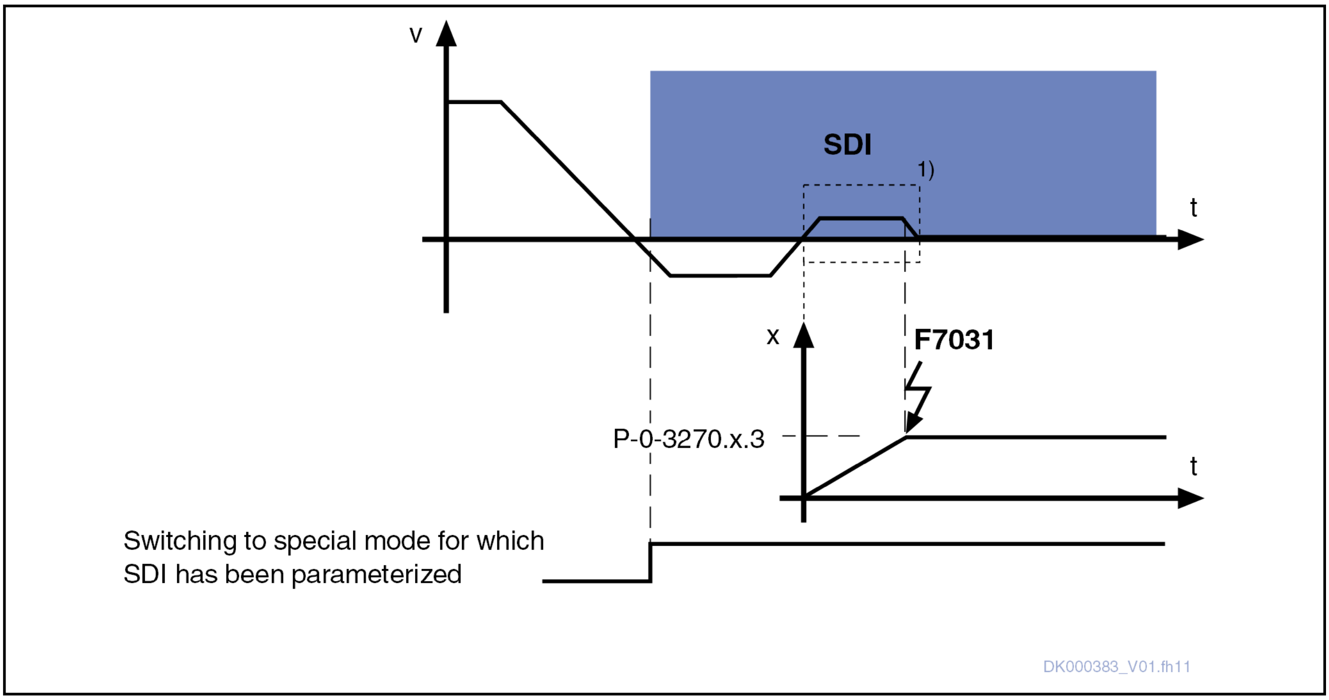


Fig. 6-14: Example of the selection of a special mode "Safe motion" for which the safety function "Safe direction" is parameterized

6.4.3 Safely-limited increment (SLI)

Brief description

In the case of the safety function "Safely-limited increment", dual-channel monitoring prevents the drive from moving by more than one maximum increment [P-0-3290.x.3 (x=1..16)]. Within the position window (maximum increment) it is possible to move in both directions.

To define a new position window it is necessary to exit the safety function "Safely-limited increment" and select it again. This can be done by changing to a different motion mode (SMM1 - SMM16) or by temporarily deselecting the active motion mode.

Features

The safety function "Safely-limited increment" has the following features:

- Is suited for safety-relevant applications up to Category 3, PL d according to EN ISO 13849-1 or up to SIL 2 according to IEC EN 62061.

  In conjunction with a suitable measuring system and the firmware option (FWS) "SIL3-MOTION" or "SIL3-PLUS", the safety level Category 4, PL e (IndraDrive Mi with KCU02.2/KCU02.3: Category 3, PL e) according to ISO 13849-1 or SIL 3 according to IEC 62061 can be achieved.
- The safety function can be used in drive systems equipped with the optional safety technology module "S3", "S4", "S5", "SB" or "SD".
- Dual-channel monitoring of the maximum increment (P-0-3290.x.3).

- When a monitoring function is triggered, this causes an error reaction which decelerates the drive system. The corresponding error message is "F7010 Safely-limited increment exceeded".
- The safety function "Safely-limited increment" is selected via the active "Safe Motion" profile using the parameter "P-0-3264, SMO: Safety function selection".
- The state of the safety function "Safely-limited increment" is displayed via parameter "P-0-3264.0.1, SMO: Safety function status".

Pertinent parameters

The following parameters are used in conjunction with the safety function "Safely-limited increment":

- P-0-3264, SMO: Safety function selection
- P-0-3264.0.1, SMO: Safety function status
- P-0-3290.1.1, SMO: Configuration of safe motion 1
- P-0-3290.2.1, SMO: Configuration of safe motion 2
- ...
- P-0-3290.16.1, SMO: Configuration of safe motion 16
- P-0-3290.1.3, SMO: Safely-limited increment 1
- P-0-3290.2.3, SMO: Safely-limited increment 2
- ...
- P-0-3290.16.3, SMO: Safely-limited increment 16

Pertinent diagnostic messages

The following diagnostic messages can be generated in conjunction with the safety function "Safely-limited increment":

- C0214 SMO: Incorrect configuration
- F7010 Safely-limited increment exceeded

With motion monitoring activated, the display of the IndraDrive control panel shows "SMM".

Safety function

Configuration and selection

To use the safety function "Safely-limited increment", it has to be configured during the commissioning of the safety technology for the corresponding motion mode (SMM1 - SMM16) via the parameters "P-0-3290.x.1, SMO: Configuration of safe motion" (x=1..16). In addition, the effective increment has to be parameterized via the parameters "P-0-3290.x.3, SMO: Safely-limited increment" (x=1..16).

The safety function "Safely-limited increment" is selected via the active "Safe Motion" profile using the parameter "P-0-3264, SMO: Safety function selection". The effective increment is selected via the same profile and parameter.

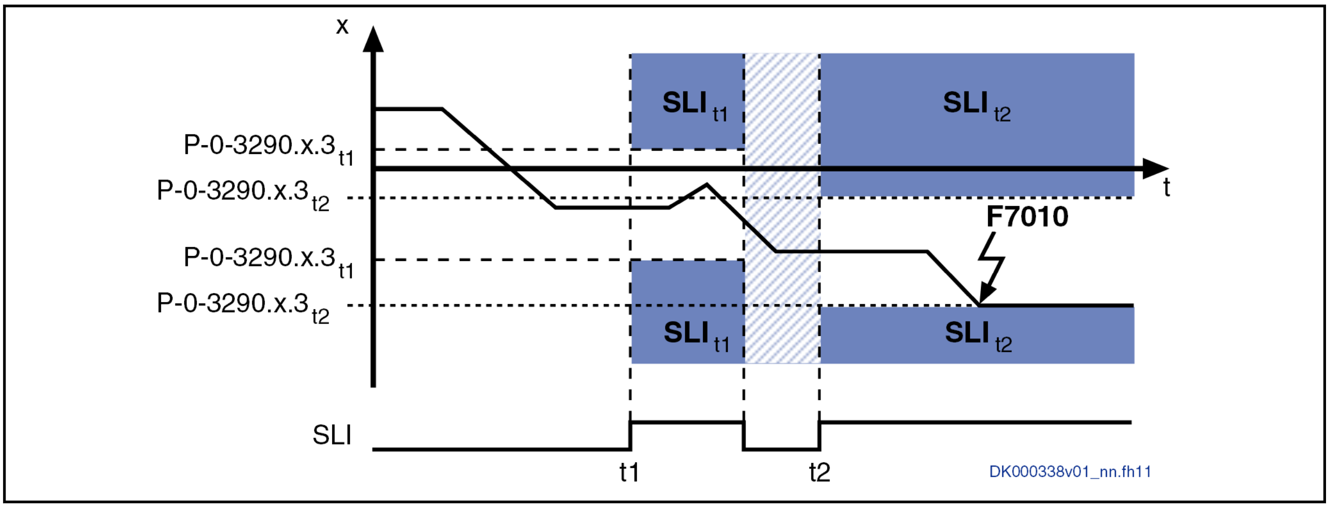
Selecting the effective limit value

The effective threshold is selected via the active "Safe Motion" profile using the parameter "P-0-3264, SMO: Safety function selection". For example, the 16 different "Safe motions" (SMM) with the corresponding increments can be selected via the SMMx signals 1 to 16 (A_SMMx, x=1..16) in the Safe Motion profile "Bosch Rexroth".

Monitoring function

In the case of the safety function "Safely-limited increment", dual-channel monitoring prevents the drive from moving by more than one maximum increment [P-0-3290.x.3 (x=1..16)]. Within the position window (maximum increment) it is possible to move in both directions.

If the axis, with the safety function activated, moves by more than the maximum increment [P-0-3290.x.3 (x=1..16)] in one direction, the drive generates the error "F7010 Safely-limited increment exceeded" and the drive is decelerated.



F7010 Safely-limited increment exceeded
P-0-3290.x.3 SMO: Safely-limited increment

Fig. 6-15: Safely-limited increment (NC-controlled transition to the safe motion from normal operation)

To define a new position window it is necessary to exit the safety function "Safely-limited increment" and select it again. This can be done by changing to different motion mode (SMM1 - SMM 16) or by temporarily deselecting the active motion mode.

Terminating the safety function The safety function "Safely-limited increment" is deselected by deselecting the special mode "Safe motion".

6.4.4 Safely-monitored position (SMP)

Brief description

The safety function "Safely-monitored position (SMP)" is one of the safe absolute position monitoring functions.

It can be activated for any of the 16 motion modes of the "Safe motion" special mode.

Alternatively, the "Safely-limited position (SLP)" absolute position monitoring may be active.

Simultaneously, the "Safely-limited end position (SLE)" absolute position monitoring may be active.

Overview of "Safe absolute position monitoring functions"

Normal operation	Special mode		
	SMES	SMST1/SMST2	SMM1...SMM16
SLE	SLE	SLE	SLE
SLE			SMP
			SLP

With the safety function "Safely-monitored position (SMP)", it is detected in the "Safe motion" special mode by two channels when the drive moves beyond a monitored position range. The position range has to be set by a positive and a negative **end position limit value.**

Features

The safety function "Safely-monitored position (SMP)" has the following features:

- The safety function can be used with the firmware MPx-20 and above in drive systems equipped with the optional safety technology module "S3", "S4", "S5", "SB" or "SD"

  AND

  with the firmware option (FWS) "SAFETY-PLUS" or "SIL3-PLUS".
- Is currently suited for safety-relevant applications up to Category 3, PL d according to EN ISO 13849-1 or SIL 2 according to IEC 62061.

☞ The auxiliary safety technology function "Safe homing procedure" is used to determine the safe absolute position, and is the prerequisite for the safety function "Safely-monitored position (SMP)". "Safe homing procedure" currently is only suited for safety-relevant applications up to Category 3, PL d according to EN ISO 13849-1 or up to SIL 2 according to IEC EN 62061, and thus limits the possible SLE SIL level to SIL 2.

With the availability of the safe absolute position in Category 4, PL e or SIL 3, the safety function can be used in conjunction with the firmware option (FWS) "SIL3-PLUS" for safety-relevant applications up to Category 4, PL e according to EN ISO 13849-1 or SIL 3 according to IEC EN 62061.

- It can be parameterized and activated for any of the 16 motion modes of the "Safe motion" special mode.
- The actual position value (P-0-3257) is monitored by two channels to check whether it exceeds and/or falls below the parameterized position limit values "P-0-3290.x.4, SMO: Safe position limit value, positive" and/or "P-0-3290.x.5 SMO: Safe position limit value, negative" of the selected motion mode SMMx.
- When a monitoring function is triggered, this causes an error reaction which shuts down the drive system. The corresponding error messages are "F7011 SMP, SLP: Safe position limit value, positive exceeded" and "F7012 SMP, SLP: Safe position limit value, negative exceeded".
- The state of the safety function "Safely-monitored position (SMP)" (active/not active) is displayed via parameter "P-0-3264.0.1, SMO: Safety function status", bit 10 .

Pertinent parameters

The following parameters are used in conjunction with the safety function "Safely-monitored position (SMP)":

- P-0-3253.0.5, SMO: Maximum homing velocity
- P-0-3221.0.6, SMO: Modulo value
- P-0-3221.0.7, SMO: Maximum travel range
- P-0-3238, SMO: Active velocity threshold
- P-0-3238.0.1, SMO: Active position limit value, positive
- P-0-3238.0.2, SMO: Active position limit value, negative
- P-0-3253.0.1, SMO: Safe homing procedure configuration
- P-0-3257, SMO: Position feedback value
- P-0-3258, SMO: Velocity feedback value
- P-0-3263.0.1, SMO: Configuration of stopping process

- P-0-3263.0.5, SMO: SMD-E delay
- P-0-3263.0.8, SMO: SMD-E jerk
- P-0-3264, SMO: Safety function selection
- P-0-3264.0.1, SMO: Safety function status
- P-0-3264.0.2, SMO: Safety function diagnostics
- P-0-3270.0.3, SMO: Standstill window for safe direction
- P-0-3290.x.1, SMO: Configuration of safe motion
- P-0-3290.x.4, SMO: Safe position limit value, positive
- P-0-3290.x.5, SMO: Safe position limit value, negative

Pertinent diagnostic messages

The following diagnostic messages can be generated in conjunction with the safety function:

- C0214 SMO: Incorrect configuration
- F7009 Homing velocity exceeded
- F7011 SMP, SLP: Safe position limit value, positive exceeded
- F7012 SMP, SLP: Safe position limit value, negative exceeded

Safety function

Configuration and selection

☞ Using the safety function "Safely-monitored position" is only allowed if the Safe homing procedure has been activated in "P-0-3253.0.1, SMO: Safe homing procedure configuration" (bit 0="1").

For any of the 16 safe motion modes SMMx, **either** the safety function "Safely-monitored position (SMP)" (bit 5) **or** "Safely-limited position (SLP)" (bit 7) can be activated via "P-0-3290.x.1, SMO: Configuration of safe motion".

The position limits for the safety function "Safely-limited position (SMP)" must be parameterized in "P-0-3290.x.4, SMO: Safe position limit value, positive" and "P-0-3290.x.5, SMO: Safe position limit value, negative". With **absolute scaling**, the position limits to be monitored have to be within "P-0-3221.0.7, SMO: Maximum travel range". With **modulo scaling**, the position limits to be monitored have to be within "P-0-3221.0.6, SMO: Modulo value".

In addition, make sure to comply with the minimum distances to the position limits of the axis.

⚠ DANGER

Lethal injury / property damage caused by operating the drive with incorrect position limit values parameterization, as the safe end positions (positive / negative) can be exceeded!

Check the required minimum distances of the parameterized position limits "P-0-3290.x.4, SMO: Safe position limit value, positive" and "P-0-3290.x.5, SMO: Safe position limit value, negative".

Minimum distances to the position limits of the axis in the case of modulo scaling

P-0-3221.0.6 - P-0-3290.x.4 + P-0-3290.x.5 > 2 ms × maximum travel velocity of the drive.
Legend: P-0-3221.0.6, SMO: Modulo value P-0-3290.x.4, SMO: Safe position limit value, positive P-0-3290.x.5, SMO: Safe position limit value, negative

Minimum distances to the position limits of the axis in the case of absolute scaling

(2 × P-0-3221.0.7) - P-0-3290.x.4 + P-0-3290.x.5 > 2 ms × maximum travel velocity of the drive
Legend: P-0-3221.0.7, SMO: Maximum travel range P-0-3290.x.4, SMO: Safe position limit value, positive P-0-3290.x.5, SMO: Safe position limit value, negative

The safety function "Safely-monitored position (SMP)" is selected with the selection of the motion mode SMMx of the special mode "Safe motion" for which the safety function was activated.

☞ The position limits are only monitored by the safety function "Safely-monitored position" after the "Safe homing procedure" was carried out.

⚠ DANGER **Lethal injury / property damage caused by operating the drive without reference, as the safe position limit values (positive / negative) can be exceeded!**

As long as the drive has not been safely homed, make sure by further measures that the position limit values (P-0-3290.x.4 and P-0-3290.x.5) are not exceeded to prevent hazards.

The status (active/inactive) returned by the safety function "Safely-monitored position (SMP)" is displayed in "P-0-3264.0.1, SMO: Safety function status", bit 10.

If the safety function SMP or SLP has been selected, "P-0-3264.0.2, SMO: Safety function diagnostics" displays whether the actual position is within the positive (bit 2)/negative (bit 3) position limit.

If the safety function has **not** been selected or if safe reference is missing, bit 2 and bit 3 are set to "0" (actual position outside of position limits).

Monitoring functions

The safety function "Safely-monitored position (SMP)" detects that the drive moves beyond a monitored position range. For this purpose, the actual position value of P-0-3257 is monitored by two channels to check whether it exceeds and/or falls below the parameterized position limit values P-0-3290.x.4, and/or P-0-3290.x.5 of the selected motion mode SMMx.

If the limit values are not complied with, error"F7011 SMP, SLP: Safe position limit value, positive exceeded" and/or "F7012 SMP, SLP: Safe position limit value, negative exceeded" is generated in a direction-dependent way and the drive is shut-down in accordance with the reaction parameterized for F7 errors. In this connection, the admissible position range is usually left.

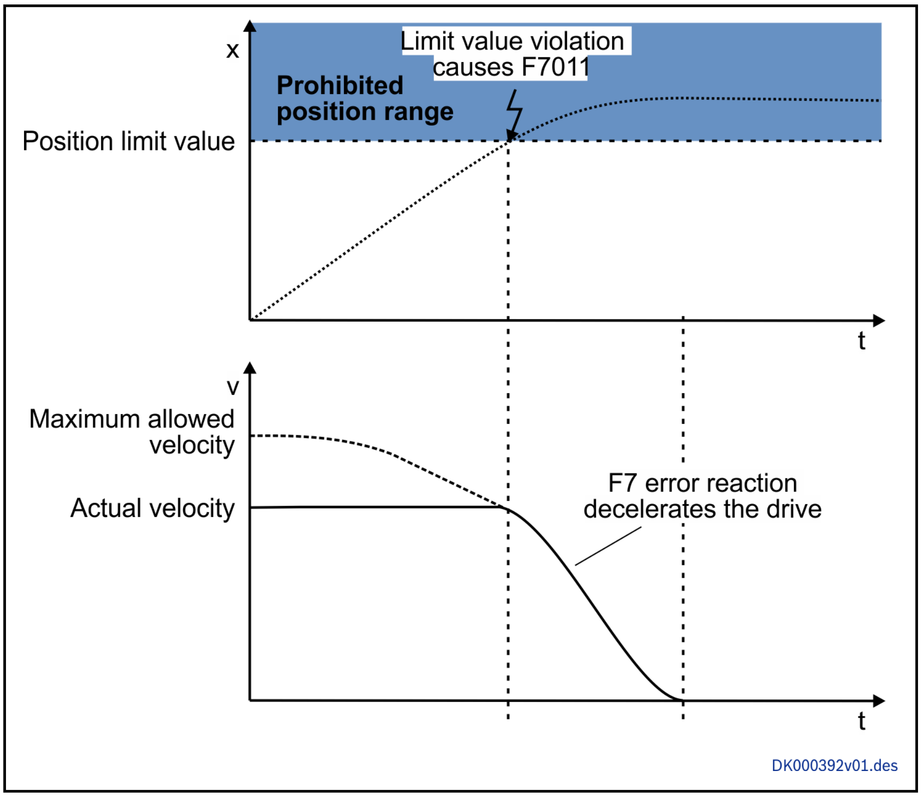


Fig. 6-16: Shut-down of the drive upon exceedance of the position limit value

In addition to the safety function "Safely-monitored position (SMP)", the absolute position monitoring "Safely-limited end position (SLE)" can be active in the operation modes of the special mode "Safe motion". The currently monitored active position limits are made available via "P-0-3238.0.1, SMO: Active position limit value, positive" and "P-0-3238.0.2, SMO: Active position limit value, negative".

The drive has to have been safely homed for the safety function "Safely-monitored position". If Safe reference is not available, the position range is not monitored and the drive may be moved with no more than the velocity parameterized in P-0-3253.0.5. When this speed threshold is exceeded, the drive generates the error F7009.

With active safety function "Safely-monitored position (SMP)" and missing Safe reference (P-0-3256, bit 5="0"), error "F3112 Safe reference missing" will be generated immediately and permanently.

⚠ DANGER

Lethal injury / property damage caused by operating the drive without reference, as the safe position limit values (positive / negative) can be exceeded!

As long as the drive has not been safely homed, make sure by further measures that the position limit values (P-0-3290.x.4 and P-0-3290.x.5) are not exceeded to prevent hazards.

Return motion to allowed position range

If the axis is outside the admissible position range, the error "F7011 SMP, SLP: Safe position limit value, positive exceeded" or "F7012 SMP, SLP: Safe position limit value, negative exceeded" is generated. The error can be reset by the command "S-0-0099, C0500 Reset class 1 diagnostics". The drive can then be moved. As long as the actual position of the drive is outside the admissible position range, dual-channel monitoring makes sure that the drive only moves in the direction of the allowed position range with a velocity lower than "P-0-3253.0.5, SMO: Maximum homing velocity". If the velocity threshold is exceeded, the corresponding position limit value error is generated again. Movements in the opposite direction are allowed within the tolerance window defined in "P-0-3270.0.3, SMO: Standstill window for safe direction". Movements beyond will cause the error F7011 or F7012 again.

6.4.5 Safely-limited position (SLP)

Brief description

The safety function "Safely-limited position (SLP)" is one of the safe absolute position monitoring functions.

The safety function "Safely-limited position (SLP)" can be activated for any of the 16 motion modes of the "Safe motion" special mode.

Alternatively, the "Safely-monitored position (SMP)" absolute position monitoring may be active.

Simultaneously, the "Safely-limited end position (SLE)" absolute position monitoring may be active.

Overview of "Safe absolute position monitoring functions"

<table>
<tr><th rowspan="2">Normal operation</th><th colspan="3">Special mode</th></tr>
<tr><th>SMES</th><th>SMST1/SMST2</th><th>SMM1...SMM16</th></tr>
<tr><td colspan="4">SLE</td></tr>
<tr><td rowspan="2">SLE</td><td colspan="2" rowspan="2"></td><td>SMP</td></tr>
<tr><td>SLP</td></tr>
</table>

In the case of the safety function "Safely-limited position (SLP)", dual-channel monitoring in the "Safe motion" special mode prevents the drive from leaving a position range. The position range has to be set by a positive and a negative **end position limit value.**

Features

The safety function "Safely-limited position (SLP)" has the following features:

- The safety function can be used with the firmware MPx-20 and above in drive systems equipped with the optional safety technology module "S3", "S4", "S5", "SB" or "SD"

  AND

  with the firmware option (FWS) "SAFETY-PLUS" or "SIL3-PLUS".
- Is currently suited for safety-relevant applications up to Category 3, PL d according to EN ISO 13849-1 or SIL 2 according to IEC 62061.

☞ The auxiliary safety technology function "Safe homing procedure" is used to determine the safe absolute position, and is the prerequisite for the safety function "Safely-limited position (SLP)". "Safe homing procedure" currently is only suited for safety-relevant applications up to Category 3, PL d according to EN ISO 13849-1 or up to SIL 2 according to IEC EN 62061, and thus limits the possible SLE SIL level to SIL 2.

With the availability of the safe absolute position in Category 4, PL e or SIL 3, the safety function can be used in conjunction with the firmware option (FWS) "SIL3-PLUS" for safety-relevant applications up to Category 4, PL e according to EN ISO 13849-1 or SIL 3 according to IEC EN 62061.

- It can be activated for any of the 16 motion modes of the "Safe motion" special mode.
- Monitors the maximum admissible velocity at which the drive can still be stopped within the parameterized position limits ("P-0-3290.x.4, SMO: Safe position limit value, positive"; "P-0-3290.x.5, SMO: Safe position limit value, negative"), taking a parameterized deceleration and, where applicable, a jerk into account.
- When a monitoring function is triggered, this causes an error reaction which shuts down the drive system. The corresponding error messages are "F7011 SMP, SLP: Safe position limit value, positive exceeded" and "F7012 SMP, SLP: Safe position limit value, negative exceeded".
- The state of the safety function "Safely-limited position (SLP)" (active/not active) is displayed via parameter "P-0-3264.0.1, SMO: Safety function status", bit 9 .

Pertinent parameters

The following parameters are used in conjunction with the safety function "Safely-limited position (SLP)":

- P-0-3253.0.5, SMO: Maximum homing velocity
- P-0-3221.0.6, SMO: Modulo value
- P-0-3221.0.7, SMO: Maximum travel range
- P-0-3238, SMO: Active velocity threshold
- P-0-3238.0.1, SMO: Active position limit value, positive
- P-0-3238.0.2, SMO: Active position limit value, negative
- P-0-3253.0.1, SMO: Safe homing procedure configuration
- P-0-3257, SMO: Position feedback value
- P-0-3258, SMO: Velocity feedback value
- P-0-3263.0.1, SMO: Configuration of stopping process
- P-0-3263.0.5, SMO: SMD-E delay
- P-0-3263.0.8, SMO: SMD-E jerk
- P-0-3264, SMO: Safety function selection
- P-0-3264.0.1, SMO: Safety function status
- P-0-3264.0.2, SMO: Safety function diagnostics
- P-0-3270.0.3, SMO: Standstill window for safe direction
- P-0-3290.x.1, SMO: Configuration of safe motion
- P-0-3290.x.4, SMO: Safe position limit value, positive
- P-0-3290.x.5, SMO: Safe position limit value, negative

Pertinent diagnostic messages

The following diagnostic messages can be generated in conjunction with the safety function:

- C0214 SMO: Incorrect configuration
- F7009 Homing velocity exceeded
- F7011 SMP, SLP: Safe position limit value, positive exceeded
- F7012 SMP, SLP: Safe position limit value, negative exceeded

Safety function

Configuration and selection

☞ Using the safety function "Safely-limited position" is only allowed if the Safe homing procedure has been activated in "P-0-3253.0.1, SMO: Safe homing procedure configuration" (bit 0="1").

For any of the 16 safe motion modes SMMx, **either** the safety function "Safely-monitored position (SMP)" (bit 5) **or** "Safely-limited position (SLP)" (bit 7) can be activated via "P-0-3290.x.1, SMO: Configuration of safe motion".

The position limits for the safety function "Safely-limited position (SLP)" must be parameterized in "P-0-3290.x.4, SMO: Safe position limit value, positive" and "P-0-3290.x.5, SMO: Safe position limit value, negative". With **absolute scaling**, the position limits to be monitored have to be within P-0-3221.0.7, SMO: Maximum travel range. With **modulo scaling**, the position limits to be monitored have to be within "P-0-3221.0.6, SMO: Modulo value".

In addition, make sure to comply with the minimum distances to the position limits of the axis.

⚠ DANGER

Lethal injury / property damage caused by operating the drive with incorrect position limit values parameterization, as the safe end positions (positive / negative) can be exceeded!

Check the required minimum distances of the parameterized position limits "P-0-3290.x.4, SMO: Safe position limit value, positive" and "P-0-3290.x.5, SMO: Safe position limit value, negative".

Minimum distances to the position limits of the axis in the case of modulo scaling

P-0-3221.0.6 - P-0-3290.x.4 + P-0-3290.x.5 > 2 ms × maximum travel velocity of the drive.
Legend: P-0-3221.0.6, SMO: Modulo value P-0-3290.x.4, SMO: Safe position limit value, positive P-0-3290.x.5, SMO: Safe position limit value, negative

Minimum distances to the position limits of the axis in the case of absolute scaling

(2 × P-0-3221.0.7) - P-0-3290.x.4 + P-0-3290.x.5 > 2 ms × maximum travel velocity of the drive
Legend:
P-0-3221.0.7, SMO: Maximum travel range
P-0-3290.x.4, SMO: Safe position limit value, positive
P-0-3290.x.5, SMO: Safe position limit value, negative

☞ "P-0-3263.0.5, SMO: SMD-E delay" and "P-0-3263.0.8, SMO: SMD-E jerk" define the envelope curve of SMD-E delay monitoring and should be set in such a way that they correspond to the parameterization of the best possible deceleration of the drive in the case of F7 error. The correct parameterization ensures that the drive can come to standstill before exceeding the position limit.

☞ If the safety function "Safely-limited position" is used, the "torque disable" error reaction is not allowed for F7xxx errors.

The safety function "Safely-limited position (SLP)" is selected with the selection of the motion mode SMMx of the special mode "Safe motion" for which the safety function was activated.

☞ The position limits are only monitored by the safety function "Safely-limited position" after the "Safe homing procedure" was carried out.

⚠ DANGER **Lethal injury / property damage caused by operating the drive without reference, as the safe position limit values (positive / negative) can be exceeded!**

As long as the drive has not been safely homed, make sure by further measures that the position limit values (P-0-3290.x.4 and P-0-3290.x.5) are not exceeded to prevent hazards.

The status (active/inactive) returned by the safety function "Safely-limited position (SLP)" is displayed in "P-0-3264.0.1, SMO: Safety function status", bit 9.

If the safety function SMP or SLP has been selected, "P-0-3264.0.2, SMO: Safety function diagnostics" displays whether the actual position is within the positive (bit 2)/negative (bit 3) position limit.

If the safety function has **not** been selected or if safe reference is missing, bit 2 and bit 3 are set to "0" (actual position outside of position limits).

Monitoring functions

The safety function "Safely-limited position (SLP)" monitors that the drive can be decelerated within the parameterized position limits with the current actual velocity and the parameterized braking ability.

For this purpose, the safety function in a direction-dependent way determines the braking distance available to the position limit. On the basis of the parameterized delay (P-0-3263.0.5, SMO: SMD-E delay) and the jerk (P-0-3263.0.8, SMO: SMD-E jerk), it calculates the maximum allowed velocity limit with which the drive can still come to standstill within the parameterized position limits. If the actual velocity (P-0-3258, SMO: Velocity feedback value) is greater than the maximum admissible velocity, the error "F7011 SMP, SLP: Safe position limit value, positive exceeded" or "F7012 SMP, SLP: Safe position limit value, negative exceeded" is generated in a direction-dependent way, and the drive is decelerated in accordance with the reaction parameterized for F7 errors.

The maximum admissible velocity limit of the active safety function is displayed as an absolute value in "P-0-3238, SMO: Active velocity threshold", provided that no other safety function (e.g., SMS, SLS, SLS-LT, SLE) reduces the value in P-0-3238 even more.

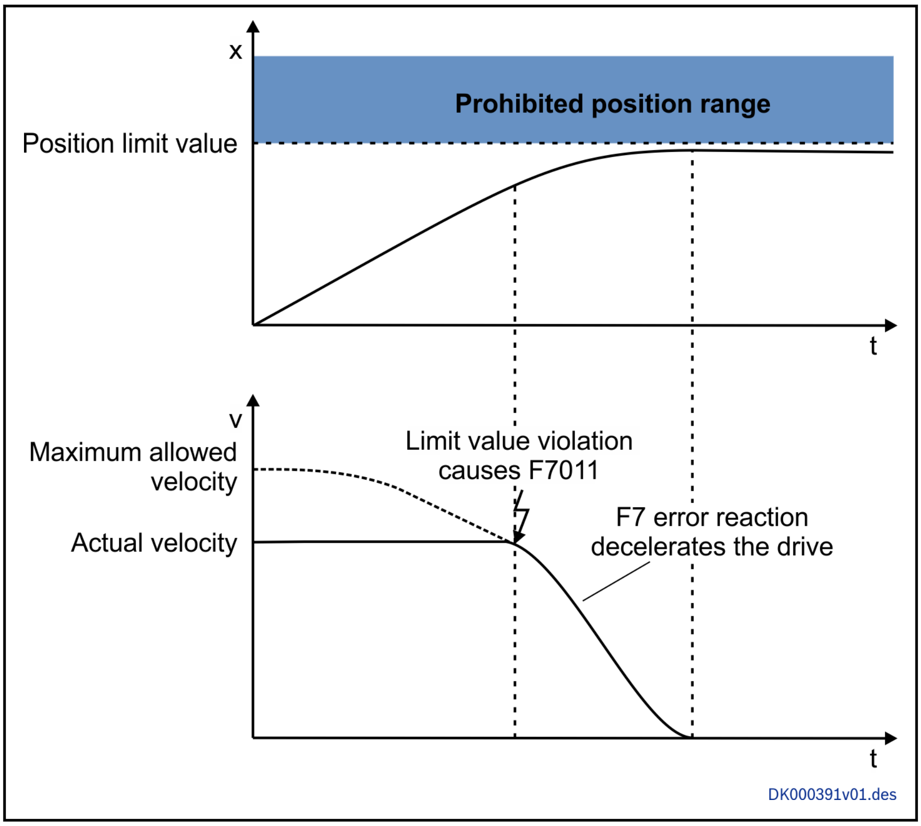


Fig. 6-17: Decelerating the drive when exceeding the maximum allowed velocity

In addition to the safety function "Safely-limited position (SLP)", the absolute position monitoring "Safely-limited end position (SLE)" can be active in the operation modes of the special mode "Safe motion". The currently monitored active position limits are made available via "P-0-3238.0.1, SMO: Active position limit value, positive" and "P-0-3238.0.2, SMO: Active position limit value, negative".

The drive has to have been safely homed for the safety function "Safely-limited position". If Safe reference is not available, the position range is not monitored and the drive may be moved with no more than the velocity parameterized in P-0-3253.0.5. When this speed threshold is exceeded, the drive generates the error F7009.

With active safety function "Safely-limited position (SLP)" and missing Safe reference (P-0-3256, bit 5="0"), error "F3112 Safe reference missing" will be generated immediately and permanently.

⚠ DANGER **Lethal injury / property damage caused by operating the drive without reference, as the safe position limit values (positive / negative) can be exceeded!**

As long as the drive has not been safely homed, make sure by further measures that the position limit values (P-0-3290.x.4 and P-0-3290.x.5) are not exceeded to prevent hazards.

Return motion to allowed position range

If the axis is outside the admissible position range, the error "F7011 SMP, SLP: Safe position limit value, positive exceeded" or "F7012 SMP, SLP: Safe position limit value, negative exceeded" is generated. The error can be reset by the command "S-0-0099, C0500 Reset class 1 diagnostics". The drive can then be moved. As long as the actual position of the drive is outside the admissible position range, dual-channel monitoring makes sure that the drive only moves in the direction of the allowed position range with a velocity lower than "P-0-3253.0.5, SMO: Maximum homing velocity". If the velocity threshold is exceeded, the corresponding position limit value error is generated again. Movements in the opposite direction are allowed within the tolerance window defined in "P-0-3270.0.3, SMO: Standstill window for safe direction". Movements beyond will cause the error F7011 or F7012 again.

6.5 Transition functions

6.5.1 Safe stop 1 (SS1)

Brief description

When the transition function "Safe stop 1 (SS1)" is activated, the drive is decelerated in a safely monitored way.

After the deceleration process has been completed, the safety function "Safe torque off (STO)" is activated and the energy supply to the motor is safely interrupted. The motor cannot generate any torque/any force and therefore no dangerous movements.

The transition to standstill by the transition function "Safe stop 1 (SS1)" can be performed in different ways:

- "Drive-controlled", i.e. the drive is decelerated by the standard firmware, and the safety technology monitors the deceleration process **or**
- "NC-controlled", i.e. the higher-level control unit decelerates the drive via the command value system, and the safety technology monitors the deceleration process and

Both the drive-controlled and the NC-controlled transition can be executed in a "time-prioritized" **or** in a "standstill-prioritized" way.

The **time-prioritized** transition has the following features:

- The functionality is **independent** of the measuring system used and achieves the safety level Category 4, PL e (IndraDrive Mi with KCU02.2/ KCU02.3 Category 3, PL e) according to ISO 13849-1 or SIL 3 according to IEC 62061.
- STO function is activated in standstill with drive enable removed, but **at the latest after the parameterized delay is over.** Even an error reaction running in parallel does not have an influence on this behavior.
- To monitor the deceleration process, the delay monitoring is active [safety function "Safely-monitored deceleration (SMD)" with safety level

Category 3, PL d according to ISO 13849-1 or SIL 2 according to IEC 62061].

The **standstill-prioritized** transition has the following features:

- The functionality **depends** on the measuring system used and can achieve the safety level Category 3, PL d according to ISO 13849-1 or SIL 2 according to IEC 62061.

  In conjunction with a suitable measuring system and the firmware option (FWS) "SIL3-MOTION" or "SIL3-PLUS", the safety level Category 4, PL e (IndraDrive Mi with KCU02.2/KCU02.3: Category 3, PL e) according to ISO 13849-1 or SIL 3 according to IEC 62061 can be achieved.
- STO function is activated in standstill with drive enable removed.
- The deceleration process is always monitored, with regard to the maximum transition time, by the delay monitoring [safety function "Safely-monitored deceleration (SMD)"] with integrated monitoring. If the maximum transition time is exceeded, the STO function is not necessarily activated. This is done within the scope of the parameterized error reaction (P-0-3263.0.1).

Features

The function has the following features:

- Corresponds to stop category 1 according to EN 60204-1.
- The energy supply to the motor is safely interrupted.
- The transition function can be used in drive systems equipped with the optional safety technology module "S3", "S4", "S5", "SB" or "SD".
- The transition can be performed in a "drive-controlled" or in an "NC-controlled" way.
- At the end of the transition, the safety function "Safe torque off" is activated.
- The duration of the transition is monitored (cf. "P-0-3280.0.2" and "P-0-3280.0.3"). When the monitoring function is triggered, this causes an error reaction which decelerates the drive system. The corresponding error message is "F7050 Maximum transition time exceeded" or "F8350 Maximum transition time exceeded".
- The deceleration can be optionally monitored during the transition using the safety function "Safely-monitored deceleration (SMD)". When the monitoring function is triggered, this causes an error reaction which decelerates the drive system. The corresponding error message is "F7051 Safely-monitored deceleration exceeded" or "F8351 Safely-monitored deceleration exceeded".
- The transition function "Safe stop 1" is selected via the active "Safe Motion" profile using "P-0-3264, SMO: Safety function selection".
- The status of the transition function "Safe stop 1" is displayed by the parameter "P-0-3264.0.1, SMO: Safety function status".

Pertinent parameters

The following parameters are used in conjunction with the transition function "Safe stop 1":

- P-0-3238, SMO: Active velocity threshold
- P-0-3255, SMO: Velocity threshold for safe standstill
- P-0-3263.0.1, SMO: Configuration of stopping process
- P-0-3280.0.1, SMO: Configuration of operation mode transitions
- P-0-3280.0.2, SMO: Max. transition time normal oper. to safe standstill
- P-0-3280.0.3, SMO: Max. transition time between safe operating states

Pertinent diagnostic messages

The following diagnostic messages can be generated in conjunction with the transition function "Safe stop 1":

- C0214 SMO: Incorrect configuration
- F7050 Maximum transition time exceeded
- F7051 Safely-monitored deceleration exceeded
- F8350 Maximum transition time exceeded
- F8351 Safely-monitored deceleration exceeded

With the transition function "Safe stop 1" activated, the display of the IndraDrive control panel does not show any specific message.

Transition function

Basic principle

When the transition function "Safe stop 1 (SS1)" is activated, the drive is decelerated in a safely monitored way. After the deceleration process has been completed, the safety function "Safe torque off (STO)" is activated and the energy supply to the motor is safely interrupted. The motor cannot generate any torque/any force and therefore no dangerous movements.

☞ The transition function "Safe stop 1" detects a successful deceleration process, if the following conditions have been fulfilled:

- The motor has stopped, i.e. the actual velocity is smaller than the value parameterized in "P-0-3255, SMO: Velocity threshold for safe standstill", **and**
- the drive is no longer in control.

Configuring the transition function

To use the transition function "Safe stop 1", it has to be configured via the parameter "P-0-3280.0.1, SMO: Configuration of operation mode transitions" during the commissioning of safety technology.

The transition function "Safe stop 1" can be executed in 8 variants, as the table below shows:

<table>
<tr><th>No.</th><th>Monitoring</th><th>Execution SS1</th><th>Operation mode transitions to standstill</th><th>Execution SMD</th><th>Depends on measuring system used</th><th>Maximum safety level</th></tr>
<tr><td>1</td><td>SS1, standstill-prioritized with drive-controlled transition</td><td rowspan="3">Standstill-prioritized</td><td>Drive-controlled</td><td>Based on actual velocity</td><td rowspan="3">Yes</td><td rowspan="3">Category 3, PL d according to ISO 13849-1 or SIL 2 according to IEC 62061</td></tr>
<tr><td>2a</td><td>SS1, standstill-prioritized with NC-controlled transition (with trend monitoring)</td><td rowspan="2">NC-controlled</td><td>Trend monitoring</td></tr>
<tr><td>2b</td><td>SS1, standstill-prioritized with NC-controlled transition (based on actual velocity)</td><td>Based on actual velocity</td></tr>
<tr><td>3</td><td>SS1, time-prioritized with drive-controlled transition</td><td>Time-prioritized</td><td rowspan="2">Drive-controlled</td><td>-</td><td>No</td><td rowspan="5">Category 4, PL e (IndraDrive Mi with KCU02.2 Category 3, PL e) according to ISO 13849-1 or SIL 3 according to IEC 62061
(The safety level is determined by the time-prioritized monitoring.)</td></tr>
<tr><td>3 (+1)</td><td>SS1, time- and standstill-prioritized with drive-controlled transition</td><td>Time-*1) & standstill-prioritized</td><td>Based on actual velocity</td><td>Yes</td></tr>
<tr><td>4</td><td>SS1, time-prioritized with NC-controlled transition</td><td>Time-prioritized</td><td rowspan="3">NC-controlled</td><td>-</td><td>No</td></tr>
<tr><td>4 (+2a)</td><td>SS1, time- and standstill-prioritized with NC-controlled transition (with trend monitoring)</td><td rowspan="2">Time-*1) & standstill-prioritized</td><td>Trend monitoring</td><td rowspan="2">Yes</td></tr>
<tr><td>4 (+2b)</td><td>SS1, time- and standstill-prioritized with NC-controlled transition (on basis of actual velocity)</td><td>Based on actual velocity</td></tr>
</table>

*1) Monitoring function of higher priority

Tab. 6-2: Configurable variants of the transition function "Safe stop 1 (SS1)"

Selecting the transition function

If the safety function "Safe torque off" (STO) has been configured, but is **not** active, the transition function "Safe stop 1 (SS1)" can be activated via the active "Safe Motion" profile using the parameter "P-0-3264, SMO: Safety function selection".

Transition to the safe state

Monitoring function 1: "SS1, standstill-prioritized with drive-controlled transition"

When the monitoring function 1 (SS1, standstill-prioritized with drive-controlled transition) has been configured, the axis is decelerated in a drive-controlled way when SS1 is selected. That is to say the drive makes itself independent of the command value input of the control unit and is decelerated by the standard firmware in accordance with the parameterization of "P-0-3263.0.1, SMO: Configuration of stopping process" (bit 0-3). At the end of the deceleration process, drive enable is removed.

To monitor the deceleration process, the Transition function Safely-monitored deceleration based on actual velocity (SMD) is called by the transition function "Safe stop 1 (SS1)". If the SMD detects that the velocity has been exceeded, the error "F7051 Safely-monitored deceleration exceeded" or "F8351 Safely-monitored deceleration exceeded" [only if F3 reaction equals F7 reaction (P-0-3263.0.1)] is signaled. The drive keeps being decelerated in accordance with the parameterized error reaction (P-0-3263.0.1) (see chapter "Error reaction / escalation strategy").

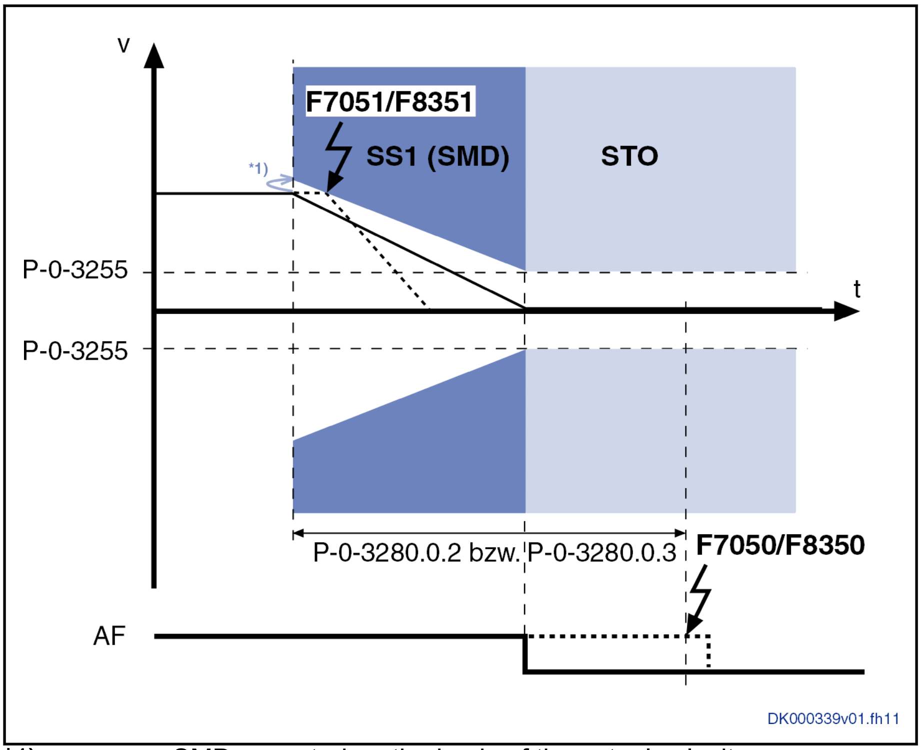
The currently active velocity monitoring limit of Safe Motion is displayed in "P-0-3238, SMO: Active velocity threshold". With this parameter it is possible to check in the control unit whether the velocity command values are within the allowed limits.

With the auxiliary function "limitation of the positioning velocity", it is possible to monitor and, if necessary, limit the velocity command value effective in the drive to the active velocity threshold (P-0-3238).

In parallel with velocity monitoring, the SMD also monitors that the deceleration process is completed within the parameterized transition time (P-0-3280.0.2 or P-0-3280.0.3). If the transition is not completed within the parameterized transition time, the error "F7050 Maximum transition time exceeded" or "F8350 Maximum transition time exceeded" [only if F3 reaction equals F7 reaction (P-0-3263.0.1)] is signaled. The drive keeps being decelerated in accordance with the parameterized error reaction (P-0-3263.0.1) (see chapter "Error reaction / escalation strategy").

⇒ The maximum time span between the selection of the transition function "Safe stop 1 (SS1)" and the activation of the safety function "Safe torque off (STO)" **depends on** the course of the transition! When an error occurs, the time span can be extended at most by the time parameterized in P-0-3263.0.7. In the case of a configured F7 error reaction="torque disable" (P-0-3263.0.1) or direct switching to the F8 error reaction (F3 reaction = F7 reaction in P-0-3263.0.1), the time is not extended.

If the SMD acknowledges the transition process without error, the transition by SS1 is completed by the transition function with the selection of the safety function STO.



***1)**	SMD executed on the basis of the actual velocity
P-0-3255	SMO: Velocity threshold for safe standstill
P-0-3280.0.2	SMO: Max. transition time normal oper. to safe standstill
P-0-3280.0.3	SMO: Max. transition time between safe operating states

Fig. 6-18: Monitoring function 1: "SS1, standstill-prioritized with drive-controlled transition"

Monitoring function 2a: "SS1, standstill-prioritized with NC-controlled transition (with trend monitoring)"

When the monitoring function 2a [SS1, standstill-prioritized with NC-controlled transition (with trend monitoring)] has been configured, the axis is decelerated in an NC-controlled way when SS1 is selected. That is to say the higher-level control unit decelerates the drive using the command value system and removes drive enable at the end of the deceleration process.

To monitor the deceleration process, the Transition function Safely-monitored deceleration with trend monitoring is called by the transition function "Safe stop 1 (SS1)". If the SMD detects that the velocity has been exceeded, the error "F7051 Safely-monitored deceleration exceeded" is signaled. The drive keeps being decelerated in accordance with the parameterized error reaction (P-0-3263.0.1) (see chapter "Error reaction / escalation strategy").

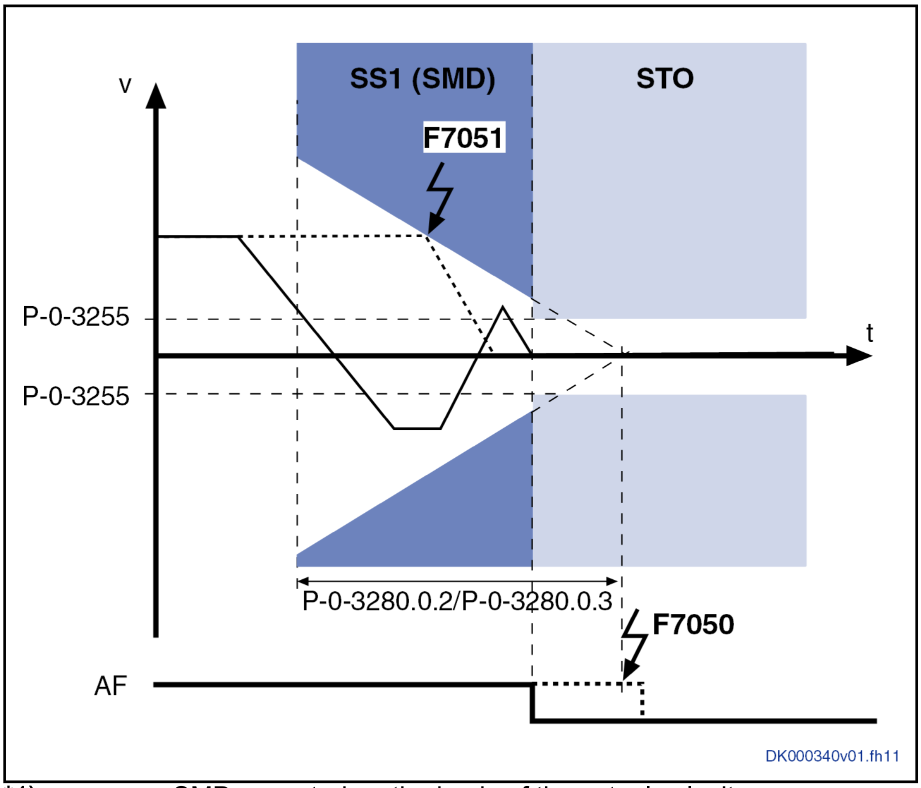
The currently active velocity monitoring limit of Safe Motion is displayed in "P-0-3238, SMO: Active velocity threshold". With this parameter it is possible to check in the control unit whether the velocity command values are within the allowed limits.

With the auxiliary function "limitation of the positioning velocity", it is possible to monitor and, if necessary, limit the velocity command value effective in the drive to the active velocity threshold (P-0-3238).

In parallel with velocity monitoring, the SMD also monitors that the deceleration process is completed within the parameterized transition time (P-0-3280.0.2 or P-0-3280.0.3). If the transition is not completed within the parameterized transition time, the error "F7050 Maximum transition time exceeded" is signaled. The drive keeps being decelerated in accordance with the parameterized error reaction (P-0-3263.0.1) (see chapter "Error reaction / escalation strategy").

⇒ The maximum time span between the selection of the transition function "Safe stop 1 (SS1)" and the activation of the safety function "Safe torque off (STO)" **depends on** the course of the transition! When an error occurs, the time span can be extended at most by the time parameterized in P-0-3263.0.7. In the case of a configured F7 error reaction="torque disable" (P-0-3263.0.1) or direct switching to the F8 error reaction (F3 reaction = F7 reaction in P-0-3263.0.1), the time is not extended.

If the SMD acknowledges the transition process without error, the transition by the transition function SS1 is completed with the selection of the safety function "Safe torque off".



***1)** SMD executed on the basis of the actual velocity
P-0-3255 SMO: Velocity threshold for safe standstill
P-0-3280.0.2 SMO: Max. transition time normal oper. to safe standstill
P-0-3280.0.3 SMO: Max. transition time between safe operating states

Fig. 6-19: Monitoring function 2a: "SS1, standstill-prioritized with NC-controlled transition (with trend monitoring)"

Monitoring function 2b: "SS1, standstill-prioritized with NC-controlled transition (based on actual velocity)"

When the monitoring function 2b [SS1, standstill-prioritized with NC-controlled transition (based on actual velocity)] has been configured, the axis is decelerated in an NC-controlled way when SS1 is selected. That is to say the higher-level control unit decelerates the drive using the command value system and removes drive enable at the end of the deceleration process.

To monitor the deceleration process, the Transition function Safely-monitored deceleration based on actual velocity is called by the transition function "Safe stop 1 (SS1)". If the SMD detects that the velocity has been exceeded, the error "F7051 Safely-monitored deceleration exceeded" is signaled. The drive keeps being decelerated in accordance with the parameterized error reaction (P-0-3263.0.1) (see chapter "Error reaction / escalation strategy").

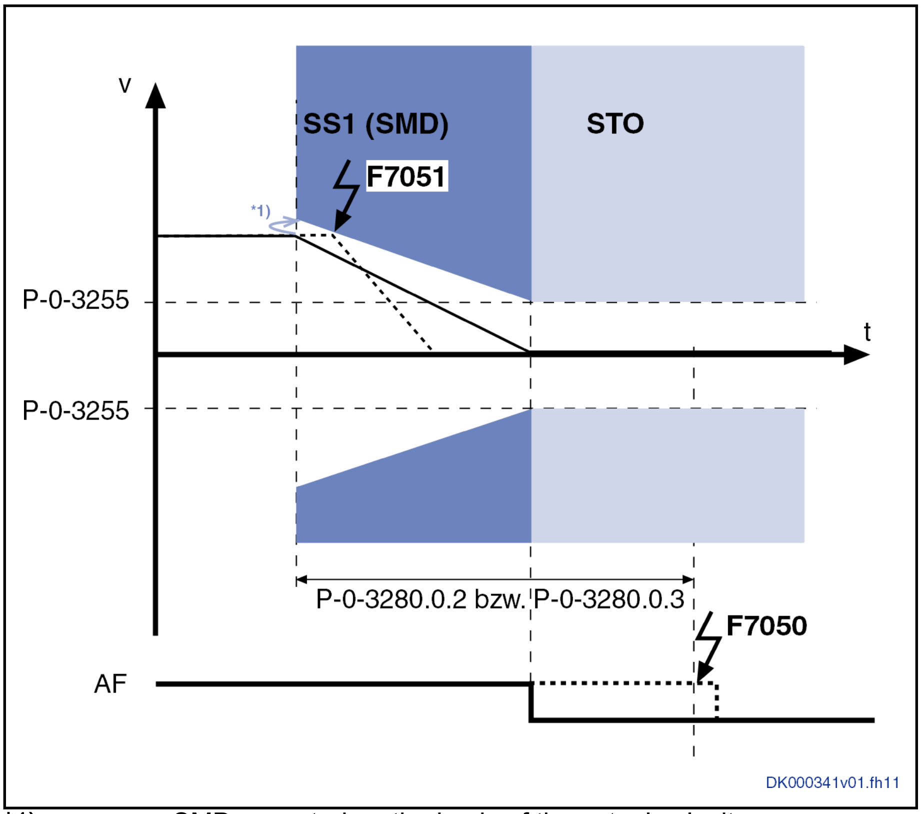
The currently active velocity monitoring limit of Safe Motion is displayed in "P-0-3238, SMO: Active velocity threshold". With this parameter it is possible to check in the control unit whether the velocity command values are within the allowed limits.

With the auxiliary function "limitation of the positioning velocity", it is possible to monitor and, if necessary, limit the velocity command value effective in the drive to the active velocity threshold (P-0-3238).

In parallel with velocity monitoring, the SMD also monitors that the deceleration process is completed within the parameterized transition time (P-0-3280.0.2 or P-0-3280.0.3). If the transition is not completed before the transition time is over, the error "F7050 Maximum transition time exceeded" is signaled. The drive keeps being decelerated in accordance with the parameterized error reaction (P-0-3263.0.1) (see chapter "Error reaction / escalation strategy").

⇒ The maximum time span between the selection of the transition function "Safe stop 1 (SS1)" and the activation of the safety function "Safe torque off (STO)" **depends on** the course of the transition! When an error occurs, the time span can be extended at most by the time parameterized in P-0-3263.0.7. In the case of a configured F7 error reaction="torque disable" (P-0-3263.0.1) or direct switching to the F8 error reaction (F3 reaction = F7 reaction in P-0-3263.0.1), the time is not extended.

If the SMD acknowledges the transition process without error, the transition by the transition function SS1 is completed with the selection of the safety function "Safe torque off (STO)".



***1)**	SMD executed on the basis of the actual velocity
P-0-3255	SMO: Velocity threshold for safe standstill
P-0-3280.0.2	SMO: Max. transition time normal oper. to safe standstill
P-0-3280.0.3	SMO: Max. transition time between safe operating states

Fig. 6-20: Monitoring function 2b: "SS1, standstill-prioritized with NC-controlled transition (based on actual velocity)"

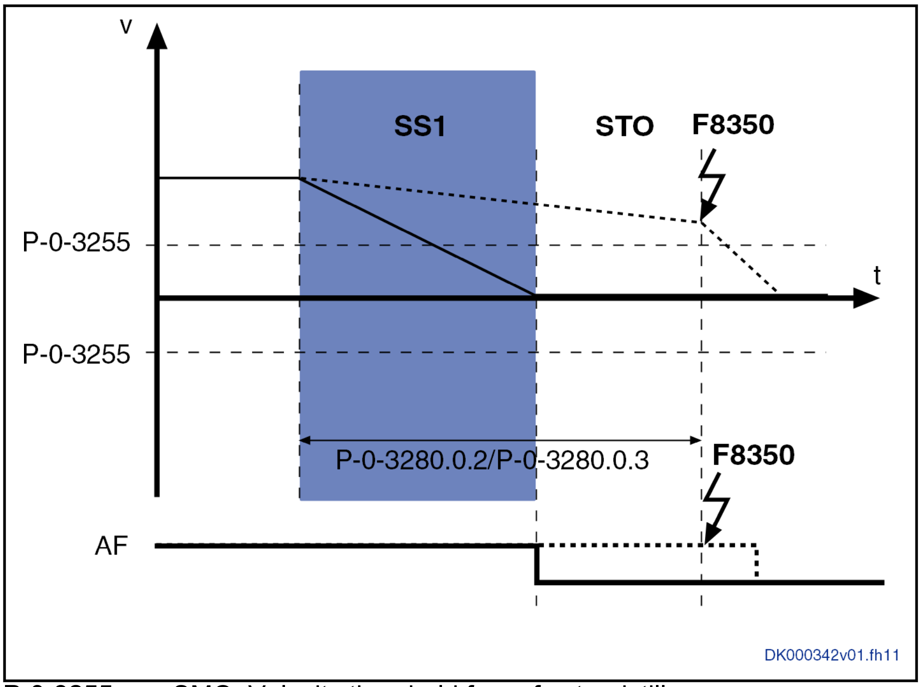
Monitoring function 3: "SS1, time-prioritized with drive-controlled transition"

When the monitoring function 3 (SS1, time-prioritized with drive-controlled transition) has been configured, the axis is decelerated in a drive-controlled way when SS1 is selected. That is to say the drive makes itself independent of the command value input of the control unit and is decelerated by the standard firmware in accordance with the parameterization of "P-0-3263.0.1, SMO: Configuration of stopping process" (bit 0-3). At the end of the deceleration process, drive enable is removed.

The transition function "Safe stop 1 (SS1)" monitors that the deceleration process is completed within the parameterized transition time (P-0-3280.0.2 or P-0-3280.0.3). If the transition is not completed within the parameterized transition time, the error "F8350 Maximum transition time exceeded" is signaled and the safety function "Safe torque off (STO)" is activated.

⇒ The maximum time span between the selection of the transition function "Safe stop 1 (SS1)" and the activation of the safety function "Safe torque off (STO)" is **independent of** the course of the transition! The maximum time span is **not** extended when an error occurs.

If the drive has been decelerated without error within the parameterized transition time (P-0-3280.0.2 or P-0-3280.0.3), the transition by the transition function SS1 is completed with the selection of the safety function "Safe torque off (STO)".



P-0-3255 SMO: Velocity threshold for safe standstill
P-0-3280.0.2 SMO: Max. transition time normal oper. to safe standstill
P-0-3280.0.3 SMO: Max. transition time between safe operating states

Fig. 6-21: Monitoring function 3: "SS1, time-prioritized with drive-controlled transition"

Monitoring function 3(+1): "SS1, time- and standstill-prioritized with drive-controlled transition"

When the monitoring function 3(+1) (SS1, time- and standstill-prioritized with drive-controlled transition) has been configured, the axis is decelerated in a drive-controlled way when SS1 is selected. That is to say the drive makes itself independent of the command value input of the control unit and is decelerated by the standard firmware in accordance with the parameterization of "P-0-3263.0.1, SMO: Configuration of stopping process" (bit 0-3). At the end of the deceleration process, drive enable is removed.

The transition function "Safe stop 1 (SS1)" monitors that the deceleration process is completed within the parameterized transition time (P-0-3280.0.2 or P-0-3280.0.3). If the transition is not completed within the parameterized transition time, the error "F8350 Maximum transition time exceeded" is signaled and the safety function "Safe torque off (STO)" is activated.

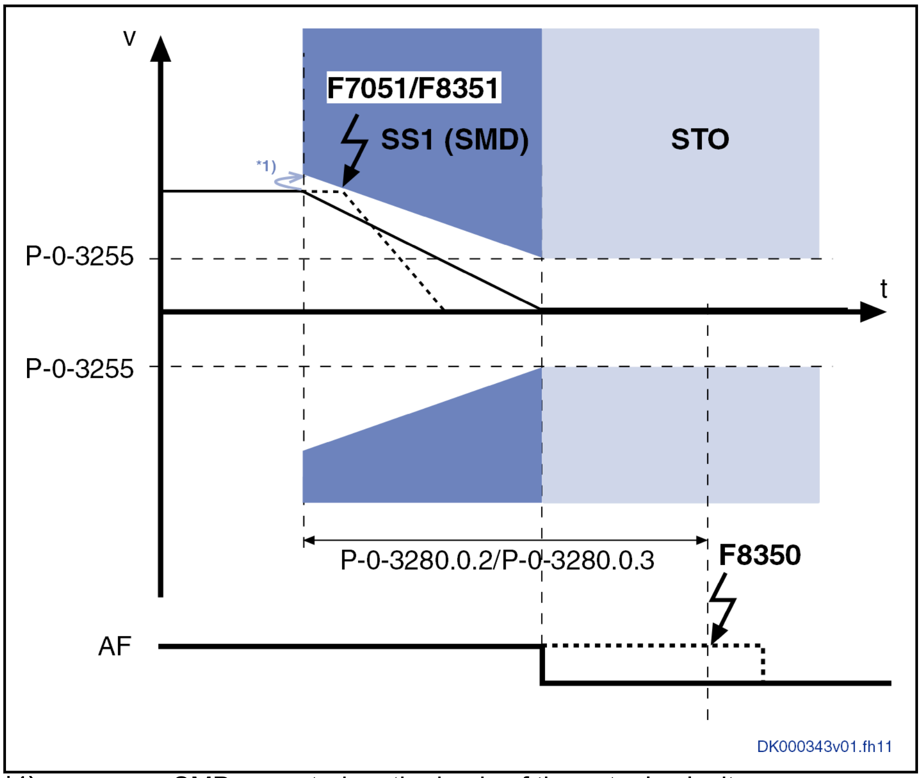
In addition to the time monitoring of the transition function "Safe stop 1 (SS1)", the Transition function Safely-monitored deceleration based on actual velocity is called. If the SMD detects that the velocity has been exceeded, the error "F7051 Safely-monitored deceleration exceeded" or "F8351 Safely-monitored deceleration exceeded" [only if F3 reaction equals F7 reaction (P-0-3263.0.1)] is signaled. The drive keeps being decelerated in accordance with the parameterized error reaction (P-0-3263.0.1) (see chapter "Error reaction / escalation strategy"). With the start of the error reaction, the running transition time monitoring is neither aborted nor retriggered. When the transition time (P-0-3280.0.2 or P-0-3280.0.3) is over, the error "F8350 Maximum transition time exceeded" is additionally signaled independently of the status of the error reaction, and the safety function "Safe torque off (STO)" is activated.

⇒ The maximum time span between the selection of the transition function "Safe stop 1 (SS1)" and the activation of the safety function "Safe torque off (STO)" is **independent of** the course of the transition! The maximum time span is **not** extended when an error occurs.

The currently active velocity monitoring limit of Safe Motion is displayed in "P-0-3238, SMO: Active velocity threshold". With this parameter it is possible to check in the control unit whether the velocity command values are within the allowed limits.

With the auxiliary function "limitation of the positioning velocity", it is possible to monitor and, if necessary, limit the velocity command value effective in the drive to the active velocity threshold (P-0-3238).

If the drive has been decelerated without error within the parameterized transition time (P-0-3280.0.2 or P-0-3280.0.3), the transition by the transition function SS1 is completed with the selection of the safety function "Safe torque off (STO)".



***1)** SMD executed on the basis of the actual velocity
P-0-3255 SMO: Velocity threshold for safe standstill
P-0-3280.0.2 SMO: Max. transition time normal oper. to safe standstill
P-0-3280.0.3 SMO: Max. transition time between safe operating states

Fig. 6-22: Monitoring function 3(+1): "SS1, time- and standstill-prioritized with drive-controlled transition"

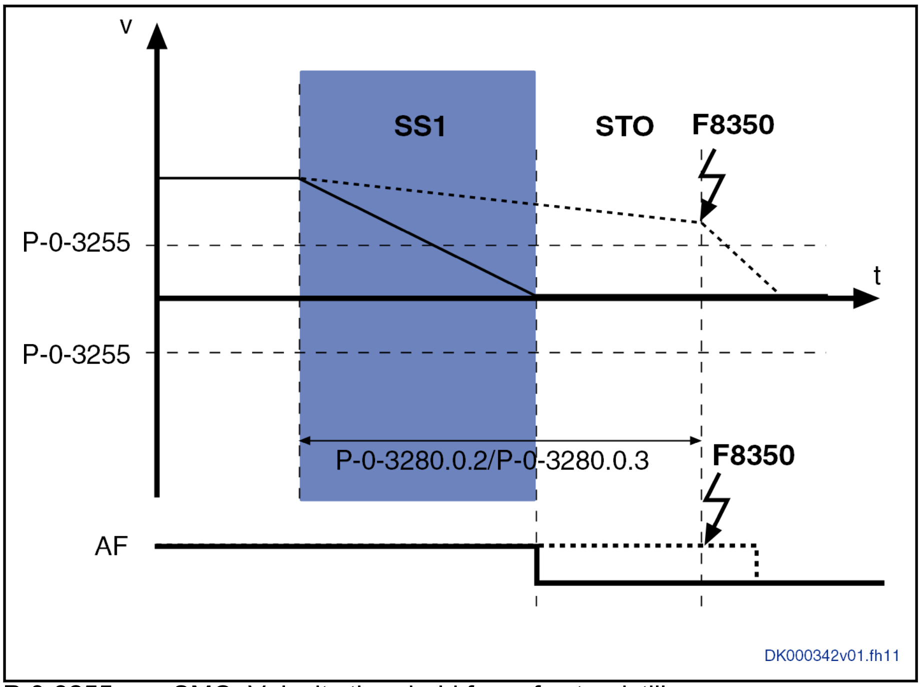
Monitoring function 4: "SS1, time-prioritized with NC-controlled transition"

When the monitoring function 4 (SS1, time-prioritized with NC-controlled transition) has been configured, the axis is decelerated in an NC-controlled way when SS1 is selected. That is to say the higher-level control unit decelerates the drive using the command value system and removes drive enable at the end of the deceleration process.

The transition function "Safe stop 1 (SS1)" monitors that the deceleration process is completed within the parameterized transition time (P-0-3280.0.2 or P-0-3280.0.3). If the transition is not completed within the parameterized transition time, the error "F8350 Maximum transition time exceeded" is signaled and the safety function "Safe torque off (STO)" is activated.

⇒ The maximum time span between the selection of the transition function "Safe stop 1 (SS1)" and the activation of the safety function "Safe torque off (STO)" is **independent of** the course of the transition! The maximum time span is **not** extended when an error occurs.

If the drive has been decelerated without error within the parameterized transition time (P-0-3280.0.2 or P-0-3280.0.3), the transition by the transition function SS1 is completed with the selection of the safety function "Safe torque off (STO)".



P-0-3255 SMO: Velocity threshold for safe standstill
P-0-3280.0.2 SMO: Max. transition time normal oper. to safe standstill
P-0-3280.0.3 SMO: Max. transition time between safe operating states

Fig. 6-23: Monitoring function 4: "SS1, time-prioritized with NC-controlled transition"

Monitoring function 4(+2a): "SS1, time- and standstill-prioritized with NC-controlled transition (with trend monitoring)"

When the monitoring function 4(+2a) [SS1, time- and standstill-prioritized with NC-controlled transition (with trend monitoring)] has been configured, the axis is decelerated in an NC-controlled way when SS1 is selected. That is to say the higher-level control unit decelerates the drive using the command value system and removes drive enable at the end of the deceleration process.

The transition function "Safe stop 1 (SS1)" monitors that the deceleration process is completed within the parameterized transition time (P-0-3280.0.2 or P-0-3280.0.3). If the transition is not completed within the parameterized transition time, the error "F8350 Maximum transition time exceeded" is signaled and the safety function "Safe torque off (STO)" is activated.

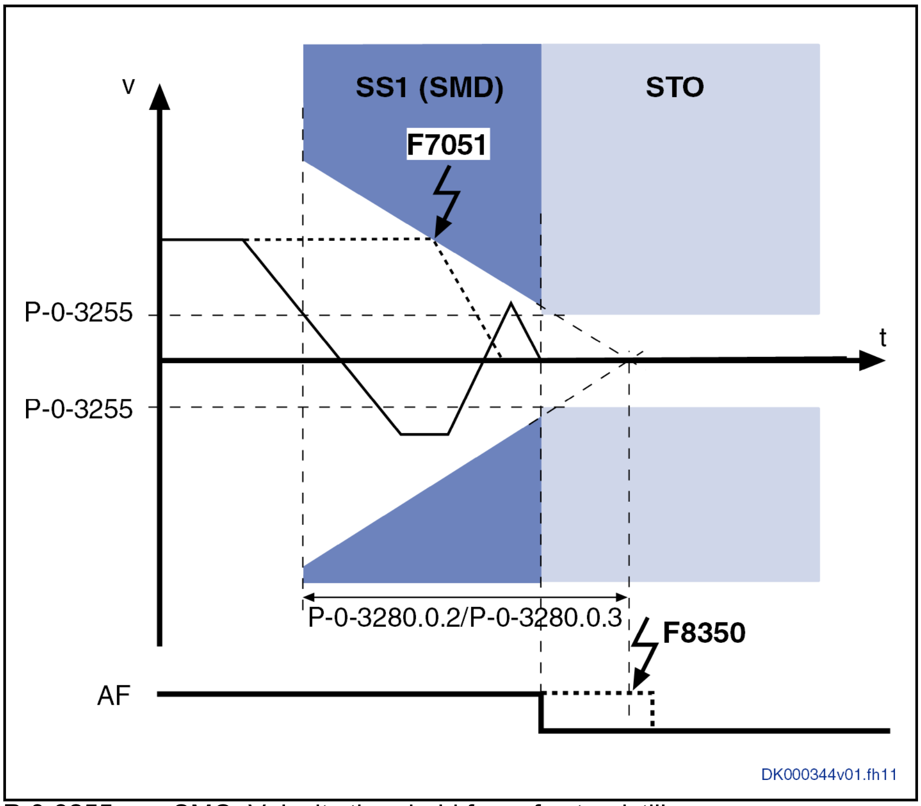
In addition to the time monitoring of the transition function "Safe stop 1", the Transition function Safely-monitored deceleration with trend monitoring is called. If the SMD detects that the velocity has been exceeded, the error "F7051 Safely-monitored deceleration exceeded" is signaled. The drive keeps being decelerated in accordance with the parameterized error reaction (P-0-3263.0.1) (see chapter "Error reaction / escalation strategy"). With the start of the error reaction, the running transition time monitoring is neither aborted nor retriggered. When the transition time (P-0-3280.0.2 or P-0-3280.0.3) is over, the error "F8350 Maximum transition time exceeded" is additionally signaled independently of the status of the error reaction, and the safety function "Safe torque off (STO)" is activated.

⇒ The maximum time span between the selection of the transition function "Safe stop 1 (SS1)" and the activation of the safety function "Safe torque off (STO)" is **independent of** the course of the transition! The maximum time span is **not** extended when an error occurs.

The currently active velocity monitoring limit of Safe Motion is displayed in "P-0-3238, SMO: Active velocity threshold". With this parameter it is possible to check in the control unit whether the velocity command values are within the allowed limits.

With the auxiliary function "limitation of the positioning velocity", it is possible to monitor and, if necessary, limit the velocity command value effective in the drive to the active velocity threshold (P-0-3238).

If the drive has been decelerated without error within the parameterized transition time (P-0-3280.0.2 or P-0-3280.0.3), the transition by the transition function SS1 is completed with the selection of the safety function "Safe torque off (STO)".



P-0-3255	SMO: Velocity threshold for safe standstill
P-0-3280.0.2	SMO: Max. transition time normal oper. to safe standstill
P-0-3280.0.3	SMO: Max. transition time between safe operating states

Fig. 6-24: Monitoring function 4(+2a): "SS1, time- and standstill-prioritized with NC-controlled transition (with trend monitoring)"

Monitoring function 4(+2b): "SS1, time- and standstill-prioritized with NC-controlled transition (based on actual velocity)"

When the monitoring function 4(+2b) [SS1, time- and standstill-prioritized with NC-controlled transition (based on actual velocity)] has been configured, the axis is decelerated in an NC-controlled way when SS1 is selected. That is to say the higher-level control unit decelerates the drive using the command value system and removes drive enable at the end of the deceleration process.

The transition function "Safe stop 1 (SS1)" monitors that the deceleration process is completed within the parameterized transition time (P-0-3280.0.2 or P-0-3280.0.3). If the transition is not completed within the parameterized transition time, the error "F8350 Maximum transition time exceeded" is signaled and the safety function "Safe torque off" is activated.

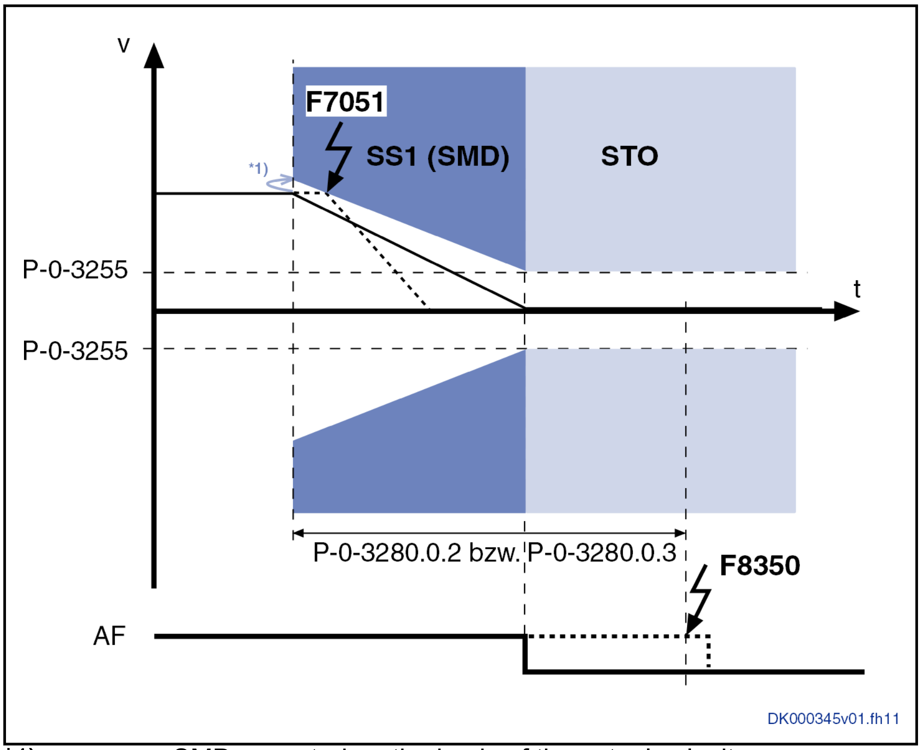
In addition to the time monitoring of the transition function "Safe stop 1 (SS1)", the Transition function Safely-monitored deceleration based on actual velocity is called. If the SMD detects that the velocity has been exceeded, the error "F7051 Safely-monitored deceleration exceeded" is signaled. The drive keeps being decelerated in accordance with the parameterized error reaction (P-0-3263.0.1) (see chapter "Error reaction / escalation strategy"). With the start of the error reaction, the running transition time monitoring is neither aborted nor retriggered. When the transition time (P-0-3280.0.2 or P-0-3280.0.3) is over, the error "F8350 Maximum transition time exceeded" is additionally signaled independently of the status of the error reaction, and the safety function "Safe torque off (STO)" is activated.

⇒ The maximum time span between the selection of the transition function "Safe stop 1 (SS1)" and the activation of the safety function "Safe torque off (STO)" is **independent of** the course of the transition! The maximum time span is **not** extended when an error occurs.

The currently active velocity monitoring limit of Safe Motion is displayed in "P-0-3238, SMO: Active velocity threshold". With this parameter it is possible to check in the control unit whether the velocity command values are within the allowed limits.

With the auxiliary function "limitation of the positioning velocity", it is possible to monitor and, if necessary, limit the velocity command value effective in the drive to the active velocity threshold (P-0-3238).

If the drive has been decelerated without error within the parameterized transition time (P-0-3280.0.2 or P-0-3280.0.3), the transition by the transition function SS1 is completed with the selection of the safety function "Safe torque off (STO)".



***1)** SMD executed on the basis of the actual velocity
P-0-3255 SMO: Velocity threshold for safe standstill
P-0-3280.0.2 SMO: Max. transition time normal oper. to safe standstill
P-0-3280.0.3 SMO: Max. transition time between safe operating states

Fig. 6-25: Monitoring function 4(+2b): "SS1, time- and standstill-prioritized with NC-controlled transition (based on actual velocity)"

Deselecting the transition function

An active transition function "Safe stop 1" (SS1) becomes inactive under the following conditions:

- By activating the STO function after the deceleration process has been completed

  \- or -

- By deselecting the transition function via the active "Safe Motion" profile using the parameter "P-0-3264, SMO: Safety function selection"

  \- or -

- When a safety technology error occurs in the standstill-prioritized variants of the transition function "Safe stop 1 (SS1)". In this case, the parameterized error reaction (P-0-3263.0.1) decelerates the drive and activates the STO function.

☞ In the case of a drive-controlled operation mode transition, the started deceleration process is continued by the standard firmware, even if the safety function is deselected.

6.5.2 Safe stop 2 (SS2)

Brief description

When the transition function "Safe stop 2 (SS2)" is activated, the drive is decelerated in a safely monitored way. After the deceleration process has been completed, the safety function "Safe operating stop (SOS)" is activated.

The transition to standstill by the transition function "Safe stop 2 (SS2)" can be performed in different ways:

- "Drive-controlled", i.e. the drive is decelerated by the standard firmware, and the safety technology monitors the deceleration process **or**
- "NC-controlled", i.e. the higher-level control unit decelerates the drive via the command value system, and the safety technology monitors the deceleration process

The deceleration process is always monitored, with regard to the maximum transition time, by the delay monitoring [safety function "Safely-monitored deceleration (SMD)"] with integrated monitoring. If the maximum transition time is exceeded, the STO function is not necessarily activated. This is done within the scope of the parameterized error reaction (P-0-3263.0.1).

Features

The function has the following features:

- Corresponds to stop category 2 according to EN 60204-1.
- Is suited for safety-relevant applications up to Category 3, PL d according to ISO 13849-1 or SIL 2 according to IEC 62061.

  In conjunction with a suitable measuring system and the firmware option (FWS) "SIL3-MOTION" or "SIL3-PLUS", the safety level Category 4, PL e (IndraDrive Mi with KCU02.2/KCU02.3: Category 3, PL e) according to ISO 13849-1 or SIL 3 according to IEC 62061 can be achieved.
- The energy supply to the motor is **not** interrupted.
- The transition function can be used in drive systems equipped with the optional safety technology module "S3", "S4", "S5", "SB" or "SD".
- The transition can be performed in a "drive-controlled" or in an "NC-controlled" way.
- The safety function "Safe operating stop (SOS)" is automatically activated at the end of the transition function "Safe stop 2" (SS2).
- The duration of the transition is monitored (cf. "P-0-3280.0.2" and "P-0-3280.0.3"). When the monitoring function is triggered, this causes an error reaction which decelerates the drive system. The corresponding error message is "F7050 Maximum transition time exceeded" or "F8350 Maximum transition time exceeded".
- The deceleration during the transition is monitored via the safety function "Safely-monitored deceleration (SMD)". When the monitoring function is triggered, this causes an error reaction which decelerates the drive system. The corresponding error message is "F7051 Safely-monitored deceleration exceeded" or "F8351 Safely-monitored deceleration exceeded".
- The transition function "Safe stop 2" is selected via the active "Safe Motion" profile using the parameter "P-0-3264, SMO: Safety function selection".
- The state of the transition function "Safe stop 2" is displayed via parameter "P-0-3264.0.1, SMO: Safety function status".

Pertinent parameters

The following parameters are used in conjunction with the transition function "Safe stop 2 (SS2)":

- P-0-3238, SMO: Active velocity threshold
- P-0-3255, SMO: Velocity threshold for safe standstill
- P-0-3261.0.1, SMO: State machine control word, functional
- P-0-3263.0.1, SMO: Configuration of stopping process

- P-0-3264, SMO: Safety function selection
- P-0-3264.0.1, SMO: Safety function status
- P-0-3280.0.1, SMO: Configuration of operation mode transitions
- P-0-3280.0.2, SMO: Max. transition time normal oper. to safe standstill
- P-0-3280.0.3, SMO: Max. transition time between safe operating states

Pertinent diagnostic messages

The following diagnostic messages can be generated in conjunction with the safety function "Safe stop 2 (SS2)":

- C0214 SMO: Incorrect configuration
- F7050 Maximum transition time exceeded
- F7051 Safely-monitored deceleration exceeded
- F7052 Selected target velocity exceeded
- F8350 Maximum transition time exceeded
- F8351 Safely-monitored deceleration exceeded

With the transition function "Safe stop 2 (SS2)" activated, the display of the IndraDrive control panel does not show any specific message.

Transition function

Basic principle

When the transition function "Safe stop 2 (SS2)" is activated, the drive is decelerated in a safely monitored way. After the deceleration process has been completed, the safety function "Safe operating stop (SOS)" is activated.

☞ The transition function "Safe stop 2 (SS2)" detects a successful deceleration process, when the motor has stopped; i.e. the actual velocity is smaller than the value parameterized in "P-0-3255, SMO: Velocity threshold for safe standstill".

Configuring the transition function

To use the transition function "Safe stop 2 (SS2)", it has to be configured via the parameter "P-0-3280.0.1, SMO: Configuration of operation mode transitions" during the commissioning of the safety technology.

The transition function "Safe stop 2" can be executed in 3 variants, as the table below shows:

No.	Monitoring	Execution SS2	Operation mode transitions to standstill	Execution SMD	Depends on measuring system used	Maximum safety level
1	SS2, standstill-prioritized with drive-controlled transition	Standstill-prioritized	Drive-controlled	Based on actual velocity	Yes	Category 3, PL d according to ISO 13849-1 or SIL 2 according to IEC 62061
2a	SS2, standstill-prioritized with NC-controlled transition (with trend monitoring)		NC-controlled	Trend monitoring		
2b	SS2, standstill-prioritized with NC-controlled transition (based on actual velocity)			Based on actual velocity		

Tab. 6-3: Configurable variants of the safety function "Safe stop 2 (SS2)"

Selecting the transition function

The transition function "Safe stop 2 (SS2)" can be activated via the active "Safe Motion" profile using the parameter "P-0-3264, SMO: Safety function selection", when the following conditions have been fulfilled:

- SOS has been configured, but is **not** active **and**
- SS1 or STO is **not** active

Transition to the safe state

Monitoring function 1: "SS2, standstill-prioritized with drive-controlled transition"

When the monitoring function 1 (SS2, standstill-prioritized with drive-controlled transition) has been configured, the axis is decelerated in a drive-controlled way when SS2 is selected; i.e. the drive makes itself independent of the command value input of the control unit and is decelerated via the "Drive Halt" function of the standard firmware (see also Functional Description of firmware "Drive Halt").

To monitor the deceleration process, the Transition function Safely-monitored deceleration based on actual velocity is called by the transition function "Safe stop 2 (SS2)". If the SMD detects that the velocity has been exceeded, the error "F7051 Safely-monitored deceleration exceeded" or "F8351 Safely-monitored deceleration exceeded" [only if F3 reaction equals F7 reaction (P-0-3263.0.1)] is signaled. The drive keeps being decelerated in accordance with the parameterized error reaction (P-0-3263.0.1) (see chapter "Error reaction / escalation strategy").

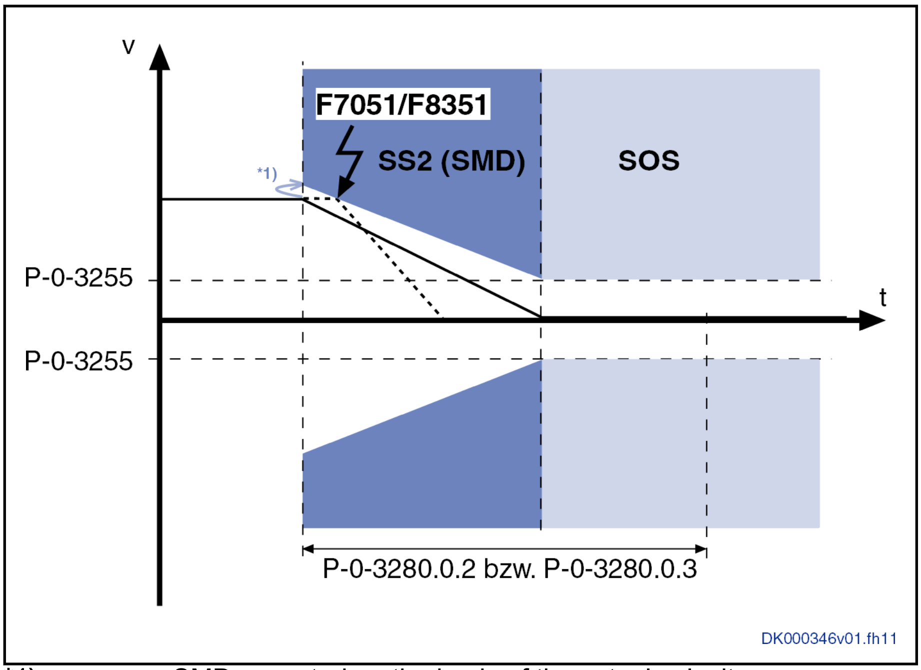
The currently active velocity monitoring limit of Safe Motion is displayed in "P-0-3238, SMO: Active velocity threshold". With this parameter it is possible to check in the control unit whether the velocity command values are within the allowed limits.

With the auxiliary function "limitation of the positioning velocity", it is possible to monitor and, if necessary, limit the velocity command value effective in the drive to the active velocity threshold (P-0-3238).

In parallel with velocity monitoring, the SMD also monitors that the deceleration process is completed within the parameterized transition time (P-0-3280.0.2 or P-0-3280.0.3). If the transition is not completed within the parameterized transition time, the error "F7050 Maximum transition time exceeded" or "F8350 Maximum transition time exceeded" [only when F3 reaction equals F7 reaction (P-0-3263.0.1)] is signaled; the drive keeps being decelerated in accordance with the parameterized error reaction (P-0-3263.0.1) (see chapter "Error reaction / escalation strategy").

⇒ The maximum time span between the selection of the transition function "Safe stop 2 (SS2)" and the time at which safe standstill is reached ("SOS" with error-free transition or "STO" in the case of error) **depends on** the course of the transition! When an error occurs, the time span can be extended at most by the time parameterized in P-0-3263.0.7. In the case of a configured F7 error reaction="torque disable" (P-0-3263.0.1) or direct switching to the F8 error reaction (F3 reaction=F7 reaction in P-0-3263.0.1), the time is not extended.

When the SMD acknowledges the transition process without error, the transition by the transition function "Safe stop 2 (SS2)" is completed with the selection of the safety function "Safe operating stop (SOS)".



***1)**	SMD executed on the basis of the actual velocity
P-0-3255	SMO: Velocity threshold for safe standstill
P-0-3280.0.2	SMO: Max. transition time normal oper. to safe standstill
P-0-3280.0.3	SMO: Max. transition time between safe operating states

Fig. 6-26: Monitoring function 1: "SS2, standstill-prioritized with drive-controlled transition"

Monitoring function 2a: "SS2, standstill-prioritized with NC-controlled transition (with trend monitoring)"

When the monitoring function 2a [SS2, standstill-prioritized with NC-controlled transition (with trend monitoring)] has been configured, the axis is decelerated in an NC-controlled way when SS2 is selected; i.e. the higher-level control unit decelerates the drive within the parameterized transition time (P-0-3280.0.2 or P-0-3280.0.3) via the command value system.

To monitor the deceleration process, the Transition function Safely-monitored deceleration with trend monitoring is called by the transition function "Safe stop 2 (SS2)". If the SMD detects that the velocity has been exceeded, the error "F7051 Safely-monitored deceleration exceeded" is signaled and the drive keeps being decelerated in accordance with the parameterized error reaction (P-0-3263.0.1) (see chapter "Error reaction / escalation strategy").

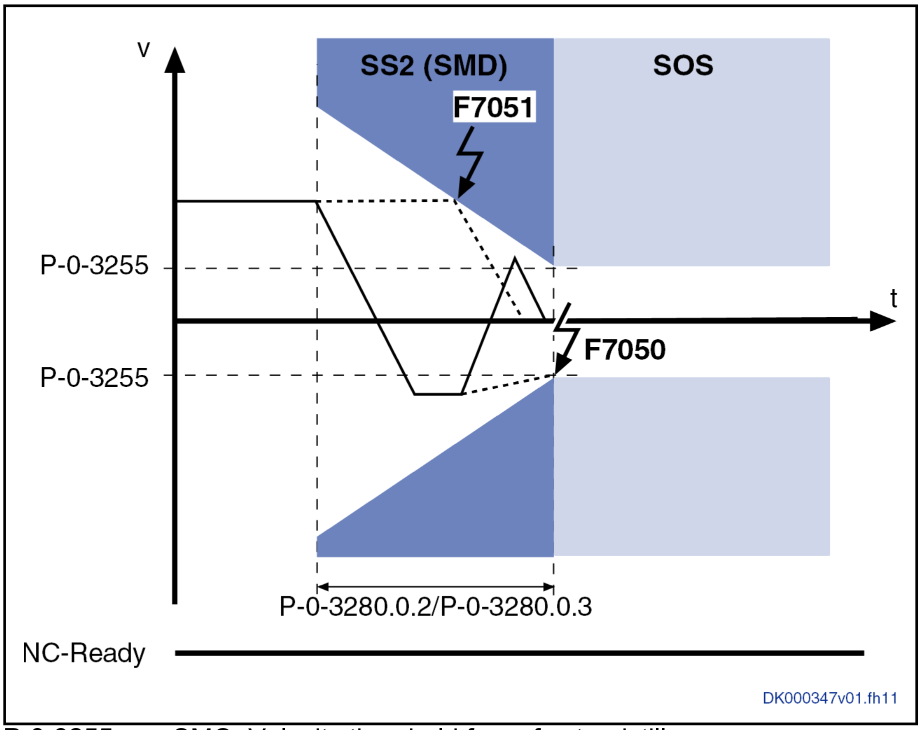
The currently active velocity monitoring limit of Safe Motion is displayed in "P-0-3238, SMO: Active velocity threshold". With this parameter it is possible to check in the control unit whether the velocity command values are within the allowed limits.

With the auxiliary function "limitation of the positioning velocity", it is possible to monitor and, if necessary, limit the velocity command value effective in the drive to the active velocity threshold (P-0-3238).

In parallel with velocity monitoring, the SMD also monitors that the deceleration process is completed within the parameterized transition time (P-0-3280.0.2 or P-0-3280.0.3). If the transition is not completed within the parameterized transition time, the error "F7050 Maximum transition time exceeded" is signaled and the drive keeps being decelerated in accordance with the parameterized error reaction (P-0-3263.0.1) (see chapter "Error reaction / escalation strategy").

⇒ The maximum time span between the selection of the transition function "Safe stop 2 (SS2)" and the time at which safe standstill is reached ("SOS" with error-free transition or "STO" in the case of error) **depends on** the course of the transition! When an error occurs, the time span can be extended at most by the time parameterized in P-0-3263.0.7. In the case of a configured F7 error reaction="torque disable" (P-0-3263.0.1) or direct switching to the F8 error reaction (F3 reaction=F7 reaction in P-0-3263.0.1), the time is not extended.

When the SMD signals motor standstill (actual velocity < P-0-3255) and the transition time (P-0-3280.0.2 or P-0-3280.0.3) is over, the transition by the transition function "Safe stop 2 (SS2)" is completed with the selection of the safety function "Safe operating stop (SOS)".



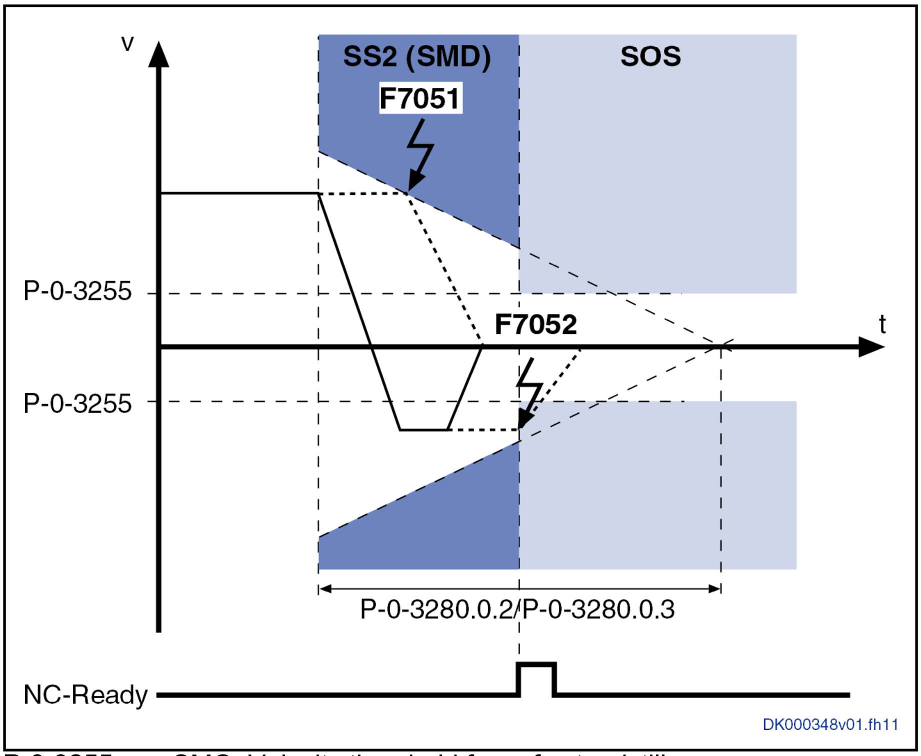
P-0-3255 SMO: Velocity threshold for safe standstill
P-0-3280.0.2 SMO: Max. transition time normal oper. to safe standstill
P-0-3280.0.3 SMO: Max. transition time between safe operating states

Fig. 6-27: Monitoring function 2a: "SS2, standstill-prioritized with NC-controlled transition (with trend monitoring)" (without "NC-Ready")

☞ Via the "NC-Ready" signal in "P-0-3261.0.1, SMO: State machine control word, functional", the control unit may signal the end of the transition process of safety technology. The SMD safety function will then immediately terminate the transition and not wait for expiry of the transition time (P-0-3280.0.2 or P-0-3280.0.3 or P-0-3280.0.4).

The "NC-Ready" signal is evaluated dynamically, i.e. in an edge-triggered way. The safety technology detects a valid edge (0-1 transition), if the signal before had been "0" for at least 10 ms.

If the transition process is terminated ahead of time via the "NC-Ready" signal, although the target velocity of the selected safety function has not yet been reached, the error "F7052 Selected target velocity exceeded" is generated and the drive is decelerated.



P-0-3255 SMO: Velocity threshold for safe standstill
P-0-3280.0.2 SMO: Max. transition time normal oper. to safe standstill
P-0-3280.0.3 SMO: Max. transition time between safe operating states

Fig. 6-28: Monitoring function 2a: "SS2, standstill-prioritized with NC-controlled transition (with trend monitoring)" (with "NC-Ready")

Monitoring function 2b: "SS2, standstill-prioritized with NC-controlled transition (based on actual velocity)"

When the monitoring function 2b [SS2, standstill-prioritized with NC-controlled transition (based on actual velocity)] has been configured, the axis is decelerated in an NC-controlled way when SS2 is selected; i.e. the higher-level control unit decelerates the drive via the command value system.

To monitor the deceleration process, the Transition function Safely-monitored deceleration based on actual velocity is called by the transition function "Safe stop 2 (SS2)". If the SMD detects that the velocity has been exceeded, the error "F7051 Safely-monitored deceleration exceeded" is signaled and the drive keeps being decelerated in accordance with the parameterized error reaction (P-0-3263.0.1) (see chapter "Error reaction / escalation strategy").

The currently active velocity monitoring limit of Safe Motion is displayed in "P-0-3238, SMO: Active velocity threshold". With this parameter it is possible to check in the control unit whether the velocity command values are within the allowed limits.

With the auxiliary function "limitation of the positioning velocity", it is possible to monitor and, if necessary, limit the velocity command value effective in the drive to the active velocity threshold (P-0-3238).

In parallel with velocity monitoring, the SMD also monitors that the deceleration process is completed within the parameterized transition time (P-0-3280.0.2 or P-0-3280.0.3). If the transition is not completed within the parameterized transition time, the error "F7050 Maximum transition time exceeded" is signaled and the drive keeps being decelerated in accordance with the parameterized error reaction (P-0-3263.0.1) (see chapter "Error reaction / escalation strategy").

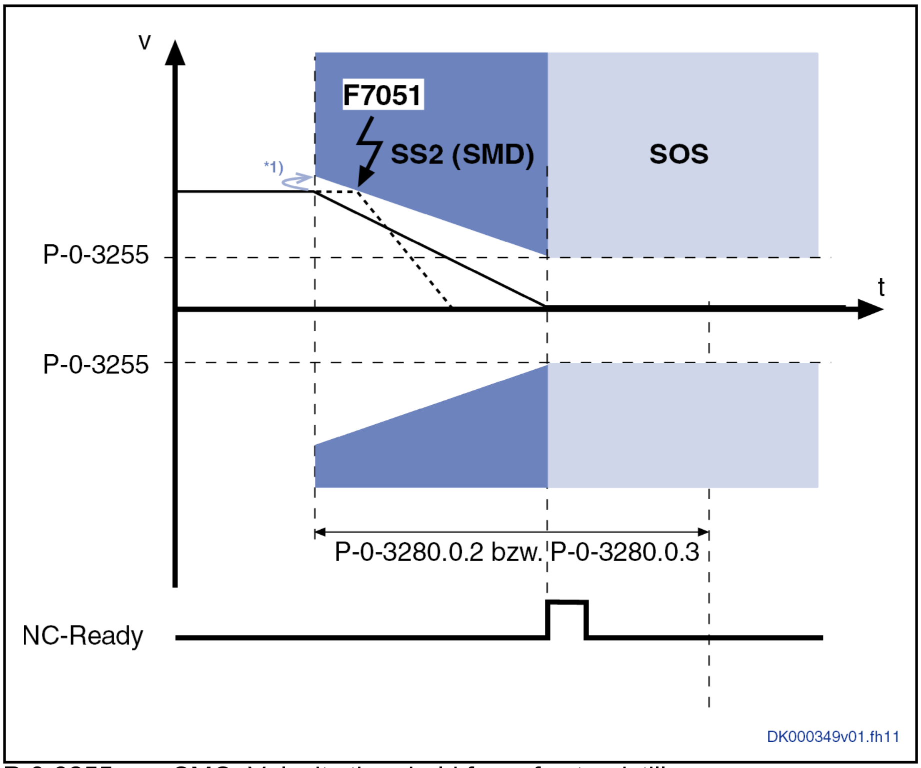
⇒ The maximum time span between the selection of the transition function "Safe stop 2 (SS2)" and the time at which safe standstill is reached ("SOS" with error-free transition or "STO" in the case of error) **depends on** the course of the transition! When an error occurs, the time span can be extended at most by the time parameterized in P-0-3263.0.7. In the case of a configured F7 error reaction="torque disable" (P-0-3263.0.1) or direct switching to the F8 error reaction (F3 reaction=F7 reaction in P-0-3263.0.1), the time is not extended.

When the SMD signals motor standstill (actual velocity < P-0-3255) and the transition time (P-0-3280.0.2 or P-0-3280.0.3) is over, the transition by the transition function "Safe stop 2 (SS2)" is completed with the selection of the safety function "Safe operating stop (SOS)".

☞ Via the "NC-Ready" signal in "P-0-3261.0.1, SMO: State machine control word, functional", the control unit may signal the end of the transition process of safety technology. The SMD safety function will then immediately terminate the transition and not wait for expiry of the transition time (P-0-3280.0.2 or P-0-3280.0.3 or P-0-3280.0.4).

The "NC-Ready" signal is evaluated dynamically, i.e. in an edge-triggered way. The safety technology detects a valid edge (0-1 transition), if the signal before had been "0" for at least 10 ms.

If the transition process is terminated ahead of time via the "NC-Ready" signal, although the target velocity of the selected safety function has not yet been reached, the error "F7052 Selected target velocity exceeded" is generated and the drive is decelerated.



P-0-3255 SMO: Velocity threshold for safe standstill
P-0-3280.0.2 SMO: Max. transition time normal oper. to safe standstill
P-0-3280.0.3 SMO: Max. transition time between safe operating states

Fig. 6-29: Monitoring function 2b: "SS2, standstill-prioritized with NC-controlled transition (based on actual velocity)"

Deselecting the safety function

An active transition function "Safe stop 2 (SS2)" becomes inactive under the following conditions:

- By activating the SOS function after the deceleration process has been completed

  - or -
- By deselecting the transition function via the active "Safe Motion" profile using the parameter "P-0-3264, SMO: Safety function selection"

  - or -
- When a safety technology error occurs

  - or -
- By selecting the safety function "STO" or "SS1"

☞ In the case of a drive-controlled operation mode transition, the started deceleration process is continued by the standard firmware, even if the safety function is deselected.

6.5.3 Safely-monitored deceleration (SMD)

Brief description

The transition function "Safely-monitored deceleration" (SMD) uses dual-channel monitoring to detect whether the actual velocity of the drive, given a change in the operating status or given an error reaction, is within a parameterized velocity envelope curve.

Three monitoring variants of the transition function "Safely-monitored deceleration (SMD)" are available.

Features

The function has the following features:

- Is suited for safety-relevant applications up to Category 3, PL d according to ISO 13849-1 or SIL 2 according to IEC 62061.

  In conjunction with a suitable measuring system and the firmware option (FWS) "SIL3-MOTION" or "SIL3-PLUS", the safety level Category 4, PL e (IndraDrive Mi with KCU02.2/KCU02.3: Category 3, PL e) according to ISO 13849-1 or SIL 3 according to IEC 62061 can be achieved.
- The transition function can be used in drive systems equipped with the optional safety technology module "S3", "S4", "S5", "SB" or "SD".
- Transitions due to a change in the operating status or due to an error reaction are monitored.
- There are three transition variants:
  - "Safely-monitored deceleration with trend monitoring" (SMD_{Trend}),
  - "Safely-monitored deceleration based on actual velocity" (SMD_{ActVel}) and
  - "Safely-monitored deceleration in the case of error (based on actual velocity)" (SMD-E)

  Furthermore, the transition can be performed in two ways:
  - "Drive-controlled", i.e. the transition of the drive is carried out by the standard firmware, and the safety technology monitors the transition process **or**
  - "NC-controlled", i.e. the higher-level control unit carries out the transition of the drive by adjusting the command value system, and the safety technology monitors the transition process
- The duration of the transition is monitored (cf. "P-0-3263.0.6", "P-0-3263.0.7", "P-0-3280.0.2", "P-0-3280.0.3", "P-0-3280.0.4"). When the monitoring function is triggered, this causes an error reaction which decelerates the drive system. The corresponding error message is "F7050 Maximum transition time exceeded" or "F8350 Maximum transition time exceeded".
- When the delay monitoring is triggered, this causes an error reaction which decelerates the drive system. The corresponding error message is "F7051 Safely-monitored deceleration exceeded" or "F8351 Safely-monitored deceleration exceeded".
- The transition function "Safely-monitored deceleration" is selected via the active "Safe Motion" profile using the parameter "P-0-3264, SMO: Safety function selection".
- The state of the transition function "Safely-monitored deceleration" is displayed via parameter "P-0-3264.0.1, SMO: Safety function status".

Pertinent parameters

The following parameters are used in conjunction with the transition function "Safely-monitored deceleration":

- P-0-3238, SMO: Active velocity threshold
- P-0-3255, SMO: Velocity threshold for safe standstill
- P-0-3261.0.1, SMO: State machine control word, functional
- P-0-3263.0.1, SMO: Configuration of stopping process
- P-0-3263.0.2, SMO: Oscillation velocity window of SMD-E

- P-0-3263.0.3, SMO: SMD-E reaction time
- P-0-3263.0.4, SMO: Velocity window of SMD-E
- P-0-3263.0.5, SMO: SMD-E delay
- P-0-3263.0.6, SMO: Error reaction F3 tolerance time
- P-0-3263.0.7, SMO: Error reaction F7 tolerance time
- P-0-3263.0.8, SMO: SMD-E jerk (MPx-20V06 and above)
- P-0-3264, SMO: Safety function selection
- P-0-3264.0.1, SMO: Safety function status
- P-0-3280.0.1, SMO: Configuration of operation mode transitions
- P-0-3280.0.2, SMO: Max. transition time normal oper. to safe standstill
- P-0-3280.0.3, SMO: Max. transition time between safe operating states
- P-0-3280.0.4, SMO: Max. transition time normal oper. to safe motion
- P-0-3280.0.6, SMO: Oscillation velocity window of SMD
- P-0-3280.0.7, SMO: SMD reaction time
- P-0-3280.0.8, SMO: Velocity window of SMD
- P-0-3280.0.9, SMO: SMD delay
- P-0-3280.0.10, SMO: SMD jerk (ab MPx-20V12)
- P-0-3290.x.2, SMO: Safely-limited speed

Pertinent diagnostic messages

The following diagnostic messages can be generated in conjunction with the transition function "Safely-monitored deceleration":

- C0214 SMO: Incorrect configuration
- F7050 Maximum transition time exceeded
- F7051 Safely-monitored deceleration exceeded
- F7052 Selected target velocity exceeded
- F8350 Maximum transition time exceeded
- F8351 Safely-monitored deceleration exceeded

With the transition function "Safely-monitored deceleration" activated, the display of the IndraDrive control panel does not show any specific message.

Transition function

Basic principle

The transition function "Safely-monitored deceleration" (SMD) uses dual-channel monitoring to detect whether the actual velocity of the drive, given a change in the operating status or given an error reaction, is within a parameterized velocity envelope curve.

Configuring the transition function

To use the transition function "Safely-monitored deceleration", it has to be configured via the parameters "P-0-3280.0.1, SMO: Configuration of operation mode transitions" and "P-0-3263.0.1, SMO: Configuration of stopping process" during the commissioning of the safety technology.

The active monitoring functions depend on the parameterization of the axis, as well as on the selected safety function. The tables below show when the different types of monitoring are active and which error is generated when the monitoring function triggers.

Safety functions

Transitions		Parameterization (P-0-3280.0.1)		Reaction		
Active safety function	Selected safety function	Bit 3	Bit 4	Monitoring	Error message when monitoring function is violated: When time monitoring is triggered	Error message when monitoring function is violated: When velocity is violated
NO	STO (SS1), SOS (SS2), SBC	0	x	SMD with trend monitoring	F7050	F7051
		1		SMD based on actual velocity		
	SMMx	x	0	SMD with trend monitoring		
			1	SMD based on actual velocity		
STO, SBC	NO, SOS (SS2), SMMx	x	x	- (**no transition** necessary, **switching takes place directly** and the output stage is enabled)	-	
SOS	STO (SS1), SBC	0	x	SMD with trend monitoring	F7050	F7051
		1		SMD based on actual velocity		
	NO, SMMx	x	x	- (**no transition** necessary, **switching takes place directly** and the output stage is enabled)	-	
SMMx	STO (SS1), SOS (SS2), SBC	0	x	SMD with trend monitoring	F7050	F7051
		1		SMD based on actual velocity		
	SMMx	x	0	SMD with trend monitoring		
			1	SMD based on actual velocity		
	NO	x	x	- (**no transition** necessary, **switching takes place directly** and the output stage is enabled)	-	

NO Normal operation, no safety function selected
SMMx Motion modes (SMM1 - SMM16), safety functions for motion monitoring
x Not relevant

Tab. 6-4: Monitoring functions during NC-controlled safety technology operation mode transitions

Transitions		Parameterization (P-0-3263.0.1)		Reaction		
Active safety function	Selected safety function	F3 reaction (bit 3-0)	F7 reaction (bit 7-4)	Monitoring	Error message when SMD monitoring is violated: When time monitoring is triggered	Error message when SMD monitoring is violated: When velocity is violated
NO	STO (SS1), SOS (SS2), SBC	0	0	SMD based on actual velocity	F8350	F8351
		1	1			
		2	0		F7050	F7051
			4			
		4	0			
			4		F8350	F8351
	SMMx	x	x	- [**transitions to SMMx** cannot be performed in a drive-controlled way, they **are always NC-controlled** (see table "Monitoring functions during NC-controlled safety technology operation mode transitions")]	-	
STO, SBC	NO, SOS (SS2), SMMx	x	x	- (**no transition** necessary, **switching takes place directly** and the output stage is enabled)	-	

<table>
<tr><th colspan="2">Transitions</th><th colspan="2">Parameterization (P-0-3263.0.1)</th><th colspan="3">Reaction</th></tr>
<tr><th rowspan="2">Active safety function</th><th rowspan="2">Selected safety function</th><th rowspan="2">F3 reaction (bit 3-0)</th><th rowspan="2">F7 reaction (bit 7-4)</th><th rowspan="2">Monitoring</th><th colspan="2">Error message when SMD monitoring is violated</th></tr>
<tr><th>When time monitoring is triggered</th><th>When velocity is violated</th></tr>
<tr><td rowspan="7">SOS</td><td rowspan="6">STO (SS1), SBC</td><td>0</td><td>0</td><td rowspan="6">SMD based on actual velocity</td><td rowspan="2">F8350</td><td rowspan="2">F8351</td></tr>
<tr><td>1</td><td>1</td></tr>
<tr><td rowspan="2">2</td><td>0</td><td rowspan="3">F7050</td><td rowspan="3">F7051</td></tr>
<tr><td>4</td></tr>
<tr><td rowspan="2">4</td><td>0</td></tr>
<tr><td>4</td><td>F8350</td><td>F8351</td></tr>
<tr><td>NO, SMMx</td><td>x</td><td>x</td><td>-
(no transition necessary, switching takes place directly and the output stage is enabled)</td><td colspan="2">-</td></tr>
<tr><td rowspan="8">SMMx</td><td rowspan="6">STO (SS1), SOS (SS2), SBC</td><td>0</td><td>0</td><td rowspan="6">SMD based on actual velocity</td><td rowspan="2">F8350</td><td rowspan="2">F8351</td></tr>
<tr><td>1</td><td>1</td></tr>
<tr><td rowspan="2">2</td><td>0</td><td rowspan="3">F7050</td><td rowspan="3">F7051</td></tr>
<tr><td>4</td></tr>
<tr><td rowspan="2">4</td><td>0</td></tr>
<tr><td>4</td><td>F8350</td><td>F8351</td></tr>
<tr><td>NO</td><td rowspan="2">x</td><td rowspan="2">x</td><td>-
(no transition necessary, switching takes place directly and the output stage is enabled)</td><td colspan="2" rowspan="2">-</td></tr>
<tr><td>SMMx</td><td>-
[transitions to SMMx cannot be performed in a drive-controlled way, they are always NC-controlled (see table "Monitoring functions during NC-controlled safety technology operation mode transitions")]</td></tr>
</table>

NO Normal operation, no safety function selected
SMMx Motion modes (SMM1 - SMM16), safety functions for motion monitoring
x Not relevant

Tab. 6-5: Monitoring functions during drive-controlled safety technology operation mode transitions

Error state	Parameterization (P-0-3263.0.1)			Reaction		
	NC/MLD error reaction (bit 16)	F3 reaction (bit 3-0)	F7 reaction (bit 7-4)	Monitoring during the error reaction	Error message when SMD monitoring is violated	
					When time monitoring is triggered	When velocity is violated
F3 error, E83 warning	0	0	0	"SMD-E" based on actual velocity	F8350	F8351
		1	1	- (no monitoring necessary, switching takes place directly and the output stage is enabled)	-	
		2	0	"SMD-E" based on actual velocity	F7050	F7051
			4			
		4	0			
			4		F8350	F8351
	1	x	x	- (no SMD active, only the time is monitored)	F7050	
F7 error	x	x	0	"SMD-E" based on actual velocity	F8350	F8351
			1	- (no monitoring necessary, switching takes place directly and the output stage is enabled)	-	
			4	"SMD-E" based on actual velocity	F8350	F8351

x Not relevant

Tab. 6-6: Monitoring during safety technology errors or safety technology warnings

Selecting the transition function

The transition function "Safely-monitored deceleration with trend monitoring" (SMD_{Trend}) or "Safely-monitored deceleration based on actual velocity" (SMD_{ActVel}) is directly selected via the active "Safe Motion" profile using the parameter "P-0-3264, SMO: Safety function selection".

Transition to the safe state

Transition function "Safely-monitored deceleration with trend monitoring"

When the transition function "Safely-monitored deceleration with trend monitoring" (SMD_{Trend}) is selected, the NC-controlled transition of the axis is performed; i.e. the higher-level control unit adjusts the command value system for the drive in accordance with the monitoring thresholds of the selected safety function.

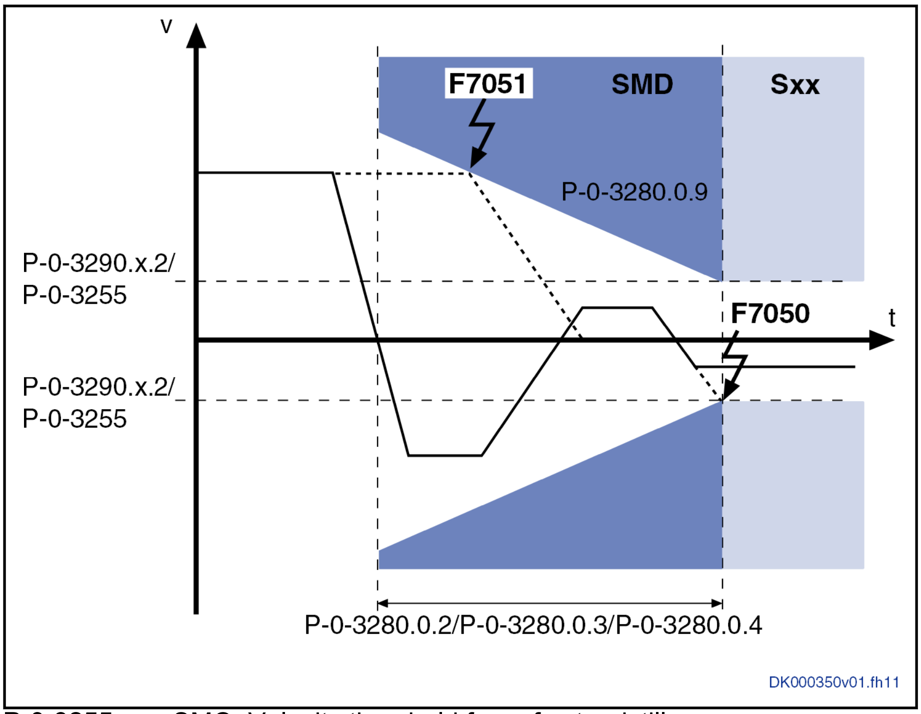
In the case of the transition function "Safely-monitored deceleration with trend monitoring", dual-channel monitoring is used to detect whether the actual velocity is within the velocity envelope curve (P-0-3238). Using the deceleration ramp (P-0-3280.0.9), the drives calculates the velocity envelope curve in such a way that the drive is at any time able - within the scope of the possible deceleration - to reach the parameterized velocity window (P-0-3255 or P-0-3290.x.2) of the selected special mode until the transition time (P-0-3280.0.2 or P-0-3280.0.3 or P-0-3280.0.4) is over. If this is no longer possible, the error "F7051 Safely-monitored deceleration exceeded" is generated and the drive is decelerated in accordance with the parameterized error reaction (P-0-3263.0.1) (see chapter "Error reaction / escalation strategy").

If the monitoring limit of the "Safe maximum speed (SMS)" (P-0-3270.0.2) or of an active "Safely-limited speed (SLS)" (P-0-3290.x.2) is below the calculated velocity envelope curve (P-0-3238), the envelope curve acts as the monitoring limit. When the monitoring limit is violated, the corresponding safety function signals an error.

The currently active velocity monitoring limit of Safe Motion is displayed in "P-0-3238, SMO: Active velocity threshold". With this parameter it is possible to check in the control unit whether the velocity command values are within the allowed limits.

With the auxiliary function "limitation of the positioning velocity", it is possible to monitor and, if necessary, limit the velocity command value effective in the drive to the active velocity threshold (P-0-3238).

In parallel with velocity monitoring, the "SMD_{Trend}" also monitors that the transition process is completed within the parameterized transition time (P-0-3280.0.2 or P-0-3280.0.3 or P-0-3280.0.4). If the transition is not completed within the parameterized transition time, the error "F7050 Maximum transition time exceeded" is signaled and the drive is decelerated in accordance with the parameterized error reaction (P-0-3263.0.1) (see chapter "Error reaction / escalation strategy").



P-0-3255 SMO: Velocity threshold for safe standstill
P-0-3290.x.2 SMO: Safely-limited speed
P-0-3280.0.2 SMO: Max. transition time normal oper. to safe standstill
P-0-3280.0.3 SMO: Max. transition time between safe operating states
P-0-3280.0.4 SMO: Max. transition time normal oper. to safe motion
P-0-3280.0.9 SMO: SMD delay

Fig. 6-30: Transition function "Safely-monitored deceleration with trend monitoring"

The "Safely-monitored deceleration with trend monitoring" is terminated before the parameterized transition time is over, as soon as one of the following conditions has been fulfilled:

- The actual velocity is within the velocity window of the selected safety function and drive enable has been removed.
- In the case of an NC-controlled transition, the control unit signals the end of the transition process via the "NC-Ready" signal (P-0-3261.0.1).

  The "NC-Ready" signal is evaluated dynamically, i.e. in an edge-triggered way. The safety technology detects a valid edge (0-1 transition), when the signal before had been "0" for at least 10 ms.

  If the transition process is terminated ahead of time via the "NC-Ready" signal, although the target velocity of the selected safety function has not yet been reached, the error "F7052 Selected target velocity exceeded" is generated and the drive is decelerated.
- Selection of an SMM safety function from normal operation, when the option "Immediate switching NO to motion mode" had been configured in the parameter "P-0-3280.0.1, SMO: Configuration of operation mode transitions" and this is possible due to the system properties (selected velocity window and selected direction of motion are complied with) (see "Immediate switching option" on page 183).
- Selection of an SMM safety function from an active SMM safety function, when the option "Immediate switching within special mode "Safe motion"" had been configured in the parameter "P-0-3280.0.1, SMO: Configuration of operation mode transitions" and this is possible due to the system properties (selected velocity window and selected direction of motion are complied with) (see "Immediate switching option" on page 183).

Transition function "Safely-monitored deceleration based on actual velocity"

When the transition function "Safely-monitored deceleration based on actual velocity" (SMD_{ActVel}) is selected, the drive-controlled or NC-controlled transition of the axis is performed in accordance with the configuration (P-0-3280.0.1).

In the case of drive-controlled transition (only possible to standstill), the drive makes itself independent of the command value input of the control unit and is decelerated by the standard firmware in accordance with the parameterization in "P-0-3263.0.1, SMO: Configuration of stopping process" [F3 error reaction (bit 0-3)].

In the case of NC-controlled transition, the higher-level control unit adjusts the command value system for the drive in accordance with the monitoring thresholds of the selected safety function.

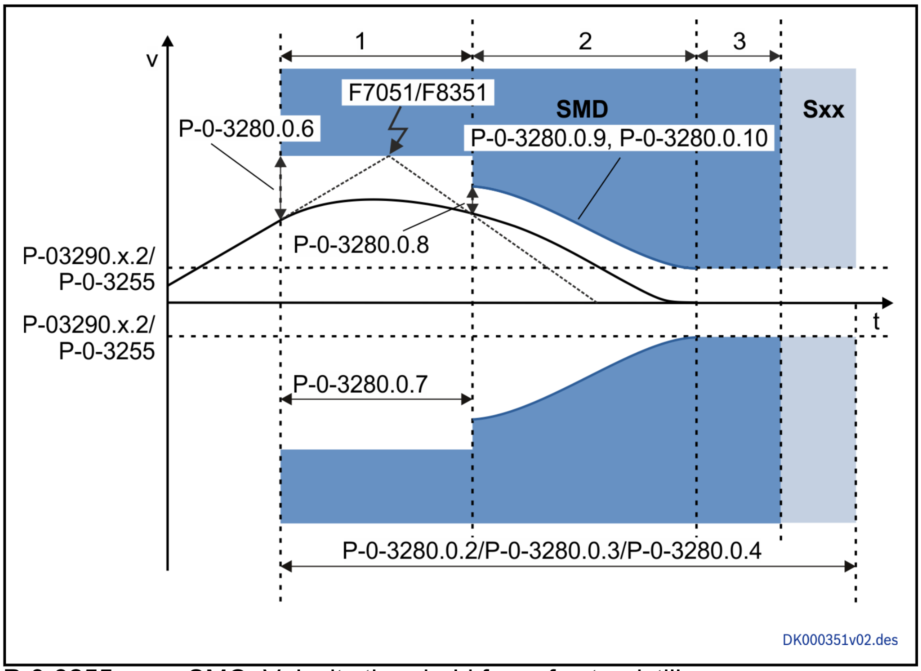
The "SMD_{ActVel}" monitors via two channels whether the actual velocity is within the velocity envelope curve (P-0-3238). Using the deceleration ramp (P-0-3280.0.9) with jerk limitation [P-0-3280.0.10 (MPx-20V12 and above)], the drives generates the velocity envelope curve. The drive calculates the start value of the velocity envelope curve from the current actual velocity plus a tolerance (P-0-3280.0.8). When the actual velocity leaves the velocity envelope curve (P-0-3238), the error "F7051 Safely-monitored deceleration exceeded" or "F8351 Safely-monitored deceleration exceeded" [only when F3 reaction equals F7 reaction (P-0-3263.0.1)] is signaled; the drive keeps being decelerated in accordance with the parameterized error reaction (P-0-3263.0.1) (see chapter "Error reaction / escalation strategy").

If the monitoring limit of the "Safe maximum speed (SMS)" (P-0-3270.0.2) or of an active "Safely-limited speed (SLS)" (P-0-3290.x.2) is below the calculated velocity envelope curve (P-0-3238), the envelope curve acts as the monitoring limit. When the monitoring limit is violated, the corresponding safety function signals an error.

The currently active velocity monitoring limit of Safe Motion is displayed in "P-0-3238, SMO: Active velocity threshold". With this parameter it is possible to check in the control unit whether the velocity command values are within the allowed limits.

With the auxiliary function "limitation of the positioning velocity", it is possible to monitor and, if necessary, limit the velocity command value effective in the drive to the active velocity threshold (P-0-3238).

In parallel with velocity monitoring, the "SMD_{ActVel}" also monitors that the transition process is completed within the parameterized transition time (P-0-3280.0.2 or P-0-3280.0.3 or P-0-3280.0.4). If the transition is not completed within the parameterized transition time, the error "F7050 Maximum transition time exceeded" or "F8350 Maximum transition time exceeded" [only when F3 reaction equals F7 reaction (P-0-3263.0.1)] is signaled; the drive keeps being decelerated in accordance with the parameterized error reaction (P-0-3263.0.1) (see chapter "Error reaction / escalation strategy").



P-0-3255	SMO: Velocity threshold for safe standstill
P-0-3290.x.2	SMO: Safely-limited speed (x=1..16)
P-0-3280.0.2	SMO: Max. transition time normal oper. to safe standstill
P-0-3280.0.3	SMO: Max. transition time between safe operating states
P-0-3280.0.4	SMO: Max. transition time normal oper. to safe motion
P-0-3280.0.6	SMO: Oscillation velocity window of SMD
P-0-3280.0.7	SMO: SMD reaction time
P-0-3280.0.8	SMO: Velocity window of SMD
P-0-3280.0.9	SMO: SMD delay
P-0-3280.0.10	SMO: SMD jerk (20V12 and above)

Fig. 6-31: Transition function "Safely-monitored deceleration based on actual velocity"

The velocity envelope curve consists of three sections and is generated as follows:

1. "Reaction time to change in selection" (drive-side or NC-side) for the duration of P-0-3280.0.7:

   For the duration of "P-0-3280.0.7, SMO: SMD reaction time", the safety technology gives the system (control unit and drive) the time to adjust the command value input for the transition process. In this space of time, monitoring takes place to find out whether the actual velocity is within the velocity envelope curve (P-0-3238). In this section, the drive calculates the velocity envelope curve from the actual velocity at selection plus the tolerance of parameter "P-0-3280.0.6, SMO: Oscillation velocity window of SMD".

☞ This section of monitoring does not exist when the value "0" is parameterized in the parameter "P-0-3280.0.7, SMO: SMD reaction time".

☞ If the monitoring limit of the "Safe maximum speed (SMS)" (P-0-3270.0.2) or of an active "Safely-limited speed (SLS)" (P-0-3290.x.2) is below the calculated velocity envelope curve (P-0-3238), the envelope curve acts as the monitoring limit. When the monitoring limit is violated, the corresponding safety function signals an error.

2. "Monitoring of transition to the selected safety function" using deceleration ramp [P-0-3280.0.9 and P-0-3280.0.10 (MPx-20V12 and above)] until the velocity window of the selected safety function has been reached:

   In section 2, monitoring via two channels takes place to find out whether the actual velocity is within the velocity envelope curve (P-0-3238). Using the deceleration ramp (P-0-3280.0.9, SMO: SMD delay) and the jerk limitation [P-0-3280.0.10, SMO: SMD jerk (MPx-20V12 and above)], the drives generates the velocity envelope curve. The drive calculates the start value of the velocity envelope curve from the current actual velocity, plus the tolerance defined by "P-0-3280.0.8, SMO: Velocity window of SMD".

   If a jerk greater than "0" has been set in parameter "P-0-3280.0.10, SMO: SMD jerk", the deceleration ramp for limiting the jerk is filtered via a PT1 element. The time constant of the filter can be determined as follows:

   T_{PT1} = P-0-3280.0.9 / P-0-3280.0.10

☞ Via "P-0-3280.0.8, SMO: Velocity window of SMD" and "P-0-3280.0.10, SMO: SMD jerk" (MPx-20V12 and above), the transient oscillation of the velocity to the new target velocity is made possible.

☞ If the monitoring limit of the "Safe maximum speed (SMS)" (P-0-3270.0.2) or of an active "Safely-limited speed (SLS)" (P-0-3290.x.2) is below the calculated velocity envelope curve (P-0-3238), the envelope curve acts as the monitoring limit. When the monitoring limit is violated, the corresponding safety function signals an error.

3. "Monitoring of the velocity window of the selected safety function" until switching to the selected safety function takes place:

   After the velocity envelope curve (P-0-3238) has reached the velocity window ("P-0-3255, SMO: Velocity threshold for safe standstill" or "P-0-3290.x.2, SMO: Safely-limited speed") of the selected safety function, the drive monitors that the actual velocity is smaller than the velocity window until switching to the selected safety function takes place.

The pertinent parameters can be used to adjust the monitoring function to many applications. This can mainly be achieved by P-0-3280.0.7 and P-0-3280.0.9.

The "Safely-monitored deceleration based on actual velocity" is terminated before the parameterized transition time is over, as soon as one of the following conditions has been fulfilled:

- The actual velocity is within the velocity window of the selected safety function and drive enable has been removed.
- – The velocity envelope curve (P-0-3238) has reached the velocity window of the selected safety function **and**
  – the monitoring of the direction of motion of the active safety function and of the selected safety function is identical or

  the selected safety function is without monitoring of the direction of motion.
- In the case of an NC-controlled transition, the control unit signals the end of the transition process via the "NC-Ready" signal (P-0-3261.0.1).

  The "NC-Ready" signal is evaluated dynamically, i.e. in an edge-triggered way. [The safety technology detects a valid edge (0-1 transition), if the signal before had been "0" for at least 10 ms.]

  If the transition process is terminated ahead of time via the "NC-Ready" signal, although the target velocity of the selected safety function has not yet been reached, the error "F7052 Selected target velocity exceeded" is generated and the drive is decelerated.
- Selection of an SMM safety function from normal operation, when the option "Immediate switching NO to motion mode" had been configured in the parameter "P-0-3280.0.1, SMO: Configuration of operation mode transitions" and this is possible due to the system properties (selected velocity window and selected direction of motion are complied with) (see "Immediate switching option" on page 183).
- Selection of an SMM safety function from an active SMM safety function, when the option "Immediate switching within special mode "Safe motion"" had been configured in the parameter "P-0-3280.0.1, SMO: Configuration of operation mode transitions" and this is possible due to the system properties (selected velocity window and selected direction of motion are complied with) (see "Immediate switching option" on page 183).

Transition function "Safely-monitored deceleration in the case of error (based on actual velocity)"

When the transition function "Safely-monitored deceleration in the case of error (based on actual velocity)" (SMD-E) is selected by a safety technology error or a safety technology warning, the axis is decelerated in a drive-controlled way; i.e. the drive makes itself independent of the command value input of the control unit and is decelerated by the standard firmware in accordance with the parameterization in "P-0-3263.0.1, SMO: Configuration of stopping process". At the end of the deceleration process, drive enable is removed.

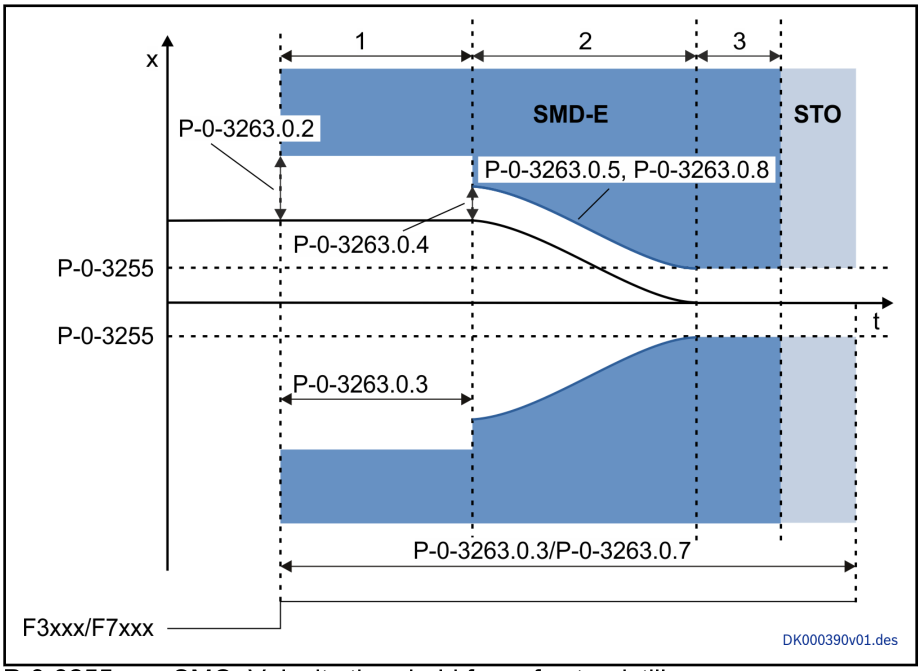
The "SMD-E" monitors via two channels whether the actual velocity is within the velocity envelope curve (P-0-3238). Using the deceleration ramp (P-0-3263.0.5) with jerk limitation [P-0-3263.0.8 (MPx-20V06 and above)], the drives generates the velocity envelope curve. The drive calculates the start value of the velocity envelope curve from the current actual velocity plus a tolerance (P-0-3263.0.2). When the actual velocity leaves the velocity envelope curve (P-0-3238), one of the following errors is signaled and the drive keeps being decelerated in accordance with the parameterized error reaction (P-0-3263.0.1) (see chapter "Error reaction / escalation strategy"):

- "SMD-E" in the case of F3 error: "F7051 Safely-monitored deceleration exceeded" or "F8351 Safely-monitored deceleration exceeded" (only when F3 reaction = F7 reaction, in P-0-3263.0.1)
- "SMD-E" in the case of F7 error: "F8351 Safely-monitored deceleration exceeded"

☞ If the monitoring limit of the "Safe maximum speed (SMS)" (P-0-3270.0.2) or of an active "Safely-limited speed (SLS)" (P-0-3290.x.2) is below the calculated velocity envelope curve (P-0-3238), the envelope curve acts as the monitoring limit. When the monitoring limit is violated, the corresponding safety function signals an error.

In parallel with velocity monitoring, the "SMD-E" also monitors that the transition process is completed within the parameterized transition time (P-0-3263.0.6 or P-0-3263.0.7). If the transition is not completed within the parameterized transition time, one of the following errors is signaled and the drive keeps being decelerated in accordance with the parameterized error reaction (P-0-3263.0.1) (see chapter "Error reaction / escalation strategy"):

- "SMD-E" in the case of F3 error: "F7050 Maximum transition time exceeded" or "F8350 Maximum transition time exceeded" (only when F3 reaction = F7 reaction, in P-0-3263.0.1)
- "SMD-E" in the case of F7 error: "F8350 Maximum transition time exceeded"



P-0-3255 SMO: Velocity threshold for safe standstill
P-0-3263.0.2 SMO: Oscillation velocity window of SMD-E
P-0-3263.0.3 SMO: SMD-E reaction time
P-0-3263.0.4 SMO: Velocity window of SMD-E
P-0-3263.0.5 SMO: SMD-E delay
P-0-3263.0.6 SMO: Error reaction F3 tolerance time
P-0-3263.0.7 SMO: Error reaction F7 tolerance time
P-0-3263.0.8 SMO: SMD-E jerk (MPx-20V06 and above)

Fig. 6-32: Transition function "Safely-monitored deceleration in the case of error (based on actual velocity)"

The velocity envelope curve consists of three sections and is generated as follows:

1. "Reaction time until the error reaction is initiated" (on the drive side) for the duration of P-0-3263.0.3:

   During the time parameterized in "P-0-3263.0.3, SMO: SMD-E reaction time", the safety technology allows the drive to adjust the command value input for the transition process. In this space of time, monitoring takes place to find out whether the actual velocity is within the velocity envelope curve (P-0-3238). The drive calculates the start value of the velocity envelope curve from the current actual velocity plus a tolerance (P-0-3263.0.2).

☞ This section of monitoring does not exist when the value "0" is parameterized in the parameter "P-0-3263.0.3, SMO: SMD reaction time".

☞ If the monitoring limit of the "Safe maximum speed (SMS)" (P-0-3270.0.2) or of an active "Safely-limited speed (SLS)" (P-0-3290.x.2) is below the calculated velocity envelope curve (P-0-3238), the envelope curve acts as the monitoring limit. When the monitoring limit is violated, the corresponding safety function signals an error.

2. "Monitoring of the transition to the "Safe standstill error"" using the deceleration ramp [P-0-3263.0.5 and P-0-3263.0.8 (MPx-20V06 and above)] until the "velocity window of Safe standstill" (P-0-3255) has been reached:

   In section 2, monitoring via two channels takes place to find out whether the actual velocity is within the velocity envelope curve (P-0-3238). Using the deceleration ramp (P-0-3263.0.5, SMO: SMD-E delay) and the jerk limitation [P-0-3263.0.8, SMO: SMD-E jerk(MPx-20V06 and above)], the drives generates the velocity envelope curve. The drive calculates the start value of the velocity envelope curve from the current actual velocity plus a tolerance (P-0-3263.0.4).

   If a jerk > "0" has been set in parameter "P-0-3263.0.8, SMO: SMD-E jerk", the deceleration ramp for limiting the jerk is filtered via a PT1 element. The time constant of the filter can be determined as follows:

   T_{PT1} = P-0-3263.0.5 / P-0-3263.0.8

☞ Via "P-0-3263.0.4, SMO: Velocity window of SMD-E" and "P-0-3263.0.8 SMO: SMD-E jerk" (MPx-20V06 and above), the transient oscillation of the velocity to the new target velocity is made possible.

☞ If the monitoring limit of the "Safe maximum speed (SMS)" (P-0-3270.0.2) or of an active "Safely-limited speed (SLS)" (P-0-3290.x.2) is below the calculated velocity envelope curve (P-0-3238), the envelope curve acts as the monitoring limit. When the monitoring limit is violated, the corresponding safety function signals an error.

3. "Monitoring of the "velocity window of Safe standstill"" until switching to "Safe standstill error" takes place:

   After the velocity envelope curve (P-0-3238) has reached the velocity window (P-0-3255, SMO: Velocity threshold for safe standstill), monitoring makes sure that the actual velocity is smaller than the velocity window until switching to "Safe standstill error" takes place.

The pertinent parameters can be used to adjust the monitoring function to many applications. This can be achieved mainly by P-0-3263.0.3 and P-0-3263.0.5.

☞ The transition to "Safe standstill error" is terminated ahead of time, when the drive has removed drive enable and the actual velocity is smaller than the parameterized velocity window (P-0-3255, SMO: Velocity threshold for safe standstill).

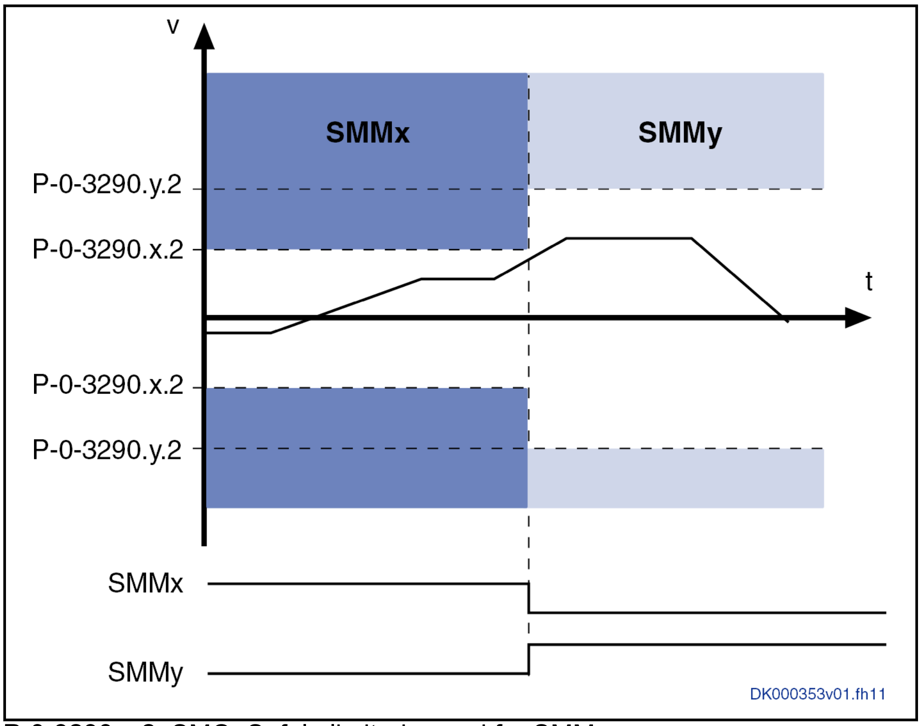
"Immediate switching" option

With the "immediate switching" option, the transition function SMD provides the user with the possibility of time-optimized switching when selecting a motion mode. As soon as the drive, due to the current system properties (parameterized monitoring function and monitoring limits, actual velocity), detects that immediate switching to the selected motion mode is possible, it performs immediate switching. This option can be separately enabled in the parameter "P-0-3280.0.1, SMO: Configuration of operation mode transitions" for changing between the motion modes and for changing from normal operation to a motion mode.

Immediate switching occurs when the following conditions have been fulfilled:

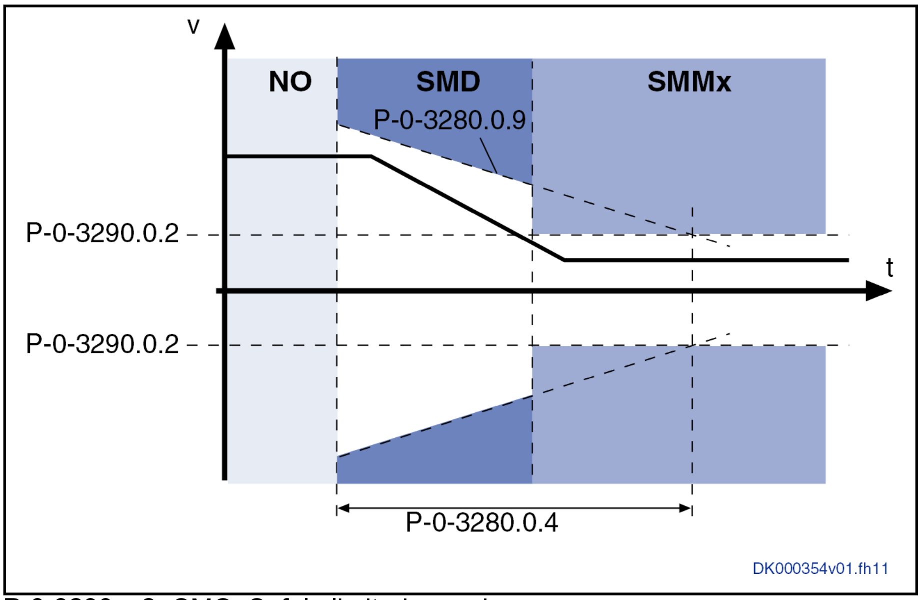
- The actual velocity is within the velocity window of the selected safety function **and**
- the monitoring of the direction of motion of the active safety function and of the selected safety function is identical or

  the selected safety function is without monitoring of the direction of motion.



P-0-3290.x.2 SMO: Safely-limited speed for SMMx
P-0-3290.y.2 SMO: Safely-limited speed for SMMy

Fig. 6-33: Immediate switching within the motion modes



P-0-3290.x.2 SMO: Safely-limited speed
P-0-3280.0.4 SMO: Max. transition time normal oper. to safe motion
P-0-3280.0.9 SMO: SMD delay

Fig. 6-34: Immediate switching from normal operation

Deselecting the transition function

An active transition function "Safely-monitored deceleration (SMD)" becomes inactive when the safety function is deselected via the active "Safe Motion" profile using the parameter "P-0-3264, SMO: Safety function selection".

☞ In the case of a drive-controlled operation mode transition, the started deceleration process is continued by the standard firmware, even if the safety function is deselected.

6.6 Additional or auxiliary functions

6.6.1 Safe parking axis

Brief description

The drive function "parking axis" can be used in conjunction with integrated safety technology, too. When this is done, it is possible to acknowledge the safety state at the diagnostic interfaces.

For a detailed description of the drive function "parking axis", see the Functional Description of the firmware.

Features

The safety function "Safe parking axis" has the following features:

- Is suited for safety-relevant applications up to Category 4, PL e according to EN ISO 13849-1 or up to SIL 3 according to IEC EN 62061.
- The safety function can be used in drive systems equipped with the optional safety technology modules "S3", "S4", "S5", "SB" or "SD".
- The output stage is locked via two channels for the duration of the parking axis.
- No encoder monitoring function is active for the safety function "Safe parking axis". This means that the monitoring functions for speed, acceleration and position are deactivated.
- Acknowledgment of safety with the corresponding result of the risk analysis.
- The state of the safety function "Safe parking axis" is displayed via parameter "P-0-3231, SMO: Operating status".

Pertinent parameters

The following parameters are used in conjunction with the safety function "Safe parking axis":

- P-0-3231.0.4, SMO: System configuration
- P-0-3231, SMO: Operating status
- P-0-3237, SMO: Status word
- P-0-3262, SMO: Selected operating status

Pertinent diagnostic messages

With safe parking axis activated, the display of the IndraDrive control panel shows "PA".

Safety function

Selecting the function

The safety function "Safe parking axis" is active after safety technology has been activated and the drive function "parking axis" has been selected. For how to proceed to activate the drive function "parking axis", see the Functional Description of the firmware.

Monitoring functions

With the safety function "Safe parking axis", the following monitoring functions are **deactivated**:

- Monitoring functions of the measuring systems

- Monitoring functions regarding speed, acceleration and position

☞ The missing speed information can be replaced via the control bit "defined safety with parked axis" in "P-0-3231.0.4, SMO: System configuration".

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

The control bit "defined safety with parked axis" in "P-0-3231.0.4, SMO: System configuration" signals safety which must result from the risk analysis. The risk analysis must show that the axis does not cause any danger to persons, when the axis has been parked. Using the function for axes with long coasting times (grinding wheels, spindles, rolls, ...) must be excluded.

Acknowledging safety

When the control bit "defined safety with parked axis" has been set in "P-0-3231.0.4, SMO: System configuration", the axis acknowledges safety with the safety function "Safe parking axis" having been activated (P-0-3237). Further safety acknowledgements in accordance with parameterization, e.g. via the local safe output pair, the safety zone bus etc.

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

The control bit "defined safety with parked axis" in "P-0-3231.0.4, SMO: System configuration" signals safety which must result from the risk analysis. The risk analysis must show that the axis does not cause any danger to persons, when the axis has been parked. Using the function for axes with long coasting times (grinding wheels, spindles, rolls, ...) must be excluded.

6.6.2 Limitation of the positioning velocity

Brief description

By means of the "limitation of the positioning velocity" function, it is possible, for drives equipped with the optional safety technology module "S3", "S4", "S5", "SB" or "SD", to activate an additional velocity limit value for the initial velocity of the operation mode.

Features

The "limitation of the positioning velocity" function has the following features:

- The function can be used in drive systems equipped with the optional safety technology module "S3", "S4", "S5", "SB" or "SD".
- The following operation modes / axis functions are supported:
  1. Drive-internal interpolation
  2. Drive-controlled positioning
  3. Positioning block mode
  4. Position spindle
  5. Establishing position data reference (relative measuring systems)

Pertinent parameters

The following parameters are used in conjunction with the "limitation of the positioning velocity" function:

- P-0-3218, SMO: Scaling factor for velocity limit value
- P-0-3219, SMO: Configuration of support functions
- P-0-3221.0.1, SMO: Polarity
- P-0-3223.0.1, SMO: Velocity data scaling type

- P-0-3223.0.2, SMO: Velocity data scaling exponent
- P-0-3238, SMO: Active velocity threshold
- S-0-0038, Positive velocity limit value
- S-0-0039, Negative velocity limit value
- S-0-0043, Velocity polarity parameter
- S-0-0044, Velocity data scaling type
- S-0-0045, Velocity data scaling factor
- S-0-0046, Velocity data scaling exponent
- S-0-0091, Bipolar velocity limit value

Pertinent diagnostic messages

With active limitation of the positioning velocity, the warning "E2049 Positioning velocity >= limit value" is output.

Function

How to use the function

By means of the "limitation of the positioning velocity" function, it is possible, for drives equipped with the optional safety technology module "S3", "S4", "S5", "SB" or "SD", to activate an additional velocity limit value for the initial velocity of the operation mode.

The function can be activated via P-0-3219, bit 0="1". It is only possible to activate the function if the scaling of the standard firmware and of the safety technology firmware is identical.

Scaling type: P-0-3223.0.1 = S-0-0044

Scaling factor: S-0-0045="1"

Scaling exponent: P-0-3223.0.2 = S-0-0046

Polarity: P-0-3221.0.1 = S-0-0043 (bit 0)

Monitoring functions

The limitation of the command velocity in the standard firmware is supposed to prevent the monitoring functions of "Safe Motion" from triggering. For this purpose, the active velocity threshold (P-0-3238) is read; the threshold and the weighting factor for the velocity limit value are used for calculation(P-0-3218: 0 .. 100%). The velocity limit value is determined as follows:

Velocity limit value = P-0-3238 × P-0-3218 / 100
Legend: P-0-3218, SMO: Scaling factor for velocity limit value P-0-3238, SMO: Active velocity threshold

Tab. 6-7: Calculating the velocity limit value

With the "limitation of the positioning velocity" function active, the velocity limit value is furthermore reduced by at least the velocity threshold for safe standstill (P-0-3255) compared to the active velocity threshold.

In addition, the limitation to the bipolar velocity limit value (S-0-0091) or S-0-0038/S-0-0039 is carried out.

With active limitation of the positioning velocity, the warning "E2049 Positioning velocity >= limit value" is output.

6.6.3 Safe homing procedure

Brief description

The Safe homing procedure by itself is not an independent safety function, but the basis of all safety functions with Safely-monitored absolute position!

To use the auxiliary function "Safe homing procedure", the standard firmware and "Safe Motion" have to feature the same position scaling, mechanics and encoder setting and position polarity.

The auxiliary safety technology function "Safe homing procedure" has to be carried out before selecting the following safety functions:

- "Safely-limited position (SLP)"
- "Safely-monitored position (SMP)"
- "Safely-limited end position (SLE)"
- "Safe CAM (SCA)"

The safe homing procedure is a homing procedure during normal operation with an additional home switch for safe determination of the reference position.

For absolute measuring systems, the Safe homing procedure has to be carried out, too.

Features

The auxiliary safety technology function "Safe homing procedure" has the following features:

- Is suited for safety-relevant applications up to Category 3, PL d according to EN ISO 13849-1 or up to SIL 2 according to IEC EN 62061.
- The safety function can be used in drive systems equipped with the optional safety technology module "S3", "S4", "S5", "SB" or "SD"

  AND

  equipped with the firmware option (FWS) "SIL3-MOTION" or "SIL3-PLUS".
- Is available with the firmware MPx-20V06 and above.
- Separate additional homing command for "Safe Motion" (C4000).
- According to the application requirements, the position data reference for "Safe Motion" can be established by a static or dynamic reference signal. The dynamic reference signal is optionally detected at a rising or a falling edge.
- Only single-channel design of the home switch required (can also be wired via non-safe inputs).
- No dynamization of the home switch.
- The position difference between the first and the second reference is monitored (P-0-3253.0.4).
- The Safe reference is lost in the "SCM" (SMO configuration mode) and "parking axis" operating states.
- The auxiliary safety technology function "Safe homing procedure" is the prerequisite of the safety functions "Safely-limited position (SLP)", "Safely-monitored position (SMP)", "Safely-limited end position (SLE)" and "Safe CAM (SCA)".

Pertinent parameters

The following parameters are used in conjunction with the auxiliary safety technology function "Safe homing procedure":

- P-0-3253, SMO: Safe homing procedure control word
- P-0-3253.0.1, SMO: Safe homing procedure configuration
- P-0-3253.0.2, SMO: C4000 Safe homing procedure command (Alias: P-0-2794)
- P-0-3253.0.3, SMO: Reference position
- P-0-3253.0.4, SMO: Safe homing procedure tolerance window
- P-0-3253.0.5, SMO: Maximum homing velocity
- P-0-3253.0.6, SMO: Reference check time interval
- P-0-3256, SMO: Encoder evaluation status
- P-0-3257, SMO: Position feedback value
- P-0-3257.0.1, SMO: Actual position value, coded
- P-0-3320, SMO: Safe Input Signals, safety zone module
- P-0-3322.0.1, SMO: Functional input signals, local
- P-0-3329, SMO: Functional input signals, drive
- P-0-3340, SMO: Safety bus control word
- S-0-0051, Position feedback value of encoder 1
- S-0-0052, Reference distance of encoder 1
- S-0-0053, Position feedback value of encoder 2
- S-0-0054, Reference distance of encoder 2
- S-0-0147, Homing parameter
- S-0-0148, C0600 Drive-controlled homing procedure command
- S-0-0150, Reference offset of encoder 1
- S-0-0151, Reference offset of encoder 2

Pertinent diagnostic messages

The following diagnostic messages can be generated in conjunction with the auxiliary safety technology function "Safe homing procedure":

- C0214 SMO: Incorrect configuration
- C8214 SMO: Incorrect configuration
- C4001 Encoder evaluation error during Safe homing procedure
- C4002 Incorrect SMO position feedback value
- C4003 Home switch distance below minimum value
- C4004 Faulty SMO reference signal
- E3112 Safe reference missing
- E3113 Prewarning: End of reference position check time interval
- F3112 Safe reference missing
- F3165 Faulty SMO reference signal
- F3166 Reference position check failed
- F3167 Encoder evaluation warning
- F7009 Homing velocity exceeded

Functional description

Basic function

Two diversitary references are required to establish Safe reference for "Safe Motion". First of all, the functional reference of the standard drive has to be established using the known mechanisms, or be already available ("set absolute position" with absolute encoders) (see Functional Description of firmware "Establishing the position data reference"). Afterwards, the functional reference is applied to "Safe Motion" within the scope of the command "C4000 SMO: Safe homing procedure command" (first reference) and validated with a second homing procedure (second reference).

The drive only remains safely homed as long as it is in the operating status "PM" or "OM" and not in the "parking axis" state. After a restart, an SMO encoder error or a change in the operating status to "SCM" or "parking axis", the Safe homing procedure has to be repeated.

The paragraphs below mainly describe the functionality of the second reference. For the functionality of the first reference, please see the Functional Description of firmware "Establishing the position data reference".

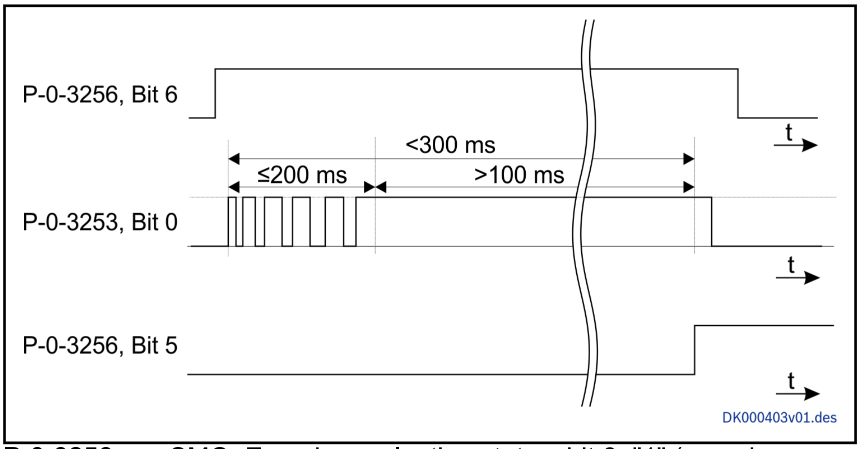
Selecting the reference signal for the second reference

When selecting the reference signal for the second reference, make sure that the second reference can detect an error made when the first reference had been established (functional reference for the standard drive). Therefore, the reference signal for the second reference has to have the following properties:

- **Spatially separated home switches:** It is not allowed to use one home switch for the first and second reference
- **Mechanical decoupling of the home switches:** The home switches of the first and second reference should not be mechanically coupled so that accidentally moving a home switch does not cause the second home switch to be moved
- **External reference signal:** The reference signal for the second reference should not be generated automatically and without an external event (e.g., mechanical switch or active operator action) in the control unit or the drive

According to the application requirements, the position data reference for the second reference can be established by a static or dynamic reference signal. The setting is made in "P-0-3253.0.1, SMO: Safe homing procedure configuration".

- "Static evaluation" means that to establish the position data reference, a high level in standstill (P-0-3256, SMO: Encoder evaluation status bit 6=1) is constantly expected at the home switch input for T>100 ms (within a maximum of 300 ms after the first edge has been detected) in "P-0-3253.0.3, SMO: Reference position".



P-0-3256, SMO: Encoder evaluation status, bit 6="1" (encoder standstill = standstill)
P-0-3253, SMO: Safe homing procedure control word, bit 0="1" (SMO reference signal = activated)
P-0-3256, SMO: Encoder evaluation status, bit 5="1" (status of SMO encoder position feedback value = safely homed)

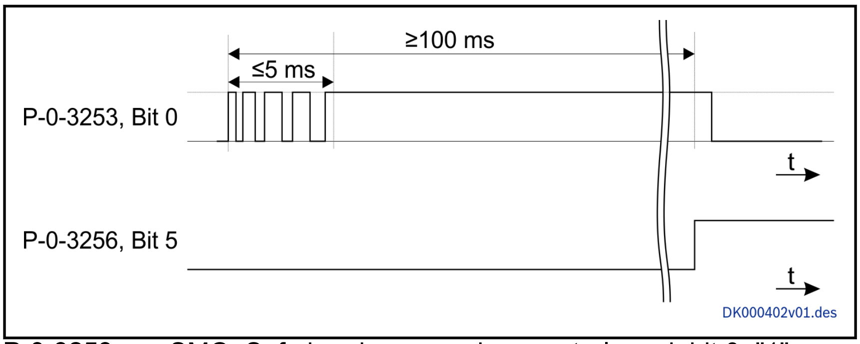
*Fig. 6-35: Evaluating a **static reference signal***

The evaluation of a **static reference signal** should be used if

– the start position of the first reference for moving to the first reference position is not unequivocally before or behind the second reference distance position and it is therefore only possible to position the drive unequivocally at this position, or

– the Safe reference is to be manually confirmed.

- "Dynamic evaluation" means that during a movement a defined edge is expected at the home switch input in "P-0-3253.0.3, SMO: Reference position" to establish the second position data reference. Afterwards, this edge has to be applied for T>95 ms with a constant level (the first 5 ms after the edge are not taken into account due to switch bouncing).



P-0-3253, SMO: Safe homing procedure control word, bit 0="1" (SMO reference signal = activated)
P-0-3256, SMO: Encoder evaluation status, bit 5="1" (status of SMO encoder position feedback value = safely homed)

*Fig. 6-36: Evaluating a **dynamic reference signal***

The evaluation of a **dynamic reference signal** should be used if it is possible to ensure, by moving to the reference mark of the first reference, that the reference position of the second reference is passed with a defined edge.

☞ Since the reference signal evaluation has a velocity and switch tolerance, the position data reference is adjusted to the position feedback value of the standard drive. During the adjustment a check is run to find out whether the difference of the position feedback values of the first and second reference is within the value parameterized in "P-0-3253.0.4, SMO: Safe homing procedure tolerance window".

If using the "dynamic evaluation" of the home switch for the second reference, make sure, when selecting the home switch and the homing velocity, that possible bouncing of the home switch contacts is < 5 ms and the reference pulse that is output is > 100 ms. Use the formula below to determine the minimum width of the home switch:

Home switch width > homing velocity × 100 ms

Tab. 6-8: Calculating the minimum width of the home switch for the second reference

Signal sources for the reference signal of the second reference

A single-channel, non-dynamized home switch is sufficient for the reference signal of the second reference. The reference signal can be read into Safe Motion in different ways. The table below shows the possible signal sources:

Signal source	Parameter for signal transmission	Safety technology option					Signal run time in the drive
		S3	SD	S4	S5	SB	
Standard input of drive	P-0-3329	✓	✓	✓	✓	✓	*In preparation*
Master communication	P-0-3329	✓	✓	✓	✓	✓	Not recommended as a signal source for the reference signal due to the long signal run times.
Safety zone module (HSZ)	P-0-3320	–	–	✓	✓	–	*In preparation*
Safety bus	P-0-3340	✓	✓	✓	✓	✓	Not recommended as a signal source for the reference signal due to the long signal run times.
Functional input of optional safety technology module (X41/X41.n/X141)	P-0-3322.0.1	✓	✓	✓	✓	–	*In preparation*

Tab. 6-9: Signal sources for the reference signal of the second reference

Using the "IO mapper inputs" of SMO, the signal source of the reference signal has to be assigned to the reference signal of the second reference (P-0-3253, SMO: Safe homing procedure control word). The signal source is assigned using the "functional connector" IO mapper block.

☞ When selecting the signal source of the reference signal for the second reference, its signal run time and the type of evaluation (dynamic or static home switch) have to be taken into account. It can have an effect on the accuracy of the safe reference and the required home switch width.

Establishing the position data reference for the second reference

☞ When using two encoders to be homed via the command "S-0-0148, C0600 Drive-controlled homing procedure command", it has to be noted that with the Safe homing procedure, the absolute position of the currently set reference encoder (S-0-0147, bit 3) will always be taken over as first reference into the Safe motion.

There are two options for establishing the position data reference for the second reference:

1. Via digital input or parameter, start the independent command "P-0-3253.0.2, SMO: C4000 Safe homing procedure command" and observe the points listed below:
   - The first reference already has to have been established (e.g., absolute encoder).
   - NC-controlled motion has to be carried out so that the selected dedicated point is "passed" (detected), since the drive does not carry out any independent motion during the execution of the command "P-0-3253.0.2, SMO: C4000 Safe homing procedure command".
2. Start "S-0-0148, C0600 Drive-controlled homing procedure command" and observe points listed belowt:
   - The command "S-0-0148, C0600 Drive-controlled homing procedure command" at the beginning internally also starts the command "P-0-3253.0.2, SMO: C4000 Safe homing procedure command" automatically, if this has been configured in "S-0-0147, Homing parameter".
   - The home switch for the second reference has to be mechanically mounted in such a way that it is actuated with the travel motion to be expected or during the concluding positioning. If this is not the case, the home switch has to be actuated by an NC-controlled motion.

☞ Using "P-0-3256, SMO: Encoder evaluation status" check whether the drive has been safely homed.

Monitoring functions

As long as the axis has not been safely homed, it may only be moved at velocities smaller than "P-0-3253.0.5, SMO: Maximum homing velocity". If this velocity threshold is exceeded, SMO generates the error "F7009 Homing velocity exceeded" and decelerates the axis.

☞ Axes with "safe reference" configured may not be operated more than 15 minutes without safe reference. After 15 minutes, the axis is switched off with the error "F3112 Safe reference missing". The error can be cleared and time monitoring is retriggered.

If a special mode is selected for which Safe absolute position monitoring has been configured, the error "F3112" is immediately generated and can only be cleared after the respective special mode was exited.

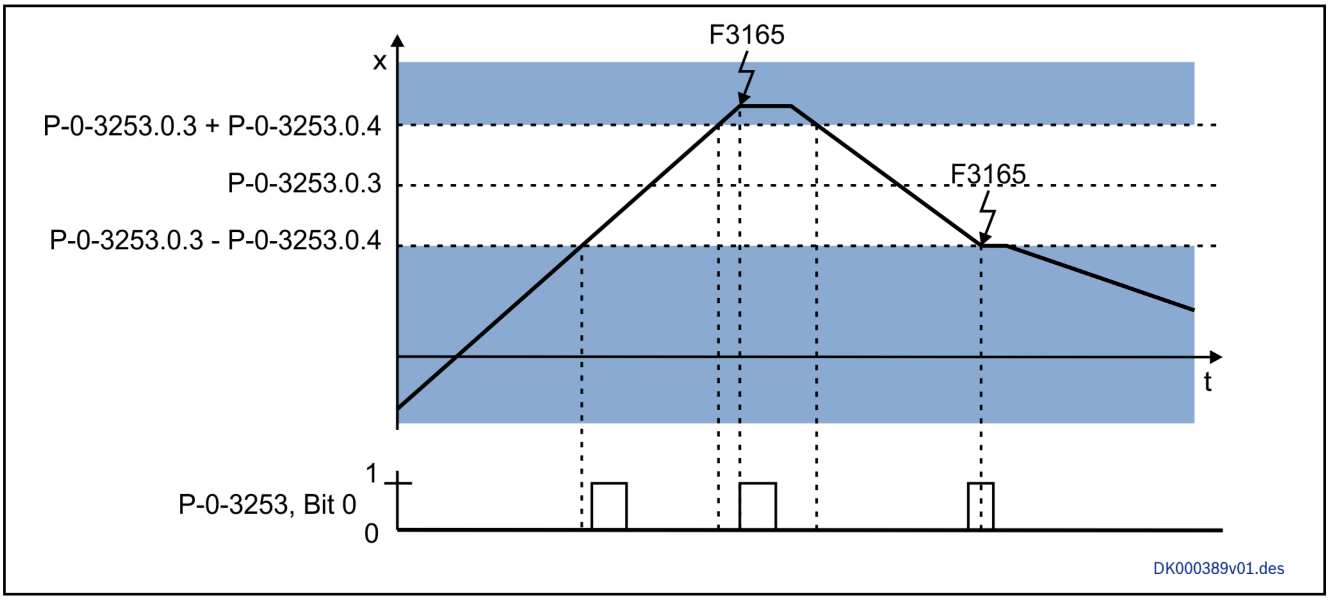
In "P-0-3253.0.1, SMO: Safe homing procedure configuration", the error message "F3112" can be reconfigured as the warning "E3112 Safe reference missing" for normal operation and the special mode (without absolute position monitoring).

If the axis has been safely homed, Safe Motion monitors whether the functional component of the drive detects a malfunction in the encoder evaluation of the encoder connected to X4 (X4.x/X104). The following warning messages cause SMO to react:

- E2074 Encoder 1: Encoder signals disturbed
- E2075 Encoder 2: Encoder signals disturbed
- E2076 Measuring encoder: Encoder signals disturbed
- E2077 Absolute encoder monitoring, encoder 1 (encoder alarm)
- E2078 Absolute encoder monitoring, opt. encoder (encoder alarm)
- E2079 Absolute enc. monitoring, measuring encoder (encoder alarm)

If one of these warning messages is generated, Safe Motion generates the error "F3167 Encoder evaluation warning" and clears the safe reference.

If the SMO reference signal is statically evaluated and safe reference has been established, monitoring takes place to find out whether the SMO reference signal is at high level although the SMO reference position is outside of the parameterized position window [reference position (P-0-3253.0.3) ±tolerance window (P-0-3253.0.4)]. In the case of error, "F3165 Faulty SMO reference signal" is generated and the safe reference is cleared.



P-0-3253 SMO: Safe homing procedure control word
P-0-3253.0.3 SMO: Reference position
P-0-3253.0.4 SMO: Safe homing procedure tolerance window

Fig. 6-37: Monitoring the reference signal of the second reference

In the case of applications for which the risk assessment shows that a creeping position offset can occur in operation during the generation of the absolute position (e.g., due to EMC interference or accumulation of dirt on the encoder code disk), a cyclic check of the safe reference can be configured. During the cyclic check of the safe reference, the safe reference is validated again in running operation as soon as the reference position of the second reference is passed. That is to say it is not necessary to activate a homing command (C0600 or C4000) for the check. The following conditions have to be fulfilled:

- The same criteria as for the safe homing procedure itself concerning the signal shape, signal duration and actual velocity apply during the cyclic check of the safe reference.
- The cyclic check was activated in "P-0-3253.0.1, SMO: Safe homing procedure configuration"
- The time interval for the cyclic check was configured in "P-0-3253.0.6, SMO: Reference check time interval"

If an error was detected during the cyclic check of the safe reference or no successful check was carried out within the time interval, SMO generates the error "F3166 Reference position check failed" and clears the safe reference.

Notes on commissioning

☞ The safe reference of Safe Motion maintained, even if the reference in the standard firmware is cleared or gets lost.

The paragraphs below describe typical commissioning sequences for different measuring systems. According to the mounting position of the home switches and the control unit used, there are up to three different commissioning sequences for each encoder type:

- Option 1: "drive-controlled"
  - The home switches are mounted in such a way that by carrying out drive-controlled homing for the first reference it can be ensured that the home switch for the second reference is passed from the correct side (dynamic evaluation) or the drive is positioned at it (static evaluation).
  - The control unit knows the command "S-0-0148, C0600 Drive-controlled homing procedure command".
- Option 2: "drive-/NC-controlled"
  - The home switches are mounted in such a way that by carrying out drive-controlled homing for the first reference it **cannot** be ensured that the home switch for the second reference is passed from the correct side (dynamic evaluation) or the drive is positioned at it (static evaluation).
  - The homing command of the control unit is extended by NC-controlled actuation of the home switch for the second reference.
- Option 3: "NC-controlled"
  - The homing of the first reference is completely carried out by the control unit (the travel motions, too), and the homed system is only transmitted to the drive.
  - The homing command of the control unit is extended by NC-controlled actuation of the home switch for the second reference.

Please see the diagram below for the commissioning example for the safe homing procedure that applies to your application:

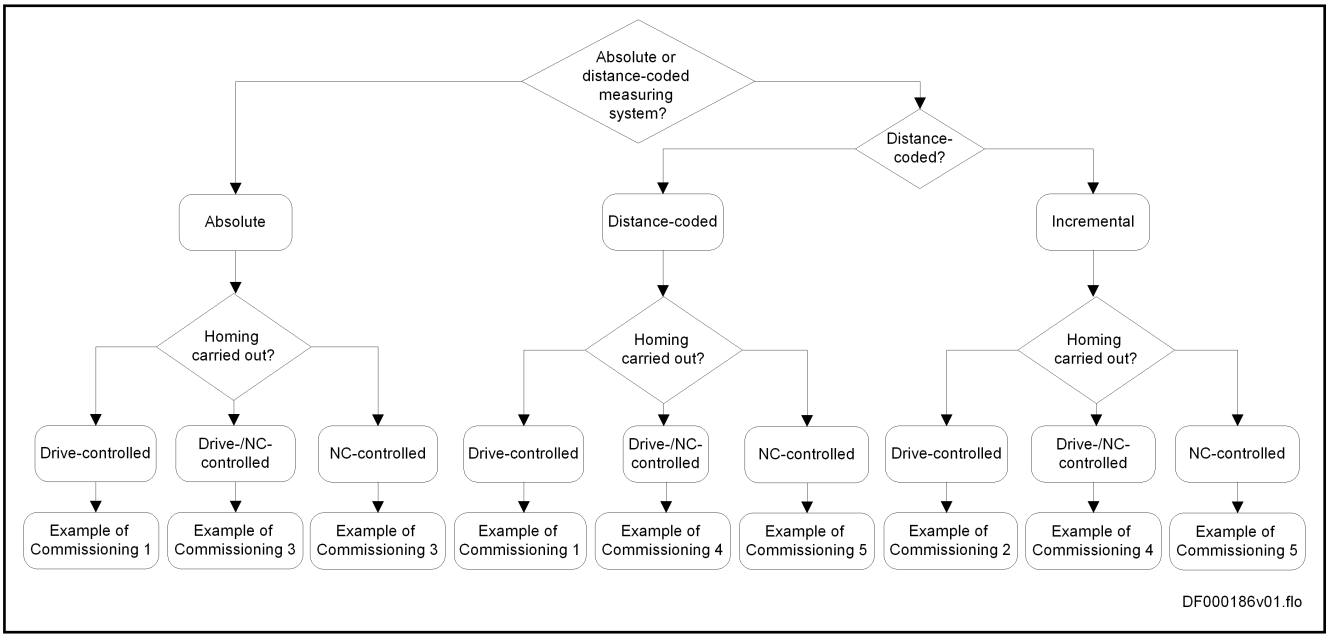


Fig. 6-38: Selection diagram for commissioning examples of Safe homing procedure

☞ In the descriptions below, the first reference always refers to the motor encoder. If an external encoder (encoder 2) or a measuring encoder has been plugged in interface 1 (or interface 2 for axis 2 with the CDB02.1 type control section) instead of the motor encoder (encoder 1), it is only necessary to replace the following parameters, the function remains as described:

- Position feedback value S-0-0051 replaced by S-0-0053 (encoder 2) or P-0-0052 (measuring encoder)
- Reference distance: S-0-0052 replaced by S-0-0054 (encoder 2)
- Reference offset: S-0-0150 replaced by S-0-0151 (encoder 2) or P-0-0087 (measuring encoder)

Commissioning example 1

Requirements

The following requirements have to have been fulfilled so that the safe reference can be established using the command "S-0-0148, C0600 Drive-controlled homing procedure command":

- The requirements for the functional homing procedure for the standard drive have been met (configuration completed, function successfully checked).
- An absolute or distance-coded measuring system is used.
- The home switch for the second reference is statically evaluated or manually operated.
- The home switch for the second reference is activated for at least 100 ms.

Presetting

The following parameter setting has to be made in the drive:

- "P-0-3253.0.1, SMO: Safe homing procedure configuration": Activate Safe homing procedure

- "P-0-3253.0.1, SMO: Safe homing procedure configuration": Set "SMO reference signal" to "Static evaluation"
- P-0-3253, SMO: Safe homing procedure control word: Assign signal source using "functional connector" in the IO mapper inputs
- P-0-3253.0.3, SMO: Reference position="S-0-0052, Reference distance of encoder 1" (or "S-0-0054, Reference distance of encoder 2")
- "P-0-3253.0.4, SMO: Safe homing procedure tolerance window": "Positioning accuracy at home switch +10%"
- P-0-3253.0.5, SMO: Maximum homing velocity: "Homing velocity +10%"
- "S-0-0147, Homing parameter": Position drive at the reference point at the end of homing procedure (S-0-0052 or S-0-0054)
- "S-0-0147, Homing parameter": Activate homing of safety technology in the command C0600

Implementation (chronological sequence)

Carry out the Safe homing procedure in the following order:

1. Start command " C0600 Drive-controlled homing procedure command"; the drive establishes the functional reference of the standard drive (first reference) and positions at reference distance [S-0-0052 (or S-0-0054)=P-0-3253.0.3].

☞ Errors during the Safe homing procedure are signaled as command error C400x. In the case of error, the command "P-0-3253.0.2, SMO: C4000 Safe homing procedure command" has to be terminated separately.

2. When the second reference position is reached, the reference signal either has to be triggered automatically using a mounted switch or by manual operation.
3. Complete command " C0600 Drive-controlled homing procedure command".

If the Safe homing procedure was successful, this is signaled in "P-0-3256, SMO: Encoder evaluation status" and the safety functions with Safely-monitored absolute position can be used.

☞ Any position errors of the size of the tolerance window (P-0-3253.0.4) will not be detected!

Commissioning example 2

Requirements

The following requirements have to have been fulfilled so that the safe reference can be established using the command "S-0-0148, C0600 Drive-controlled homing procedure command":

- The requirements for the functional homing procedure for the standard drive have been met (configuration completed, function successfully checked).
- An incremental measuring system is used.
- The home switch for the second reference is dynamically evaluated (without reference mark).
- The home switch for the second reference has to be situated on the way to reference point of the first reference.
- The home switch for the second reference is activated for at least 100 ms.

Home switch width > homing velocity × 100 ms

Tab. 6-10: Calculating the minimum width of the home switch for the second reference

- The distance between the reference point of the first and second reference has to be greater than twice the tolerance window ("P-0-3253.0.4, SMO: Safe homing procedure tolerance window")

|Reference 2 reference point - reference 1 reference point| > 2 × P-0-3253.0.4

Tab. 6-11: Calculating minimum distance between reference points for Safe homing procedure

Presetting

The following parameter setting has to be made in the drive:

- "P-0-3253.0.1, SMO: Safe homing procedure configuration": Activate Safe homing procedure
- "P-0-3253.0.1, SMO: Safe homing procedure configuration": Set "SMO reference signal" to "Dynamic evaluation" and select positive or negative "Edge evaluation"
- P-0-3253, SMO: Safe homing procedure control word: Assign signal source using "functional connector" in the IO mapper inputs
- "P-0-3253.0.3, SMO: Reference position": Enter home switch edge position of the second reference

Reference distance = reference 2 reference point - reference 1 reference point P-0-3253.0.3 = (S-0-0052) - (S-0-0150) - reference distance or P-0-3253.0.3 = (S-0-0054) - (S-0-0151) - reference distance
Legend: P-0-3253.0.3: SMO: Reference position S-0-0052: Reference distance of encoder 1 (or S-0-0054) S-0-0150: Reference offset of encoder 1 (or S-0-0151)

Tab. 6-12: Calculating "P-0-3253.0.3, SMO: Reference position"

- Adjust "P-0-3253.0.4, SMO: Safe homing procedure tolerance window" (value depends on delay of signals, as well as on homing velocity)

P-0-3253.0.4 > 2 × homing velocity × 1 ms

Tab. 6-13: Calculating the minimum value of "P-0-3253.0.4, SMO: Safe homing procedure tolerance window"

- P-0-3253.0.5, SMO: Maximum homing velocity: "Homing velocity +10%"
- "S-0-0147, Homing parameter": Activate "Evaluation of home switch"
- "S-0-0147, Homing parameter": Activate homing of safety technology in the command C0600

Implementation (chronological sequence)

Carry out the Safe homing procedure in the following order:

1. Start command " C0600 Drive-controlled homing procedure command"; the drive establishes the reference for the first reference (functional reference of the standard drive).

☞ Errors during the Safe homing procedure are signaled as command error C400x. In the case of error, the command "P-0-3253.0.2, SMO: C4000 Safe homing procedure command" has to be terminated separately.

2. During the concluding homing procedure, "Safe Motion" detects the edge of the home switch for the second reference.
3. Safe Motion checks whether the position feedback difference between the first and second reference is smaller than "P-0-3253.0.4, SMO: Safe homing procedure tolerance window".
4. Complete command " C0600 Drive-controlled homing procedure command".

If the Safe homing procedure was successful, this is signaled in "P-0-3256, SMO: Encoder evaluation status" and the safety functions with Safely-monitored absolute position can be used.

☞ Any position errors of the size of the tolerance window (P-0-3253.0.4) will not be detected!

Commissioning example 3

Requirements

The following requirements have to have been fulfilled so that the safe reference can be established using the command "P-0-3253.0.2, SMO: C4000 Safe homing procedure command":

- The requirements for the functional homing procedure for the standard drive have been met (configuration completed, function successfully checked).
- An absolute measuring system is used.
- A travel motion by the control unit has to be possible to establish the reference.
- The home switch for the second reference is evaluated dynamically or statically.
- The home switch for the second reference is activated for at least 100 ms.

Home switch width > homing velocity × 100 ms

Tab. 6-14: Calculating the minimum width of the home switch for the second reference

Presetting

The following parameter setting has to be made in the drive:

- "P-0-3253.0.1, SMO: Safe homing procedure configuration": Activate Safe homing procedure
- "P-0-3253.0.1, SMO: Safe homing procedure configuration": Evaluate home switch dynamically or statically and select corresponding edge evaluation in the case of dynamic evaluation
- P-0-3253, SMO: Safe homing procedure control word: Assign signal source using "functional connector" in the IO mapper inputs
- "P-0-3253.0.3, SMO: Reference position": Enter home switch position for the second reference
- "P-0-3253.0.4, SMO: Safe homing procedure tolerance window": Content depends on home switch evaluation type of the second reference:
  – **Static evaluation** of the home switch: Enter positioning accuracy at home switch +10%
  – **Dynamic evaluation** of the home switch: Adjust "P-0-3253.0.4, SMO: Safe homing procedure tolerance window" (value depends on delay of signals, as well as on homing velocity)

P-0-3253.0.4 > 2 × homing velocity × 1 ms

Tab. 6-15: Calculating the minimum value of "P-0-3253.0.4, SMO: Safe homing procedure tolerance window"

- P-0-3253.0.5, SMO: Maximum homing velocity: "Homing velocity +10%"

Implementation (chronological sequence)

Carry out the Safe homing procedure in the following order:

1. Establish the functional reference for the standard drive.
2. Start command " SMO: C4000 Safe homing procedure command".

   The control unit moves the drive to (static home switch evaluation) or beyond (dynamic home switch evaluation) the reference position for the second reference (P-0-3253.0.3).
3. In the case of manual operation of the home switch for the second reference, the reference signal has to be triggered when the drive is at the reference position for the second reference.
4. The drive checks whether the position feedback difference between the first and second reference is smaller than "P-0-3253.0.4, SMO: Safe homing procedure tolerance window".
5. Complete command " SMO: C4000 Safe homing procedure command".

If the Safe homing procedure was successful, this is signaled in "P-0-3256, SMO: Encoder evaluation status" and the safety functions with Safely-monitored absolute position can be used.

☞ Any position errors of the size of the tolerance window (P-0-3253.0.4) will not be detected!

Commissioning example 4

Requirements

The following requirements have to have been fulfilled so that the safe reference can be established in a drive-/NC-controlled way:

- The requirements for the functional homing procedure for the standard drive have been met (configuration completed, function successfully checked).
- An incremental or distance-coded measuring system is used.
- The position data reference for the first reference (functional reference of the standard drive) is established using the "drive-controlled homing procedure" (S-0-0148).
- A travel motion by the control unit has to be possible to establish the reference.
- The home switch for the second reference is evaluated dynamically or statically.
- The home switch for the second reference is activated for at least 100 ms.

Home switch width > homing velocity × 100 ms

Tab. 6-16: Calculating the minimum width of the home switch for the second reference

- If an incremental measuring system is used, the distance between the reference point of the first and second reference has to be greater than twice the tolerance window ("P-0-3253.0.4, SMO: Safe homing procedure tolerance window").

|Reference 2 reference point - reference 1 reference point| > 2 × P-0-3253.0.4

Tab. 6-17: Calculating minimum distance between reference points for Safe homing procedure

Presetting

The following parameter setting has to be made in the drive:

- "P-0-3253.0.1, SMO: Safe homing procedure configuration": Activate Safe homing procedure
- "P-0-3253.0.1, SMO: Safe homing procedure configuration": Evaluate home switch dynamically or statically and select corresponding edge evaluation in the case of dynamic evaluation
- P-0-3253, SMO: Safe homing procedure control word: Assign signal source using "functional connector" in the IO mapper inputs
- "P-0-3253.0.3, SMO: Reference position": Enter home switch edge position for the second reference When using an incremental encoder, calculate the position as follows:

Reference distance = reference 2 reference point - reference 1 reference point P-0-3253.0.3 = (S-0-0052) - (S-0-0150) - reference distance or P-0-3253.0.3 = (S-0-0054) - (S-0-0151) - reference distance
Legend: P-0-3253.0.3: SMO: Reference position S-0-0052: Reference distance of encoder 1 (or S-0-0054) S-0-0150: Reference offset of encoder 1 (or S-0-0151)

Tab. 6-18: Calculating "P-0-3253.0.3, SMO: Reference position"

- "P-0-3253.0.4, SMO: Safe homing procedure tolerance window": Content depends on whether home switch of the second reference is to be evaulated statically oder dynamically:
  - **Static evaluation** of the home switch: Enter positioning accuracy at home switch +10%
  - **Dynamic evaluation** of the home switch: Adjust "P-0-3253.0.4, SMO: Safe homing procedure tolerance window" (value depends on delay of signals, as well as on homing velocity)

P-0-3253.0.4 > 2 × homing velocity × 1 ms

Tab. 6-19: Calculating the minimum value of "P-0-3253.0.4, SMO: Safe homing procedure tolerance window"

- P-0-3253.0.5, SMO: Maximum homing velocity: "Homing velocity +10%"

Implementation (chronological sequence)

Carry out the Safe homing procedure in the following order:

1. Start command " C0600 Drive-controlled homing procedure command"; the drive establishes the reference for the first reference (functional reference of the standard drive).
2. Complete command " C0600 Drive-controlled homing procedure command".
3. Start command "C4000 SMO: Safe homing procedure command".
4. The control unit moves the drive to (static home switch evaluation) or beyond (dynamic home switch evaluation) the reference position for the second reference (P-0-3253.0.3).

5. In the case of manual operation of the home switch for the second reference, the reference signal has to be triggered when the drive is at the reference position for the second reference.
6. Safe Motion checks whether the position feedback difference between the first and second reference is smaller than "P-0-3253.0.4, SMO: Safe homing procedure tolerance window".
7. Complete command "C4000 SMO: Safe homing procedure command".

If the Safe homing procedure was successful, this is signaled in "P-0-3256, SMO: Encoder evaluation status" and the safety functions with Safely-monitored absolute position can be used.

☞ Any position errors of the size of the tolerance window (P-0-3253.0.4) will not be detected!

Commissioning example 5

Requirements

The following requirements have to have been fulfilled so that the safe reference can be established using the command "P-0-3253.0.2, SMO: C4000 Safe homing procedure command":

- The requirements for the functional homing procedure for the standard drive have been met (configuration completed, function successfully checked).
- An incremental or distance-coded measuring system is used.
- The position data reference for the first reference (functional reference of the standard drive) is established using the NC-controlled homing procedure.
- An additional travel motion by the control unit has to be possible to establish the reference for the second reference.
- The home switch for the second reference is evaluated dynamically or statically.
- The home switch for the second reference is activated for at least 100 ms.

Home switch width > homing velocity × 100 ms

Tab. 6-20: Calculating the minimum width of the home switch for the second reference

- If an incremental measuring system is used, the distance between the reference point of the first and second reference has to be greater than twice the tolerance window ("P-0-3253.0.4, SMO: Safe homing procedure tolerance window")

|Reference 2 reference point - reference 1 reference point| > 2 × P-0-3253.0.4

Tab. 6-21: Calculating minimum distance between reference points for Safe homing procedure

Presetting

The following parameter setting has to be made in the drive:

- "P-0-3253.0.1, SMO: Safe homing procedure configuration": Activate Safe homing procedure
- "P-0-3253.0.1, SMO: Safe homing procedure configuration": Evaluate home switch dynamically or statically and select corresponding edge evaluation in the case of dynamic evaluation
- P-0-3253, SMO: Safe homing procedure control word: Assign signal source using "functional connector" in the IO mapper inputs

- "P-0-3253.0.4, SMO: Safe homing procedure tolerance window": Content depends on home switch evaluation type of the second reference:
  – **Static evaluation** of the home switch: Enter positioning accuracy at home switch +10%
  – **Dynamic evaluation** of the home switch: Adjust "P-0-3253.0.4, SMO: Safe homing procedure tolerance window" (value depends on delay of signals, as well as on homing velocity)

P-0-3253.0.4 > 2 × homing velocity × 1 ms

Tab. 6-22: Calculating the minimum value of "P-0-3253.0.4, SMO: Safe homing procedure tolerance window"

- P-0-3253.0.5, SMO: Maximum homing velocity: "Homing velocity +10%"
- "P-0-3253.0.3, SMO: Reference position": Enter home switch position for the second reference. When using an incremental encoder, calculate the position as follows:

Reference distance = reference 2 reference point - reference 1 reference point P-0-3253.0.3 = (S-0-0052) - (S-0-0150) - reference distance or P-0-3253.0.3 = (S-0-0054) - (S-0-0151) - reference distance
Legend: P-0-3253.0.3: SMO: Reference position S-0-0052: Reference distance of encoder 1 (or S-0-0054) S-0-0150: Reference offset of encoder 1 (or S-0-0151)

Tab. 6-23: Calculating "P-0-3253.0.3, SMO: Reference position"

Implementation (chronological sequence)

Carry out the Safe homing procedure in the following order:

1. Establish the functional reference for the standard drive.
2. Start command " SMO: C4000 Safe homing procedure command".

   The control unit moves the drive to (static home switch evaluation) or beyond (dynamic home switch evaluation) the reference position for the second reference (P-0-3253.0.3).
3. In the case of manual operation of the home switch for the second reference, the reference signal has to be triggered when the drive is at the reference position for the second reference.
4. The drive checks whether the position feedback difference between the first and second reference is smaller than "P-0-3253.0.4, SMO: Safe homing procedure tolerance window".
5. Complete command " SMO: C4000 Safe homing procedure command".

If the Safe homing procedure was successful, this is signaled in "P-0-3256, SMO: Encoder evaluation status" and the safety functions with Safely-monitored absolute position can be used.

☞ Any position errors of the size of the tolerance window (P-0-3253.0.4) will not be detected!

7 Selection/acknowledgment

7.1 General

"Selection" basically is the "activation" of safety functions that were parameterized and configured during commissioning.

The firmware supports the selection of the following options:

- Single-channel "discrete selection" via safe digital inputs of the safety zone module "HSZ01" (not for IndraDrive Mi) with fault exclusion
- Dual-channel "discrete selection" via safe digital inputs of the safety zone module "HSZ01" (not for IndraDrive Mi)
- Safe selection via the "safety bus". Different types of safe transmission protocols are available:
  - CSoS CIP Safety on sercos (from MPx18VRS)
  - FSoE FailSafe over EtherCat (from MPx20V04)
  - PROFIsafe for Master communication via PROFINET (from MPx20V12)
- Parallel safe selection via "discrete selection" and the "safety bus" (not for IndraDrive Mi)

☞ The available safety functions are independent of the interface used.

The firmware supports the following options for safety-related feedback:

- Dual-channel "discrete acknowledgment" via safe digital outputs of the safety zone module "HSZ01" (not for IndraDrive Mi)
- Dual-channel "discrete acknowledgment" via the safe digital output of the optional safety technology module
- Safe acknowledgment via the "safety bus". Different types of safe transmission protocols are available:
  - CSoS CIP Safety on sercos (from MPx18VRS)
  - FSoE FailSafe over EtherCat (from MPx20V04)
  - PROFIsafe for Master communication via PROFINET (from MPx20V12)
- Parallel safe acknowledgment via "discrete acknowledgment" and the "safety bus" (not for IndraDrive Mi)
- Single-channel, non-safe acknowledgment via the digital outputs of the axis
- Single-channel, non-safe acknowledgment via the master communication of the axis

7.2 Discrete selection and acknowledgment

7.2.1 Brief description

Besides the selection and acknowledgment via the safety bus communication, the integrated safety technology in the "Safe Motion" characteristic supports the discrete selection and acknowledgment via digital inputs and outputs. The safe selection can be made either via "one channel" (with fault exclusion for the discrete wiring) or via "two channels".

Selection/acknowledgment

☞ In the case of discrete selection and acknowledgment, make sure that the wiring and the safety unit, which generates the selection, comply at least with the safety level required for the application.

Pertinent parameters

The following parameters are used in conjunction with the "discrete selection and acknowledgment":

- P-0-3320, SMO: Safe Input Signals, safety zone module
- P-0-3320.0.2, SMO: Configuration Input Signals, safety zone module
- P-0-3322.0.1, SMO: Functional input signals, local
- P-0-3323, SMO: Safe output signals, local
- P-0-3231, SMO: Operating status
- P-0-3237, SMO: Status word
- P-0-3256, SMO: Encoder evaluation status
- P-0-3261, SMO: State machine control word
- P-0-3265.0.2, SMO: Control word of safe braking and holding function

Pertinent diagnostic messages

The following diagnostic messages can be generated in conjunction with the "discrete selection and acknowledgment":

- F3153 Safety zone module: SZE/SZA error
- F3360 SMO: Local I/O system error

7.2.2 Functional principle

Definition

Safe Motion supports the following types of wiring and selection via digital inputs:

Dual-channel selection

Dual-channel selection means that Safe Motion reads in the selection signals via two digital inputs and from these two signals internally generates one safe selection signal. The wiring between the sensor required for the selection and the two digital inputs can be implemented as a "single-channel wiring" (with fault exclusion for the discrete wiring) or as a "dual-channel wiring". The two figures below illustrate the wiring types in schematic form.

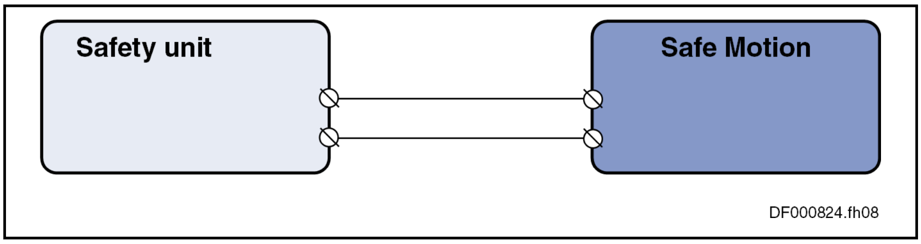


*Fig. 7-1: Dual-channel selection with **dual-channel** wiring*

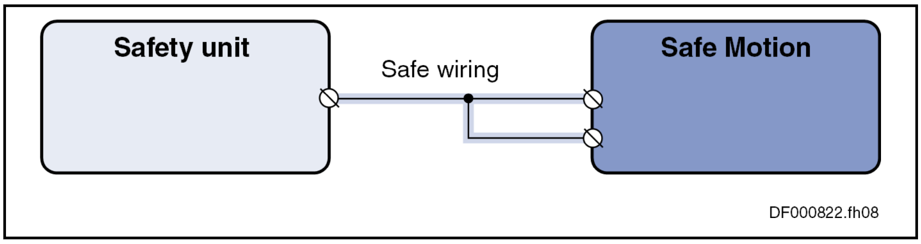


*Fig. 7-2: Dual-channel selection with **single-channel** wiring*

When "single-channel wiring" is used to select Safe Motion, the following **fault exclusion** is required:

The accidental deactivation of the safety function by short circuits with other potentials must be excluded (see EN 61800-5-2, table D.1). (Due to the isolated inputs and possible potential shifts of the 24 V systems, the contact of the selection channel with ground might cause a selection.)

If it is possible from a technical point of view, the dual-channel wiring must be preferred to the single-channel wiring with fault exclusion.

The selection signals can be generated by active or passive safety units (see chapter "Dynamization").

In the case of dual-channel wiring, the two selection channels must be separately dynamized. Only in this way is it possible to detect short circuit between the two channels.

Single-channel selection

Single-channel selection means that Safe Motion reads in the safe selection signals via one digital input and processes them. The wiring between the sensor required for the selection and the digital input is to be implemented as a "single-channel wiring" [with fault exclusion for the discrete wiring (see following note)]. The figure below illustrates the wiring type in schematic form.

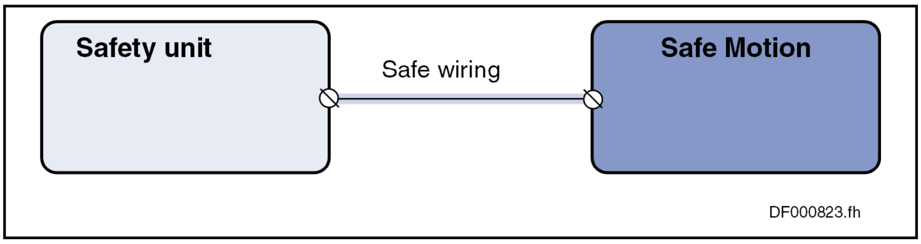


Fig. 7-3: Single-channel selection with single-channel wiring

When "single-channel wiring" is used to select Safe Motion, the following **fault exclusion** is required:

The accidental deactivation of the safety function by short circuits with other potentials must be excluded (see EN 61800-5-2, table D.1). (Due to the isolated inputs and possible potential shifts of the 24 V systems, the contact of the selection channel with ground might cause a selection.)

If it is possible from a technical point of view, the dual-channel wiring must be preferred to the single-channel wiring with fault exclusion.

The selection signals can be generated by active or passive safety units (see chapter "Dynamization"). When the single-channel selection is used, a longer reaction time of the selection evaluation is to be expected (see chapter "Performance").

Discrete selection via the safety zone module "HSZ01"

The IndraDrive Mi system does not support the discrete selection and acknowledgment via an "HSZ01" safety zone module.

Selection/acknowledgment

The safety functions of Safe Motion can be selected via the safe inputs of the safety zone module "HSZ01". For this purpose, the safety zone module "HSZ01" has to be connected to the axes of the safety zones via the zone bus (X42, X43) [see "Safety zone acknowledge (SZA)"]. With the "HSZ01" safety zone module it is possible to set up a safety zone with a maximum of 35 axes.

The "HSZ01" safety zone module makes available 2 × 8 digital inputs for dual-channel collective selection, or 16 inputs for single-channel selection of the safety zone. When the safety technology is commissioned, it is necessary to configure, in each zone node via the parameter "P-0-3320.0.2, SMO: Configuration Input Signals, safety zone module", whether the corresponding input pair is to be used as one dual-channel input or as two single-channel inputs.

When an input pair has been configured as one **dual-channel input**, the safety functions of Safe Motion can be safely selected via two channels. The wiring leading to the input pair can be implemented either as a "single-channel wiring" (with fault exclusion) or as a "dual-channel wiring". The dual-channel wiring is suited for safety-relevant applications up to Category 4, PL e according to EN ISO 13849-1 or up to SIL 3 according to IEC EN 62061. The selection is made by applying a low level at both inputs, deselection is made accordingly by a high level at both inputs. The tolerance time for unequal input states of an input pair is 1 second.

☞ In the case of dual-channel selection and more than one input pair, make sure that short circuit between two lines with the same dynamization source can be excluded.

When an input pair has been configured as two **single-channel inputs**, the safety functions of Safe Motion can be safely selected via one channel. The wiring leading to the input pair is implemented as a "single-channel wiring" (with fault exclusion). The single-channel wiring is suited for safety-relevant applications up to Category 3, PL d according to EN ISO 13849-1 or up to SIL 2 according to IEC EN 62061. The selection is made by applying a low level at both inputs, deselection is made accordingly by a high level at both inputs.

Discrete selection via the optional safety technology module

☞ In the firmware version MPx-18VRS, only the safe discrete selection via the safety zone module "HSZ01" is supported. The available digital inputs of the axis and of the optional safety technology modules "S3" and "S4" cannot be evaluated in a safety-relevant way (only in a mere functional way).

The optional safety technology modules "S3", "S4", "S5" and "SD" have two functional inputs [X41 (S4, S5) and/or X141 (S3, SD)]. These inputs can be read and assigned to individual networks via the parameter "P-0-3322.0.1, SMO: Functional input signals, local" in the "IO mapper inputs".

Discrete acknowledgment via the safety zone module "HSZ01"

☞ The IndraDrive Mi system does not support the discrete selection and acknowledgment via an "HSZ01" safety zone module.

The safety zone module "HSZ01" makes available dual-channel outputs (output pairs) for safe acknowledgment of the zone state. The outputs of the safety zone module are controlled by the zone master. There are three output pairs that have a fixed assignment to the corresponding safety functions of the safety zone:

- Safety zone acknowledge (SZA)

- Safe zone error (SZE)
- Safe door locking (SDL)

For information on how to configure the outputs, see the respective descriptions of the safety functions.

The zone state is safely acknowledged by a high signal on both outputs of the output pair. When one or both outputs have a low signal, the zone state is not acknowledged. The output pairs always have to be wired via two channels. Single-channel wiring is only allowed for diagnostic purposes (no safe acknowledgment). In addition, a 0 V reference always has to be established between the safety zone module and the target (e.g., a safety PLC).

The safe outputs are suited for safety-relevant applications up to Category 4, PL e according to EN ISO 13849-1 or up to SIL 3 according to IEC EN 62061.

Discrete acknowledgment via the optional safety technology module

The optional safety technology module makes available a dual-channel output [X41 (S4, S5) or X141 (S3, SD)] for safe acknowledgment of safety technology states. Different status bits of Safe Motion can be assigned to the output via the "signal control of outputs". The safe acknowledgment of the safety technology state (e.g., safe state of the axis, status of the safety function, …) is effected by a high signal on both outputs of the output pair. When one output or both outputs have a low signal, the safe state is not acknowledged. The output pairs always have to be wired via two channels. Single-channel wiring is only allowed for diagnostic purposes (no safe acknowledgment).

The safe local output is suited for safety-relevant applications up to Category 4, PL e according to EN ISO 13849-1 or up to SIL 3 according to IEC EN 62061.

7.3 Safety bus communication

7.3.1 Brief description

Besides the discrete selection and acknowledgment, the integrated safety technology in the "Safe Motion" characteristic supports the selection and acknowledgment of the safety functions via safe channels of master communication (Safety bus communication). For this purpose, the standard protocol of the respective master communication is extended by a safe protocol. Thus, safe information can be transmitted to and from a safety master, besides the standard communication.

Features

- The safety technology operating states of the active "Safe Motion" profile can be selected via the Safety bus communication.
- Direct selection (in parallel with the Safety bus communication) is possible.
- The following safe protocols are supported:
  - CSoS CIP Safety on sercos (MPx18VRS and above)
  - FSoE FailSafe over EtherCat (MPx20V04 and above)
  - PROFIsafe for master communication via PROFINET (MPx20V12 and above)
- The signals of the Safety bus communication are not freely configurable. Only permanently predefined configurations can be used.

Selection/acknowledgment

> Only one control word and one status word with their signals being defined by the predefined configurations can be transmitted via the Safety bus communication (see "Predefined configurations"). Other process data, such as safe position feedback values, are not available.

> In the firmware version MPx18VRS, safe communication via "CIP Safety on sercos" is automatically carried out when activating the Safety bus communication via "P-0-3345, SMO: Safety bus configuration"
>
> With the firmware version MPx20VR and above, the type of bus communication has to be selected in "P-0-3345, SMO: Safety bus configuration".

Pertinent parameters

The following parameters are used in conjunction with the "Safety bus communication":

- P-0-3231, SMO: Operating status
- P-0-3237, SMO: Status word
- P-0-3256, SMO: Encoder evaluation status
- P-0-3261, SMO: State machine control word
- P-0-3265.0.2, SMO: Control word of safe braking and holding function
- P-0-3323, SMO: Safe output signals, local
- P-0-3340, SMO: Safety bus control word
- P-0-3340.0.1, SMO: Mask of control word, safety bus
- P-0-3341, SMO: Safety bus status word
- P-0-3342, SMO: Status of consuming connection, safety bus
- P-0-3342.0.1, SMO: Configuration of consuming connection, safety bus
- P-0-3342.0.2, SMO: Consuming connection configuration list, safety bus
- P-0-3343, SMO: Status of producing connection, safety bus
- P-0-3343.0.1, SMO: Configuration of producing connection, safety bus
- P-0-3343.0.2, SMO: Producing connection configuration list, safety bus
- P-0-3345, SMO: Safety bus configuration

Pertinent diagnostic messages

The following diagnostic messages can be generated in conjunction with the "Safety bus communication":

- F3000 CRC error during safe cyclic transmission
- F3001 Time error during safe cyclic transmission
- F3002 Protocol error during safe cyclic transmission
- F3003 Safe communication: Error in internal data transfer
- F3004 Safe communication: Error in data management
- F3005 Safe communication: Error while conn. established/terminated
- F3006 Data management error of the individual assemblies

7.3.2 Functional principle

To use the Safety bus communication, it has to be activated during commissioning (P-0-3345). The safe protocol (CIP Safety on sercos, FSoE, PROFIsafe) for safe communication is determined upon activation.

Selection/acknowledgment

The Safety bus communication can only be activated/deactivated in the "SMO configuration mode (SCM)".

Establishing a connection is possible in the "SMO parameter mode (SPM)" and in the "SMO operating mode (SOM)".

The current status of the connection can be read using "P-0-3342, SMO: Status of consuming connection, safety bus" and "P-0-3343, SMO: Status of producing connection, safety bus".

The Safety bus communication only supports one consumer connection and one producer connection per drive. The active predefined configuration defines which data are transmitted via these connections (see "Predefined configurations"). The content and use of the predefined configurations are **independent** of the master communication and the safety protocol via and with which the data are transmitted.

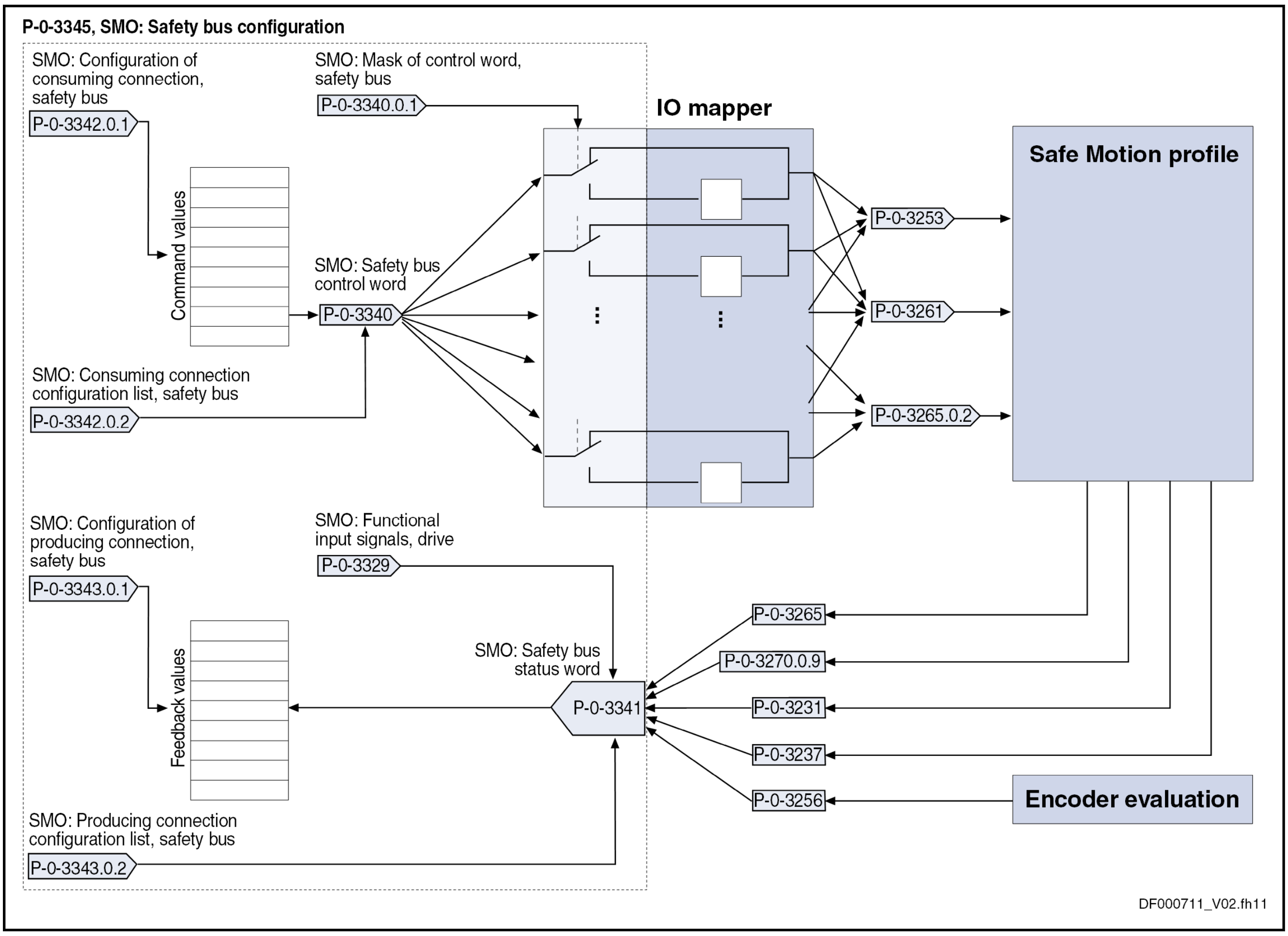


Fig. 7-4: Safety bus communication

The data of the **consumer connections** are transmitted to the inputs of the "IO mapper inputs" via P-0-3340. As a standard, the IO mapper blocks are configured as "Safe connectors" (or "binary-to-bit decoder" for binary-coded signals) in the networks of the "IO mapper inputs", when the Safety bus communication has been activated. In accordance with the predefined configuration, the bits of the control parameters are mapped for the "Safe Motion" profile (P-0-3261 and P-0-3265.0.2).

If discrete selection signals (e.g., from the safety zone module) are to be evaluated in parallel with the Safety bus communication, the corresponding bit in the predefined configuration of the consumer connections can be masked via the parameter "P-0-3340.0.1, SMO: Mask of control word, safety bus". Due to the masking, the IO mapper block can be freely configured again in the corresponding network. Thus, other signals can be processed in the network.

☞ The function block type "Safe connector" (or "binary-to-bit decoder" for binary-coded signals) is permanently assigned to all networks that are not masked via P-0-3340.0.1.

Binary-coded signals have to be masked completely. It is not allowed to mask individual bits in this case!

Depending on the active predefined configuration, the data for the **producer connection** are copied from the corresponding status parameters for encoder evaluation (P-0-3256) and for the "Safe Motion" profile (P-0-3231 and P-0-3237), and are transmitted directly to the corresponding bit in P-0-3341.

7.3.3 Predefined configurations

Introduction

For the Safety bus communication, 6 predefined configurations for the consumer connection and 7 predefined configurations for the producer connection have been defined. A predefined configuration defines the signal assembly to be transmitted using the Safety bus communication and their default connection via target and/or source parameters with the Safe motion profile. The possible predefined configurations are made available to the control unit via the device data sheet. (The format of the device data sheet varies according to the type of bus communication: SDDML for "CIP Safety on sercos" XML for "FailSafe over EtherCAT", GSDML for "PROFIsafe".) Free signal assembly is not possible. The paragraphs below describe the predefined configurations supported by "Safe Motion".

☞ Restriction for FSoE and PROFIsafe:

In the firmware version MPx20VRS, the consumer and producer connection are combined in a fixed profile.

Predefined configurations for consumer connections

The predefined configuration of the consumer connection is to be determined in P-0-3342.0.1 with the type number.

Selection/acknowledgment

Type number		Mode selection signal (MS)	EMERGENCY STOP (SMES)	Enabling control signal (EC)	Number of SMM	SMM coding	Brake control	SMO reference signal[1)]	Functional output
Decimal	Hexadecimal								
778	0x030A	✓	✓	✓	4	Bit-coded			✓
779	0x030B	✓	✓	✓	8	Binary-coded	✓		✓
780	0x030C	✓	✓	✓	12	Bit-coded			✓
781	0x030D	✓	✓	✓	16	Binary-coded	✓		✓
786	0x0312	✓	✓	✓	10	Bit-coded		✓	✓
787	0x0313	✓	✓	✓	16	Binary-coded	✓	✓	✓

1) With MPx-20 and above

Tab. 7-1: Signals of the predefined configurations for consumer connections

Type number 778: "1-byte SMO control word, bit-coded SMM (778)"			
Configuration		Target assignment	
Bit	Name	IDN, bit number	Signal name
0	ModeSelectionSignal	P-0-3261, bit 0	Mode selection signal (MS)
1	EmergencyStopSignal	P-0-3261, bit 1	Emergency stop signal (SMES)
2	EnablingControl	P-0-3261, bit 2	Enabling control signal (EC)
3	SMM1Signal	P-0-3261, bit 3	SMM1 signal (A_SMM1)
4	SMM2Signal	P-0-3261, bit 4	SMM2 signal (A_SMM2)
5	SMM3Signal	P-0-3261, bit 5	SMM3 signal (A_SMM3)
6	SMM4Signal	P-0-3261, bit 6	SMM4 signal (A_SMM4)
7	SafeOutput_local	P-0-3323, bit 0	Safe output at local interface

Selection/acknowledgment

Type number 779: "1-byte SMO control word, binary-coded SMM (779)"			
Configuration		Target assignment	
Bit	Name	IDN, bit number	Signal name
0	ModeSelectionSignal	P-0-3261, bit 0	Mode selection signal (MS)
1	EmergencyStopSignal	P-0-3261, bit 1	Emergency stop signal (SMES)
2	EnablingControl	P-0-3261, bit 2	Enabling control signal (EC)
3	SMM1Signal_coded[1)]	P-0-3261, bit 3..10	SMM1 signal (A_SMM1)...SMM8 signal (A_SMM8)
4	SMM2Signal_coded[1)]		
5	SMM3Signal_coded[1)]		
6	ReleaseBrake	P-0-3265.0.2, bit 0	Release holding brake
7	SafeOutput_local	P-0-3323, bit 0	Safe output at local interface

1) The signals are binary-coded, i.e. instead of the bit being directly converted in the control word to the target parameter via the IO mapper block "Safe connector", the binary-coded selection bits are decoded using the IO mapper block "binary-to-bit decoder".

Type number 780: "2-byte SMO control word, bit-coded SMM (780)"				
Configuration			Target assignment	
Byte	Bit	Name	IDN, bit number	Signal name
0	0	ModeSelectionSignal	P-0-3261, bit 0	Mode selection signal (MS)
	1	EmergencyStopSignal	P-0-3261, bit 1	Emergency stop signal (SMES)
	2	EnablingControl	P-0-3261, bit 2	Enabling control signal (EC)
	3	SMM1Signal	P-0-3261, bit 3	SMM1 signal (A_SMM1)
	4	SMM2Signal	P-0-3261, bit 4	SMM2 signal (A_SMM2)
	5	SMM3Signal	P-0-3261, bit 5	SMM3 signal (A_SMM3)
	6	SMM4Signal	P-0-3261, bit 6	SMM4 signal (A_SMM4)
	7	SMM5Signal	P-0-3261, bit 7	SMM5 signal (A_SMM5)
1	0	SMM6Signal	P-0-3261, bit 8	SMM6 signal (A_SMM6)
	1	SMM7Signal	P-0-3261, bit 9	SMM7 signal (A_SMM7)
	2	SMM8Signal	P-0-3261, bit 10	SMM8 signal (A_SMM8)
	3	SMM9Signal	P-0-3261, bit 11	SMM9 signal (A_SMM9)
	4	SMM10Signal	P-0-3261, bit 12	SMM10 signal (A_SMM10)
	5	SMM11Signal	P-0-3261, bit 13	SMM11 signal (A_SMM11)
	6	SMM12Signal	P-0-3261, bit 14	SMM12 signal (A_SMM12)
	7	SafeOutput_local	P-0-3323, bit 0	Safe output at local interface

Typ-Nummer 781: "2-byte SMO control word, binary-coded SMM (781)"				
Configuration			Target assignment	
Byte	Bit	Name	IDN, bit number	Signal name
0	0	ModeSelectionSignal	P-0-3261, bit 0	Mode selection signal (MS)
	1	EmergencyStopSignal	P-0-3261, bit 1	Emergency stop signal (SMES)
	2	EnablingControl	P-0-3261, bit 2	Enabling control signal (EC)
	3	SMM1Signal_coded[1]	P-0-3261, bit 3..18	SMM1 signal (A_SMM1) ... SMM16 signal (A_SMM16)
	4	SMM2Signal_coded[1]		
	5	SMM3Signal_coded[1]		
	6	SMM4Signal_coded[1]		
	7	Reserved	-	-
1	0..5	Reserved	-	-
	6	ReleaseBrake	P-0-3265.0.2, bit 0	Release holding brake
	7	SafeOutput_local	P-0-3323, bit 0	Safe output at local interface

1) The signals are binary-coded, i.e. instead of the bit being directly converted in the control word to the target parameter via the IO mapper block "Safe connector", the binary-coded selection bits are decoded using the IO mapper block "binary-to-bit decoder".

Selection/acknowledgment

Type number 786: "2-byte SMO control word, bit-coded SMM (786)"				
Configuration			Target assignment	
Byte	Bit	Name	IDN, bit number	Signal name
0	0	ModeSelectionSignal	P-0-3261, bit 0	Mode selection signal (MS)
	1	EmergencyStopSignal	P-0-3261, bit 1	Emergency stop signal (SMES)
	2	EnablingControl	P-0-3261, bit 2	Enabling control signal (EC)
	3	SMM1Signal	P-0-3261, bit 3	SMM1 signal (A_SMM1)
	4	SMM2Signal	P-0-3261, bit 4	SMM2 signal (A_SMM2)
	5	SMM3Signal	P-0-3261, bit 5	SMM3 signal (A_SMM3)
	6	SMM4Signal	P-0-3261, bit 6	SMM4 signal (A_SMM4)
	7	SMM5Signal	P-0-3261, bit 7	SMM5 signal (A_SMM5)
1	0	SMM6Signal	P-0-3261, bit 8	SMM6 signal (A_SMM6)
	1	SMM7Signal	P-0-3261, bit 9	SMM7 signal (A_SMM7)
	2	SMM8Signal	P-0-3261, bit 10	SMM8 signal (A_SMM8)
	3	SMM9Signal	P-0-3261, bit 11	SMM9 signal (A_SMM9)
	4	SMM10Signal	P-0-3261, bit 12	SMM10 signal (A_SMM10)
	5[1)]	SafeHomingProcedure	P-0-3253, bit 0	SMO reference signal
	6	Reserved	-	-
	7	SafeOutput_local	P-0-3323, bit 0	Safe output at local interface

1) With MPx-20 and above

Selection/acknowledgment

<table>
<tr><th colspan="5">Type number 787: "2-byte SMO control word, binary-coded SMM (787)"</th></tr>
<tr><th colspan="3">Configuration</th><th colspan="2">Target assignment</th></tr>
<tr><th>Byte</th><th>Bit</th><th>Name</th><th>IDN, bit number</th><th>Signal name</th></tr>
<tr><td rowspan="8">0</td><td>0</td><td>ModeSelectionSignal</td><td>P-0-3261, bit 0</td><td>Mode selection signal (MS)</td></tr>
<tr><td>1</td><td>EmergencyStopSignal</td><td>P-0-3261, bit 1</td><td>Emergency stop signal (SMES)</td></tr>
<tr><td>2</td><td>EnablingControl</td><td>P-0-3261, bit 2</td><td>Enabling control signal (EC)</td></tr>
<tr><td>3</td><td>SMM1Signal_coded[1)]</td><td rowspan="4">P-0-3261, bit 3..18</td><td rowspan="4">SMM1 signal (A_SMM1)
...
SMM16 signal (A_SMM16)</td></tr>
<tr><td>4</td><td>SMM2Signal_coded[1)]</td></tr>
<tr><td>5</td><td>SMM3Signal_coded[1)]</td></tr>
<tr><td>6</td><td>SMM4Signal_coded[1)]</td></tr>
<tr><td>7[2)]</td><td>SafeHomingProcedure</td><td>P-0-3253, bit 0</td><td>SMO reference signal</td></tr>
<tr><td rowspan="3">1</td><td>0..5</td><td>Reserved</td><td>-</td><td>-</td></tr>
<tr><td>6</td><td>ReleaseBrake</td><td>P-0-3265.0.2, bit 0</td><td>Release holding brake</td></tr>
<tr><td>7</td><td>SafeOutput_local</td><td>P-0-3323, bit 0</td><td>Safe output at local interface</td></tr>
</table>

1) The signals are binary-coded, i.e. instead of the bit being directly converted in the control word to the target parameter via the IO mapper block "Safe connector", the binary-coded selection bits are decoded using the IO mapper block "binary-to-bit decoder".

2) With MPx-20 and above

Predefined configurations for producer connections

The predefined configuration of the producer connection is to be determined by entering the type number (P-0-3342.0.1).

Selection/acknowledgment

Type number														
Decimal	Hexadecimal	EMERGENCY STOP (SMES)	Special mode Safe standstill (SMST)	Number of SMM	SMM coding	Safety technology error	Safety status	Brake status	Encoder standstill	Safe reference	Parking axis[1)]	Number of cams[1)]	Cam coding	Functional inputs
782	0x030E	✓	✓	4	Bit-coded		✓		✓			0	–	–
783	0x030F	✓	✓	8	Binary-coded	✓	✓		✓			0	–	–
784	0x0310	✓	✓	12	Bit-coded	✓	✓		✓			0	–	–
785	0x0311	✓	✓	16	Binary-coded	✓	✓	✓	✓			0	–	–
788	0x0314	✓	✓	16	Binary-coded	✓	✓	✓	✓	✓		31	Binary-coded	–
789	0x0315	✓	✓	3	Bit-coded	✓	✓	✓	✓	✓		6	Bit-coded	–
790	0x0316	✓	✓	8	Binary-coded	✓	✓	✓	✓	✓	✓	0	–	4

1) With MPx-20 and above

Tab. 7-2: Signals of the predefined configurations for producer connections

Type number 782: "1-byte SMO status word, bit-coded SMM (782)"			
Configuration		Source assignment	
Bit	Name	IDN, bit number	Signal name
0	SMESStatus	P-0-3231, bit 1	EMERGENCY STOP (SMES)
1	SMSTStatus	P-0-3231, bit 2	Special mode Safe standstill (SMST)
2	SMM1Status	P-0-3231, bit 3	Special mode Safe motion 1 (SMM1)
3	SMM2Status	P-0-3231, bit 4	Special mode Safe motion 2 (SMM2)
4	SMM3Status	P-0-3231, bit 5	Special mode Safe motion 3 (SMM3)
5	SMM4Status	P-0-3231, bit 6	Special mode Safe motion 4 (SMM4)
6	EncoderStandstill	P-0-3256, bit 6	Encoder standstill
7	SafetyStatus	P-0-3237, bit 0	Safety status

Type number 783: "1-byte SMO status word, binary-coded SMM (783)"			
Configuration		Source assignment	
Bit	Name	IDN, bit number	Signal name
0	SMESStatus	P-0-3231, bit 1	EMERGENCY STOP (SMES)
1	SMSTStatus	P-0-3231, bit 2	Special mode Safe standstill (SMST)
2	SMM1Status_coded[1)]	P-0-3231, bit 3..10	Special mode Safe motion 1 (SMM1) ... Special mode Safe motion 8 (SMM8)
3	SMM2Status_coded[1)]		
4	SMM3Status_coded[1)]		
5	SafetyError	P-0-3231, bit 25	Safety technology error
6	EncoderStandstill	P-0-3256, bit 6	Encoder standstill
7	SafetyStatus	P-0-3237, bit 0	Safety status

1) The signals are binarily coded.

Type number 784: "2-byte SMO status word, bit-coded SMM (784)"				
Configuration			Source assignment	
Byte	Bit	Name	IDN, bit number	Signal name
0	0	SMESStatus	P-0-3231, bit 1	EMERGENCY STOP (SMES)
	1	SMSTStatus	P-0-3231, bit 2	Special mode Safe standstill (SMST)
	2	SMM1Status	P-0-3231, bit 3	Special mode Safe motion 1 (SMM1)
	3	SMM2Status	P-0-3231, bit 4	Special mode Safe motion 2 (SMM2)
	4	SMM3Status	P-0-3231, bit 5	Special mode Safe motion 3 (SMM3)
	5	SMM4Status	P-0-3231, bit 6	Special mode Safe motion 4 (SMM4)
	6	SMM5Status	P-0-3231, bit 7	Special mode Safe motion 5 (SMM5)
	7	SMM6Status	P-0-3231, bit 8	Special mode Safe motion 6 (SMM6)
1	0	SMM7Status	P-0-3231, bit 9	Special mode Safe motion 7 (SMM7)
	1	SMM8Status	P-0-3231, bit 10	Special mode Safe motion 8 (SMM8)
	2	SMM9Status	P-0-3231, bit 11	Special mode Safe motion 9 (SMM9)
	3	SMM10Status	P-0-3231, bit 12	Special mode Safe motion 10 (SMM10)
	4	SMM11Status	P-0-3231, bit 13	Special mode Safe motion 11 (SMM11)
	5	SMM12Status	P-0-3231, bit 14	Special mode Safe motion 12 (SMM12)
	6	EncoderStandstill	P-0-3256, bit 6	Encoder standstill
	7	SafetyStatus	P-0-3237, bit 0	Safety status

Selection/acknowledgment

Type number 785: "2-byte SMO status word, binary-coded SMM (785)"				
Configuration			Source assignment	
Byte	Bit	Name	IDN, bit number	Signal name
0	0	SMESStatus	P-0-3231, bit 1	EMERGENCY STOP (SMES)
	1	SMSTStatus	P-0-3231, bit 2	Special mode Safe standstill (SMST)
	2	SMM1Status_coded[1]	P-0-3231, bit 3..18	Special mode Safe motion 1 (SMM1) ... Special mode Safe motion 16 (SMM16)
	3	SMM2Status_coded[1]		
	4	SMM3Status_coded[1]		
	5	SMM4Status_coded[1]		
	6..7	Reserved	-	-
1	0..5	Reserved	-	-
	4	BrakeStatus	P-0-3265, bit 0	Acknowledgment of holding brake control
	5	SafetyError	P-0-3231, bit 25	Safety technology error
	6	EncoderStandstill	P-0-3256, bit 6	Encoder standstill
	7	SafetyStatus	P-0-3237, bit 0	Safety status

1) The signals are binarily coded.

Type number 788: "2-byte SMO status word, binary-coded SMM (788)"				
Configuration			Source assignment	
Byte	Bit	Name	IDN, bit number	Signal name
0	0	SMESStatus	P-0-3231, bit 1	EMERGENCY STOP (SMES)
	1	SMSTStatus	P-0-3231, bit 2	Special mode Safe standstill (SMST)
	2	SMM1Status_coded[1]	P-0-3231, bit 3..18	Special mode Safe motion 1 (SMM1) ... Special mode Safe motion 16 (SMM16)
	3	SMM2Status_coded[1]		
	4	SMM3Status_coded[1]		
	5	SMM4Status_coded[1]		
	6[2]	HomingStatus	P-0-3256, bit 0	Status of Safe reference
	7[2]	SCA1Status_coded	P-0-3273, bit 0..4	Cam 1 status ... Cam 32 status
1	0[2]	SCA2Status_coded		
	1[2]	SCA3Status_coded		
	2[2]	SCA4Status_coded		
	3[2]	SCA5Status_coded		
	4	BrakeStatus	P-0-3265, bit 0	Acknowledgment of holding brake control
	5	SafetyError	P-0-3231, bit 25	Safety technology error
	6	EncoderStandstill	P-0-3256, bit 6	Encoder standstill
	7	SafetyStatus	P-0-3237, bit 0	Safety status

1) The signals are binarily coded.
2) With MPx-20 and above

Selection/acknowledgment

Type number 789: "2-byte SMO status word, bit-coded SMM (789)"				
Configuration			Source assignment	
Byte	Bit	Name	IDN, bit number	Signal name
0	0	SMESStatus	P-0-3231, bit 1	EMERGENCY STOP (SMES)
	1	SMSTStatus	P-0-3231, bit 2	Special mode Safe standstill (SMST)
	2	SMM1Status	P-0-3231, bit 3	Special mode Safe motion 1 (SMM1)
	3	SMM2Status	P-0-3231, bit 4	Special mode Safe motion 2 (SMM2)
	4	SMM3Status	P-0-3231, bit 5	Special mode Safe motion 3 (SMM3)
	5 [1)]	HomingStatus	P-0-3256, bit 5	Status of Safe reference
	6 [1)]	SCA1Status	P-0-3273.0.1, bit 0	Cam 1 status
	7 [1)]	SCA2Status	P-0-3273.0.1, bit 1	Cam 2 status
1	0 [1)]	SCA3Status	P-0-3273.0.1, bit 2	Cam 3 status
	1 [1)]	SCA4Status	P-0-3273.0.1, bit 3	Cam 4 status
	2 [1)]	SCA5Status	P-0-3273.0.1, bit 4	Cam 5 status
	3 [1)]	SCA6Status	P-0-3273.0.1, bit 5	Cam 6 status
	4	BrakeStatus	P-0-3265, bit 0	Acknowledgment of holding brake control
	5	SafetyError	P-0-3231, bit 25	Safety technology error
	6	EncoderStandstill	P-0-3256, bit 6	Encoder standstill
	7	SafetyStatus	P-0-3237, bit 0	Safety status

1) With MPx-20 and above

Selection/acknowledgment

Type number 790: "2-byte SMO status word, binary-coded SMM (790)"				
Configuration			Source assignment	
Byte	Bit	Name (SDDML)	IDN, bit number	Signal name
0	0	SMESStatus	P-0-3231, bit 1	EMERGENCY STOP (SMES)
	1	SMSTStatus	P-0-3231, bit 2	Special mode Safe standstill (SMST)
	2	SMM1Signal_coded 1)	P-0-3231, bit 3..10	Special mode Safe motion 1 (SMM1) ... Special mode Safe motion 8 (SMM8)
	3	SMM2Signal_coded 1)		
	4	SMM3Signal_coded 1)		
	5 2)	HomingStatus	P-0-3256, bit 5	Status of Safe reference
	6	FunctionalInput1	P-0-3329, bit 0	Functional input signals 1 drive
	7	FunctionalInput2	P-0-3329, bit 1	Functional input signals 2 drive
1	0	FunctionalInput3	P-0-3329, bit 2	Functional input signals 3 drive
	1	FunctionalInput4	P-0-3329, bit 3	Functional input signals 4 drive
	2 2)	ParkingAxis	P-0-3231, bit 27	Parking axis
	3	Reserved	-	-
	4	BrakeStatus	P-0-3265, bit 0	Acknowledgment of holding brake control
	5	SafetyError	P-0-3231, bit 25	Safety technology error
	6	EncoderStandstill	P-0-3256, bit 6	Encoder standstill
	7	SafetyStatus	P-0-3237, bit 0	Safety status

1) The signals are binarily coded.
2) With MPx-20 and above

Profiles

The predefined configuration of the producer connection and the predefined configuration of the consumer connection can be summarized in a so-called profile. Summarizing in profiles is optional with CIP Safety on SERCOS. For FSoE and PROFInet, only those combinations of predefined configurations defined in a profile may be used.

Profile	Predefined configuration		Safety bus communication		
	Consumer connection	Producer connection	CSoS	FSoE	PROFIsafe
1-byte control / status, bit SMM (778/782)	778	782	x		
1-byte control / status, binary SMM (779/783)	779	783	x		
2-byte control / status, bit SMM (780/784)	780	784	x	x	x
2-byte control / status, binary SMM (781/785)	781	785	x	x	x
2-byte control / status, binary SMM, SafeHoming, binary SCA (787/788)	787	788	x	x	x
2-byte control / status, binary SMM, SafeHoming, FunctionalInputs (787/790)	787	790	x	x	x
2-byte control / status, bit SMM, SafeHoming, bit SCA (786/789)	786	789	x	x	x
2-byte control / status, bit SMM, SafeHoming (786/784)	786	784	x	x	x

Tab. 7-3: Defined combinations of predefined configurations

7.3.4 CIP Safety on Sercos (CSoS)

Brief description

CIP Safety on sercos (CSoS) is the protocol for transmitting safety-relevant signals via Sercos. The signals are transmitted along with the other real-time data of the Sercos network.

Features

- Defined in Function-specific Profile (FSP) "CIP Safety on Sercos"
- Corresponds to CIP Safety specification according to CIP Networks Library, Volume 5 of the ODVA (Open DeviceNet Vendors Association)
  - Realization as CIP Safety Target
  - Unicast connections are supported (no Multicast connections)
  - "Forward_Open" (Safety_Open) of 2a and 2b types is supported
- The residual fault rate meets the requirements of SIL3 and PL e and can be assumed less than 10^{-9}.
- The assemblies of the selected predefined configuration are transmitted (see "Predefined configurations"). 1-byte and 2-byte assemblies are supported.
- For drives operated in the CCD system mode, the CCD master and the CCD slaves support CSoS connections to a CIP Safety Originator in the higher-level subnetwork.

  In the CCD basic mode and MLD-M system mode, only the CCD master supports CSoS connections to the higher-level subnetwork.
- Information on the configuration of the CIP Safety connection are made available via the device data sheet (SDDML).

Pertinent parameters

The following parameters are used in conjunction with "CIP Safety on sercos":

- S-0-1100.0.1, Diagnostic counter sent SMP fragments
- S-0-1100.0.2, Diagnostic counter received SMP fragments
- S-0-1100.0.3, Diagnostic counter dropped SMP fragments
- S-0-1800.0.1, List of applications
- S-0-1800.0.2, List of validator objects
- S-0-1800.0.4, SV Safety connection fault count
- S-0-1800.0.10, SSO Device Status
- S-0-1800.0.15, SSO Safety Configuration Identifier
- S-0-1800.0.16, SSO Configuration Lock
- S-0-1800.0.17, SSO Configuration UNID
- S-0-1800.0.18, SSO Proposed TUNID
- S-0-1800.0.19, SSO Target UNID
- S-0-1801.0.1, CIP Vendor ID
- S-0-1801.0.2, CIP Device Type
- S-0-1801.0.3, CIP Product Code
- S-0-1801.0.4, CIP Revision
- S-0-1801.0.5, CIP Status
- S-0-1801.0.6, CIP serial number
- S-0-1801.0.7, CIP Product Name
- S-0-1810.0.1, SV Max data age

Selection/acknowledgment

- S-0-1810.0.2, Safety Validator State
- S-0-1810.0.3, SV Error code
- S-0-1810.0.4, Safety Validator type
- S-0-1810.0.5, SV Time coord msg min multiplier
- S-0-1810.0.6, SV Max consumer number
- S-0-1810.0.7, SV Timeout multiplier
- S-0-1810.0.8, SV Ping interval EPI multiplier
- S-0-1810.0.9, SV Network time expectation multiplier
- S-0-1820.0.1, CIP assembly instance number
- S-0-1820.0.2, Safety Validator instance number
- S-0-1820.0.3, Safety application type
- S-0-1820.0.4, Safety application data size
- P-0-3345, SMO: Safety bus configuration

Pertinent diagnostic messages

The following diagnostic messages can be generated with "CIP Safety on Sercos":

- F3450 CSS stack error
- F4150 CSAL error
- With Safety bus communication via "CIP Safety on Sercos" activated, the display of the IndraDrive control panel does not show any specific message, but the standard diagnostic message (e.g. "AF") appears.
- LED diagnostic display of the optional safety technology modules "Sx" (see "Diagnostic displays")

Configuration

Overview

The figure below shows the basic structure of the CSoS communication.

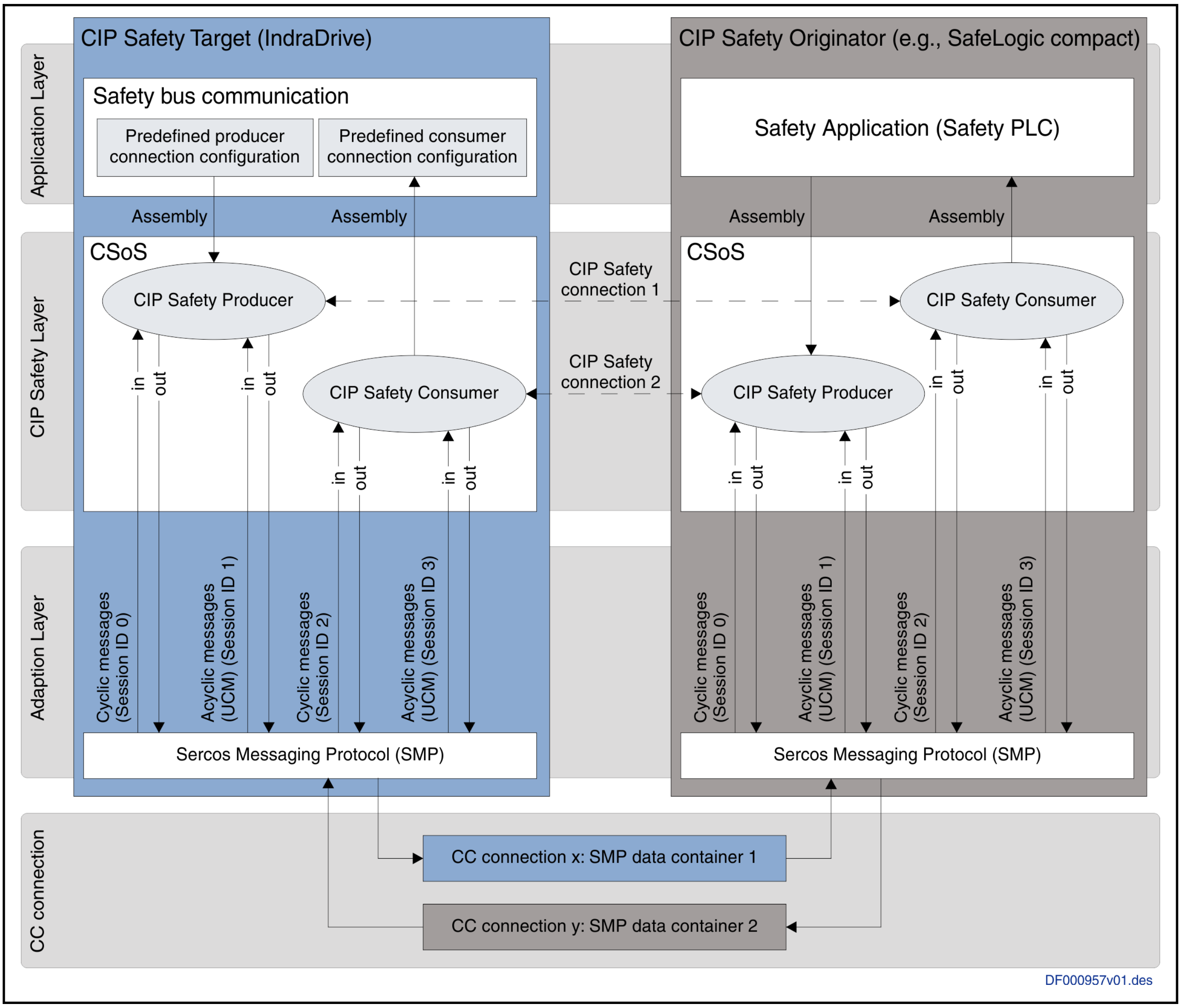


Fig. 7-5: Basic structure of the CSoS communication

The safe data are exchanged between CIP Safety Producer and CIP Safety Consumer via the safe CSoS protocol. In this course, data to be sent and received are transmitted in separate CIP Safety connections. The configuration of the CSoS communication comprises four steps:

- "Configuring the Sercos CC connections for cyclic transmission of the SMP data containers" on page 225
- "Configuring the connection of CIP Safety to the Sercos Messaging Protocol (SMP)" on page 226
- "Configuring the CIP Safety connections in the CIP Safety Target (drive)" on page 227
- "Configuring the CIP Safety connections in the CIP Safety Originator (Safety control)" on page 228

Configuring the Sercos CC connections for cyclic transmission of the SMP data containers

The transport of the data of the CIP Safety on Sercos communication between CIP Safety Originator (safety control) and CIP Safety Target ("IndraDrive") is carried out via the Sercos Messaging Protocol (SMP). To this end, a consuming and a producing CC connection (S-0-1050.y and S-0-1050.x) have to be configured in the drive. By using this connection, the data can be cyclically exchanged via the SMP containers S-0-1101.1.1 and S-0-1101.0.1 with the originator. The data length of S-0-1101.1.1 and S-0-1101.0.1 is fixed to 10 bytes in the drive.

The following data have to be configured in the drive for the producing CC connection (x=connection instance).

- Connection configuration: S-0-1050.x.1="0xC002" ("configured by master" (optional), "variable configuration of IDNs", "asynchronous operation without watchdog")
- Determining the SMP data container: S-0-1050.x.6 = S-0-1101.0.1
- Connection class: S-0-1050.x.7="5"
- Producer cycle time: S-0-1050.x.10 has to be equal to "S-0-1002, sercos: Communication Cycle time (tScyc)".

The following data have to be configured in the drive for the consuming CC connection (y=connection instance).

- Connection configuration: S-0-1050.y.1="0x8002" ("configured by master" (optional), "variable configuration of IDNs", "asynchronous operation without watchdog")
- Determining the SMP data container: S-0-1050.y.6 = S-0-1101.1.1
- Connection class: S-0-1050.y.7="4"
- Producer cycle time: S-0-1050.y.10 has to be equal to "S-0-1002, sercos: Communication Cycle time (tScyc)".

The parameterization of the CC connection is normally carried out via the Sercos master. When using a Rexroth safety control of the " SafeLogic" or "SafeLogic compact" type, integrated dialogs of IndraWorks Engineering can be used for the corresponding configuration of the Sercos master [e.g., see Project Planning Manual of the Sercos Gateway with IndraControl SafeLogic compact (material number R911338436)].

Configuring the connection of CIP Safety to the Sercos Messaging Protocol (SMP)

For the CIP Safety communication, cyclic and acyclic messages [Uncoordinated Messages (UCM)] have to be transmitted between consumer and producer. These messages are transmitted via the Sercos Messaging Protocol (SMP) on the Sercos level. When configuring the connection of CIP Safety to SMP, the message types (cyclic in, cyclic out, UCM in, UCM out) for both CIP Safety connections are to be assigned unambiguously to a SMP Session ID and a SMP data container of the drive and have to fit the assignment on the CIP Safety Originator. For this purpose, the following parameters of the drive (CIP Safety Target) have to be configured (exemplary values):

CIP Safety connection 1

- S-0-1830.0.1, List of cyclic SMP container (out) = S-0-1101.0.1
- S-0-1830.0.2, List of cyclic SMP Session ID (out) = 0
- S-0-1830.0.3, List of cyclic SMP containers (in) = S-0-1101.1.1
- S-0-1830.0.4, List of cyclic SMP Session IDs (in) = 0
- S-0-1830.0.5, List of UCM SMP containers (in) = S-0-1101.1.1
- S-0-1830.0.6, List of UCM SMP Session IDs (in) = 1
- S-0-1830.0.7, List of UCM SMP containers (out) = S-0-1101.0.1
- S-0-1830.0.8, List of UCM SMP Session IDs (out) = 1

CIP Safety connection 2

- S-0-1830.1.1, List of cyclic SMP container (out) = S-0-1101.0.1
- S-0-1830.1.2, List of cyclic SMP Session ID (out) = 2

- S-0-1830.1.3, List of cyclic SMP containers (in) = S-0-1101.1.1
- S-0-1830.1.4, List of cyclic SMP Session IDs (in) = 2
- S-0-1830.1.5, List of UCM SMP containers (in) = S-0-1101.1.1
- S-0-1830.1.6, List of UCM SMP Session IDs (in) = 3
- S-0-1830.1.7, List of UCM SMP containers (out) = S-0-1101.0.1
- S-0-1830.1.8, List of UCM SMP Session IDs (out) = 3

The configuration is normally carried out via the Sercos master. When using a Rexroth safety control of the " SafeLogic" or "SafeLogic compact" type, integrated dialogs of IndraWorks Engineering can be used for the corresponding configuration of the Sercos master [e.g., see Project Planning Manual of the Sercos Gateway with IndraControl SafeLogic compact (material number R911338436)].

Configuring the CIP Safety connections in the CIP Safety Target (drive)

For the configuration, the drive has to be in configuration mode (SCM).

Activating the CSoS communication

The CSoS communication is activated via P-0-3345="1" in the drive.

Target Unique Network Identifier

To unequivocally identify the CIP Safety Target via CSoS, it has to have an unequivocal "TUNID". The "TUNID" is composed of the "Safety Network Number (SNN)" and the "Safety Device ID (SDID)".

TUNID = [SDID (4 bytes)][SNN (6 bytes)]

The "Safety Network Number (SNN)" identifies the safe network to which the node belongs. In order to allow for the drive to communicate with the safety control, both devices have to be **in the same** safe network; i.e. both devices have to have **the same** "Safety Network Number (SNN)". The SNN is in the CIP "Date and Time" format.

SNN = [SNN-Date (bytes 6..9)][SNN-Time (bytes 0..5)]

> ☞ The SNN has to be unequivocal in the machine and cannot be used more than once!

The "Safety Device ID (SDID)" is the safe address for the CIP Safety communication. The CIP Safety originator and all CIP Safety targets have to have **different addresses**. Any value can be set, but it is recommended to choose a value unequal the Sercos address.

The TUNID can be assigned once during commissioning (initial commissioning or serial commissioning); it cannot be subsequently modified.

For the description of how to assign the TUNID, see chapter "Commissioning" under "Safety bus communication".

> ☞ Once the TUNID has been assigned, it can only be modified after completely resetting the safety technology to its condition as supplied (command C0750 or C0720). When this is done, all safety-related parameter settings of the axis will get lost!

Determining the predefined configuration

The respective setting of the predefined configuration for the producer connection and consumer connection in P-0-3343.0.1 and P-0-3342.0.1 determines the assemblies which can be transmitted via CIP Safety (see "Predefined configurations"). The predefined configurations for producer connection and consumer connection can be freely combined.

Configuring the CIP Safety connections in the CIP Safety Originator (Safety control)

SDID and SNN

The Safety Device ID (SDID) is to be set when configuring the CIP Safety connection. Additionally, it is to be checked that the SNN set in the originator corresponds with the SNN set in the target (drive) (see ""Configuring the CIP Safety connections in the CIP Safety Target (drive)" on page 227").

SCID, SCCRC and SCTS

The value of parameter S-0-1800.0.15 of the target (drive) has to be applied to the parameter "Safety Configuration Identifier (SCID)". The parameter has the following structure:

SCID = [SCCRC (bytes 6...9)][SCTS (bytes 0 ...5)]

"Safety Configuration CRC (SCCRC)" is generated from the checksum of the SMO configuration in the drive (P-0-3234.0.1) and the checksum of the SMO parameterization (P-0-3234.0.4). "Safety Configuration Time Stamp (SCTS)" is always "0".

When establishing a connection, the SCID is transferred to the target and compared with S-0-1800.0.15. The connection establishment is canceled in the event of disparity. This shall ensure that the connection is established with only one target and one defined Safety configuration and parameterization. When SCID="0", this verification is not carried out in the target.

Electronic Key

The "Electronic Key" identifies the target (drive) unequivocally. The "Electronic Key" is to be indicated when configuring the connection in the originator (Safety control). A connection is successfully established only if the configured "Electronic Key" in the originator corresponds with the actual "Electronic Key" in the target.

Using the compatibility bit of the CIP Revision (bit 15), the originator can control whether the Minor Revision is ignored when checking the "Electronic Key".

The suitable Electronic Key can be read from the Sercos device data sheet (SDDML) of the drive for the configuration of the originator. Alternatively, the information can be found in the respective display parameters of the drive as well.

CIP Safety parameter of the "Electronic Key"	"Electronic Key" display in the drive	Comment
CIP Vendor ID	S-0-1801.0.1	Unequivocal CIP ID of the manufacturer
CIP Device Type	S-0-1801.0.2	Unequivocal CIP ID of the device type
CIP Product Code	S-0-1801.0.3	Unequivocal CIP product code
CIP Revision	S-0-1801.0.4	CIP Safety version ID: • Bit 0..7: Minor Revision; is increased for compatible modifications • Bit 7..14: Major Revision; is increased for incompatible modifications • Bit 15: Compatibility bit – Bit 15="0": Compatibility mode deactivated Exactly this firmware version (Major Revision and Minor Revision are identical) is supported only. – Bit 15="1": Compatibility mode activated Every compatible firmware version (Major Revision is identical, Minor Revision is ignored) is supported.

Tab. 7-4: Structure of the Electronic Key

Assembly Instance

By using the "Assembly Instance", the combination of signals transmitted between originator and target is determined. It corresponds with the type number of the selected predefined configuration in the target (see "Predefined configurations"). In the originator, this number is configured for outgoing and incoming data of a connection respectively. When establishing the connection, this information is transmitted to the target and compared with the predefined configuration set in P-0-3342.0.1 and P-0-3343.0.1. The connection establishment is canceled in the event of disparity. The possible assemblies are provided via the Sercos device data sheet SDDML for the configuration tool of the originator.

CSoS state machine

Overview

The CSoS communication is transmitted via the Sercos Messaging Protocol on the Sercos level. Therefore, the establishment of a CSoS connection and the exchange of the safe signals can only be realized in Sercos phase 4, when Sercos data are transmitted cyclically via the bus. For the CIP Safety Producer and CIP Safety Consumer, the following states are displayed via the parameters P-0-1810.0.2 and P-0-1810.1.2 respectively.

- Idle
- Initializing
- Established
- Connection Failed

If the Sercos communication is not in phase 4, the CIP Safety connection is in the "Idle" state.

When switching to the SMO system state SCM (configuration mode) takes place, the mandatory switching to the "Idle" state occurs.

"Idle" state

In the "Idle" state, the CSoS connection has not been established yet. The signals for the "Safety bus control word" are set to "0" ("Fail Safe").

Selection/acknowledgment

"Initializing" state

In the "Initializing state", the initialization of the CSoS connection takes place. There is no exchange of safety signals with the CIP Safety Originator. The signals for the "Safety bus control word" are set to "0" ("Fail Safe").

"Established" state

In the "Established" state, safe signals are exchanged with the CIP Safety Originator.

"Connection Failed" state

In the "Connection Failed" state, the connection is in an error state (e.g. error when establishing the connection, timeout). The signals for the "Safety bus control word" are set to "0" ("Fail Safe").

7.3.5 FailSafe over EtherCAT (FSoE)

Brief description

Features

"FailSafe over EtherCAT" allows safe communication as an FSoE slave with other EtherCAT-based SoE devices with integrated FSoE master. It contains the safety bus transmission protocol FSoE which was specified by the "EtherCAT Technology Group" (ETG) and concept-tested by TÜV.

This specification is available from the ETG (www.ethercat.org/en/safety.html) and consists of the following documents:

- ETG.5100 Safety over EtherCAT Specification (V1.2.0)
- ETG.5101 Safety over EtherCAT Implementation Guide (V1.2.0)
- ETG.5120 Safety over EtherCAT Protocol Enhancements (V1.0.0)

- In the firmware version MPx20VRS, FSoE is exclusively suppported for the "Servodrive-Profile over EtherCAT" (SoE).
- Drives operated in the CCD system mode (CCD master and CCD slaves) do not support FSoE.

  In the CCD basic mode and MLD-M system mode, only the CCD master supports FSoE.
- The assemblies of the selected predefined configuration are transmitted (see "Predefined configurations"). Specific 2-byte assemblies (profiles) are supported only.
- All pieces of information required to establish a connection are made available to the control unit via the device data sheet (XML).

Pertinent parameters

The following parameters are used in conjunction with "FailSafe over EtherCAT":

- P-0-3342.0.1, SMO: Configuration of consuming connection, safety bus
- P-0-3343.0.1, SMO: Configuration of producing connection, safety bus
- P-0-3345, SMO: Safety bus configuration
- P-0-3350, FSoE: Slave address
- P-0-3352, FSoE: Slave state

Pertinent diagnostic messages

The following diagnostic messages can be generated with "FailSafe over EtherCAT":

- C0214 SMO: Incorrect configuration
- F3451 FSoE stack error
- F3452 FSoE stack connection error
- With Safety bus communication via "FailSafe over EtherCAT" activated, the display of the IndraDrive control panel does not show any specific message, but the standard diagnostic message (e.g. "AF") appears.

- LED diagnostic display of the optional safety technology modules "Sx" (see "Diagnostic displays")

Functional principle

Configuration

The FSoE connection to the axis is configured in the control unit. The information required for this purpose is made available to the control unit via a device data sheet in the XML format. The XML file describes the predefined configurations that are supported.

> ☞ For error-free configuration of the FSoE connection to the axis, the XML file used has to be consistent with the hardware and firmware.

Besides the configuration in the control unit, an "FSoE slave address" also has to be assigned in the axis so that the axis can be unequivocally and safely addressed.

Furthermore, a profile for the configuration of the consumer and producer connections has to be selected during the commissioning of safety technology in the axis.

> ☞ The settings made in the control unit and in the drive controller, for the FSoE slave address and for the configurations of the consumer and producer connections, have to match so that an error-free communication can be established.

FSoE slave address

To unequivocally identify all bus nodes via FSoE, each node has to have an unequivocal "FSoE slave address" (P-0-3350).

This address can be assigned once during commissioning (initial commissioning or serial commissioning); it cannot be subsequently modified.

For the description of how to assign the FSoE address, see chapter "Commissioning" under "Safety bus communication".

> ☞ Once the FSoE address has been assigned, it can only be modified by completely resetting the safety technology to its condition as supplied (command C0750 or C0720). When this is done, all safety-related parameter settings of the axis will get lost!

FSoE system states

Overview

The FSoE state machine of the drive is controlled by the master via the cyclic FSoE data. The following system states have been defined:

- Reset
- Session
- Connection
- Parameter
- Data

Furthermore, the FSoE system states are linked to the Safe Motion state machine and to the communication state machine.

As the FSoE data are transmitted with the cyclic command values / actual values of EtherCAT, the FSoE connection is only running when the slave is in the "Operational phase". In the EtherCAT phases "Init", "PreOp" and "SafeOp", the FSoE connection is in the "Reset" state.

When switching to the SMO system state CM (configuration mode) takes place, the mandatory switching to the FSoE system state "Reset" occurs.

Selection/acknowledgment

System state "Reset"

In the system state "Reset" the connection is reset and the outputs are put into the "Fail Safe" state.

- The content "0" is supplied to the safety bus in accordance with the data width.
- Protocols from the SoE connection layer are processed.

System state "Session"

The session IDs are exchanged in the system state "Session".

- The content "0" is supplied to the safety bus in accordance with the data width.
- Protocols from the SoE connection layer are processed.

System state "Connection"

The connection IDs and the slave addresses are exchanged in the system state "Connection".

- The content "0" is supplied to the safety bus in accordance with the data width.
- Protocols from the SoE connection layer are processed.

System state "Parameters"

In the system state "Parameters" the communication and application parameters are transmitted. They were specified via the device data sheet and configured in the control project.

- The content "0" is supplied to the safety bus in accordance with the data width.
- Protocols from the SoE connection layer are processed.

Systems state "Data"

In the system state "Data" the master transmits the safe outputs to the slave and the slave responds with its safe inputs.

- The data of the connection are supplied to the slave as consumer data.
- The safe producer data from the safety bus are transmitted to the master.

Diagnostics

The FSoE state can be read from the parameter "P-0-3352, FSoE: Slave state" and using the LED at the optional safety technology module.

7.3.6 PROFIsafe

Brief description

"PROFIsafe" is the protocol for transmitting safety-relevant signals via PROFINET. The PROFIsafe protocol has no impacts on the PROFINET network. Safety messages can thus be transmitted via PROFINET along with standard messages.

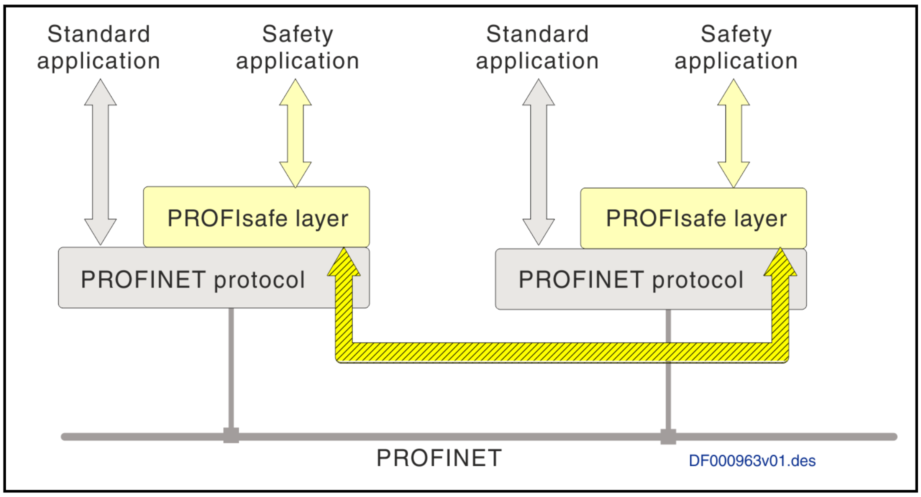


Fig. 7-6: Overview

Features

The PROFIsafe communication has the following features:

- Implemented as F-Device according to PROFIsafe version 2.4
- Supported with firmware version MPx20V12 and above
- For drives operated in a CCD mode (CCD system mode, CCD basic mode and MLD-M system mode), PROFIsafe is only supported in the CCD master.
- The residual fault rate meets the requirements of SIL3 and PL e and can be assumed less than 10^{-9}.
- The assemblies of the predefined configuration are transmitted. The selectable assemblies are defined in profiles (see "Predefined configurations").
- Information on the configuration of the PROFIsafe communication in the higher-level control is made available via the device data sheet (GSD).

Pertinent parameters

The following parameters are used in conjunction with "PROFIsafe":

- P-0-3360.0.1, PROFIsafe: F-Device Address
- P-0-3360.0.2, PROFIsafe: Proposed F-Device address
- P-0-3360.0.3, PROFIsafe: Current F-Device state
- P-0-3360.0.4, PROFIsafe: F-parameters
- P-0-3360.0.5, PROFIsafe: Application parameters

Pertinent diagnostic messages

The following diagnostic messages can be generated with "PROFIsafe":

- E3460 PROFIsafe: Wrong F-module selected
- F3460 PROFIsafe error
- F3461 PROFIsafe connection error
- With Safety bus communication via "PROFIsafe" activated, the display of the IndraDrive control panel does not show any specific message, but the standard diagnostic message (e.g. "AF") appears.
- LED diagnostic display of the optional safety technology modules "Sx" (see "Diagnostic displays")

Configuration

Overview

In the PROFIsafe communication, the drive (F-Device) cyclically exchanges data with a safety control (F-Host). In addition to the useful data (assemblies), the data to be transmitted are transmitted in a PROFIsafe telegram which contains control and status data as well as information on the verification of the integrity of the useful data in the receiver.

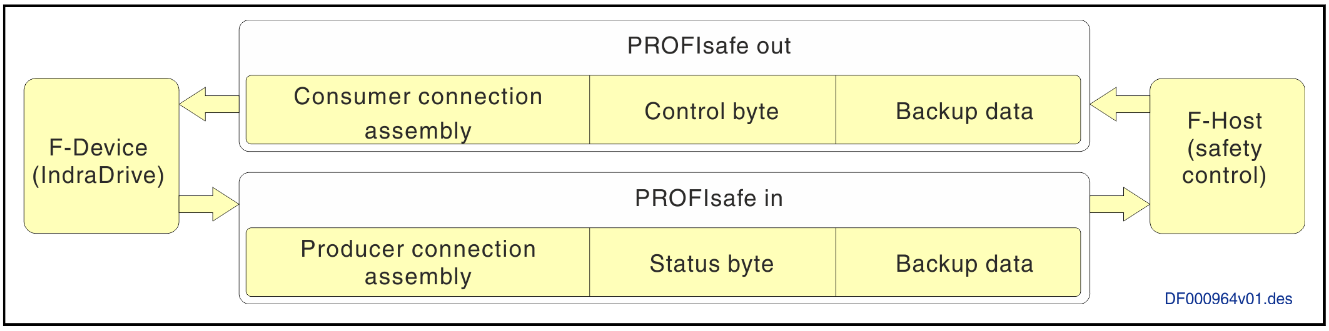


Fig. 7-7: PROFIsafe communication

The protocol for the safe data exchange is realized in a so-called PROFIsafe driver which uses the subordinate PROFINET communication to transmit the PROFIsafe telegram to the other PROFIsafe node (see illustration).

Selection/acknowledgment

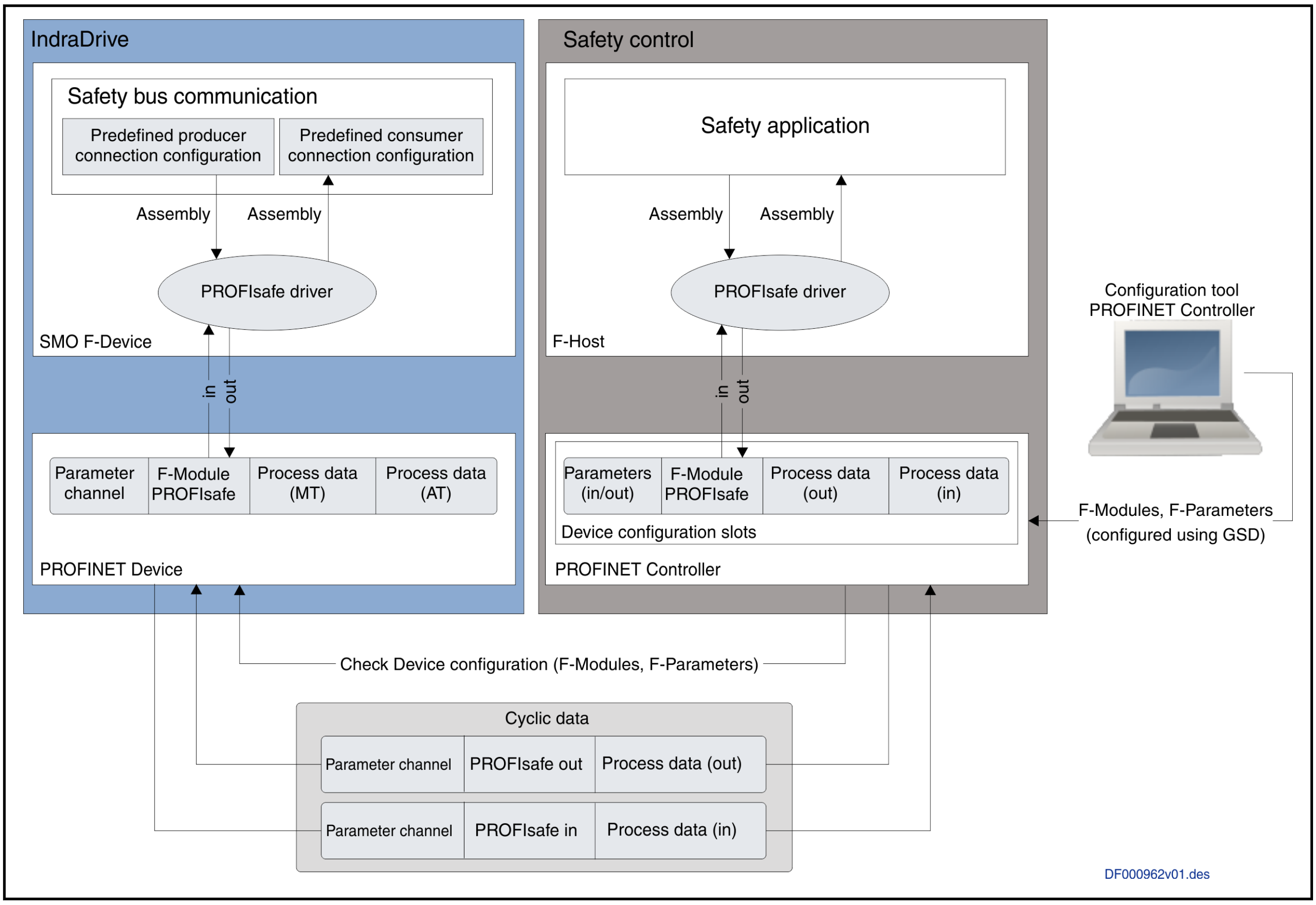


Fig. 7-8: PROFIsafe communication

The assembly of the "Predefined producer connection configuration" is transmitted to the PROFIsafe driver of the drive and transmitted from there to the F-Host via the safe PROFIsafe protocol. The safe data received by the F-Host are transmitted by the PROFIsafe driver to target parameters according to the "Predefined consumer connection configuration". The data exchange is carried out using the cyclic data of the PROFINET communication.

☞ Please pay attention to the byte order in the F-Host when programming the access to 2-byte assemblies! With PROFIsafe, bit information is transmitted in bytes; transmission in words has not been provided for. The less significant byte in the PROFIsafe telegram comes before the more significant byte. Thus, bit information so to speak is transmitted in the Little Endian format.

The configuration of the PROFIsafe communication is divided into three steps:

- Configuring the F-Device (drive)
- Configuring the cyclic transmission of the PROFIsafe data via PROFINET
- Configuring the F-Host (safety control)

Configuring the F-Device (drive)

The drive has to be in configuration mode (SCM) to configure the F-Device.

Activating the PROFIsafe communication

The PROFIsafe communication is activated via P-0-3345="3" in the drive.

F-Device address

To unequivocally identify the F-Device within the PROFIsafe network, it has to have an unequivocal address, the F-Device address. The F-Device address has to be other than "0".

The F-Device address can be assigned once during commissioning (initial commissioning or serial commissioning); it cannot be subsequently modified.

For the description of how to assign the address, see chapter "Commissioning" under "Safety bus communication".

☞ Once the F-Device address has been assigned, it can only be modified after completely resetting the safety technology to its condition as supplied (command C0750 or C0720). When this is done, all safety-related parameter settings of the axis will get lost!

Determining the predefined configuration

The respective setting of the predefined configuration for the producer connection and consumer connection in P-0-3343.0.1 and P-0-3342.0.1 determines the signal combinations (assemblies) for the PROFIsafe transmission. Only specific combinations of predefined configurations, so-called profiles, can be used (see "Profiles" in "Predefined configurations").

Configuring the cyclic transmission of the PROFIsafe data via PROFINET

The data of the PROFIsafe communication are transported between F-Host (safety control) and F-Device ("IndraDrive") via the cyclic data of the PROFINET communication. For this purpose, a corresponding slot has to be configured for the PROFIsafe data in the PROFINET telegram. Corresponding F-modules are provided via the device data sheet (GSD file) for the slot configuration for a configuration tool of the PROFINET controller. An F-module from the GSD corresponds to one specific profile for the producer and consumer connection. When establishing the connection, it is checked in the drive whether the F-module configured in the PROFINET controller fits the profile for the producer and consumer connection configured in the drive, before the PROFINET communication starts the cyclic data exchange (DATA-EX). The F-module ID received by the PROFINET controller is displayed in P-0-3360.0.4.

Configuring F-parameters in the F-Host (safety control)

With the F-parameters, the information required to establish a PROFIsafe connection to an F-Device is provided in the F-Host. The F-parameters to be set for the drive can be obtained from a GSD device data sheet by a configuration tool of the F-Host. Upon connection establishment, the F-parameters set in the F-Host are transmitted to the F-Device and checked for validity. The transmitted F-parameters are displayed in P-0-3360.0.5.

F-parameters in the F-Host	Parameter description
F target address "F_Dest_Add"	The F-Device address of the drive is to be configured in the F-parameter "F_Dest_Add". This F-Device address has to be consistent with the F-Device address configured in the drive and be unequivocal within the PROFIsafe network.
F source address "F_Source_Add"	The address of the F-Host is assigned in "F_Source_Add". It has to be unequivocal within the PROFIsafe network.

Selection/acknowledgment

F-parameters in the F-Host	Parameter description
PROFIsafe watchdog "F_WD_Time"	The "F_WD_Time" is transmitted along with the other F-parameters from the F-Host to each F-Device and is used to monitor the time of the cyclic PROFIsafe telegrams. If not at least one new PROFIsafe telegram is received within the "Watchdog Time", the PROFIsafe driver sets the data content of the assemblies to "0" (Fail Safe) and triggers the error F3461 in the drive. The maximum monitoring time is 200 ms.
Checksum "F_iPar_CRC"	The checksum "F_iPar_CRC" is to ensure that the connection is established to only one F-Device with a specific safety configuration and parameterization. To this end, the value from the parameter S-0-1800.0.15 (element 0..3) of the drive has to be applied to this parameter. Upon connection establishment, "F_iPar_CRC" is compared with the value from S-0-1800.0.15. In case the values are not identical, the drive reports the error F3460. If "F_iPar_CRC" is at the value "0", no verification will take place.

Tab. 7-5: Description of the F-parameters in the F-Host (safety control)

PROFIsafe state machine

Overview

The PROFIsafe state machine of the F-Device displays the current state of the PROFIsafe communication. The table below shows an overview of the states:

PROFIsafe F-Device state	Description	Value in P-0-3360.0.3
PSD_RESET	In the "PSD_RESET" state, the F-Device is in run-up and the PROFIsafe driver has not been initialized yet. The outputs of the F-Device (assembly of the consumer connection) are set to "0" (Fail Safe). After error-free initialization, the state changes to "PSD_INIT".	0x0001
PSD_INIT	In the "PSD_INIT" state, the PROFIsafe driver has been initialized in an error-free manner. The PROFIsafe driver is ready for receiving F-parameters from the F-Host. The outputs of the F-Device (assembly of the consumer connection) are set to "0" (Fail Safe). When switching to the SMO system state SCM (configuration mode) takes place, the mandatory switching to the "PSD_INIT" state occurs.	0x0032
PSD_PARAM	In the "PSD_PARAM" state, there are valid parameters from the F-Host available. The outputs of the F-Device (assembly of the consumer connection) are set to "0" (Fail Safe). The PROFIsafe driver is ready for the cyclic data exchange.	0x0054
PSD_DATAEX	In the "PSD_DATAEX" state, the cyclic exchange of valid PROFIsafe data (assemblies) with the F-Host has been started. The state can only be reached if the PROFINET communication is in cyclic data exchange (DATAEX).	0x0067
PSD_HARD_FAIL	In the "PSD_HARD_FAIL" state, a hardware error has been detected. F8304 is triggered in the drive.	0x00FF

Tab. 7-6: PROFIsafe F-Device states

7.4 IO mapper inputs

7.4.1 Introduction

Using the "IO mapper inputs" function, input signals can be processed and assigned to the selection signals of the active Safe Motion profile. The inputs are processed in so-called "IO mapper blocks". The following input signals can be used to control the IO mapper blocks:

- The safe discrete input signals (P-0-3320) of the safety zone module interface (X41),
- the functional discrete input signals (P-0-3322.0.1) of the local interface of the optional safety module (S3/SD: X141, S4/S5: X41),
- the control word (P-0-3340) of the Safety bus communication,
- the functional inputs of the drive (P-0-3329) that are read in via functional interfaces of the drive (X31, X32, master communication,...). (The bit assignment of P-0-3329 can be configured.)
- MPx-20 and above: "Safe cams (SCA)"; cam status bits of cams 1 to 16 via "P-0-3273.0.1, SMO: Status word, bit-coded SCA". The relevant cam status bit is used as safe input signal

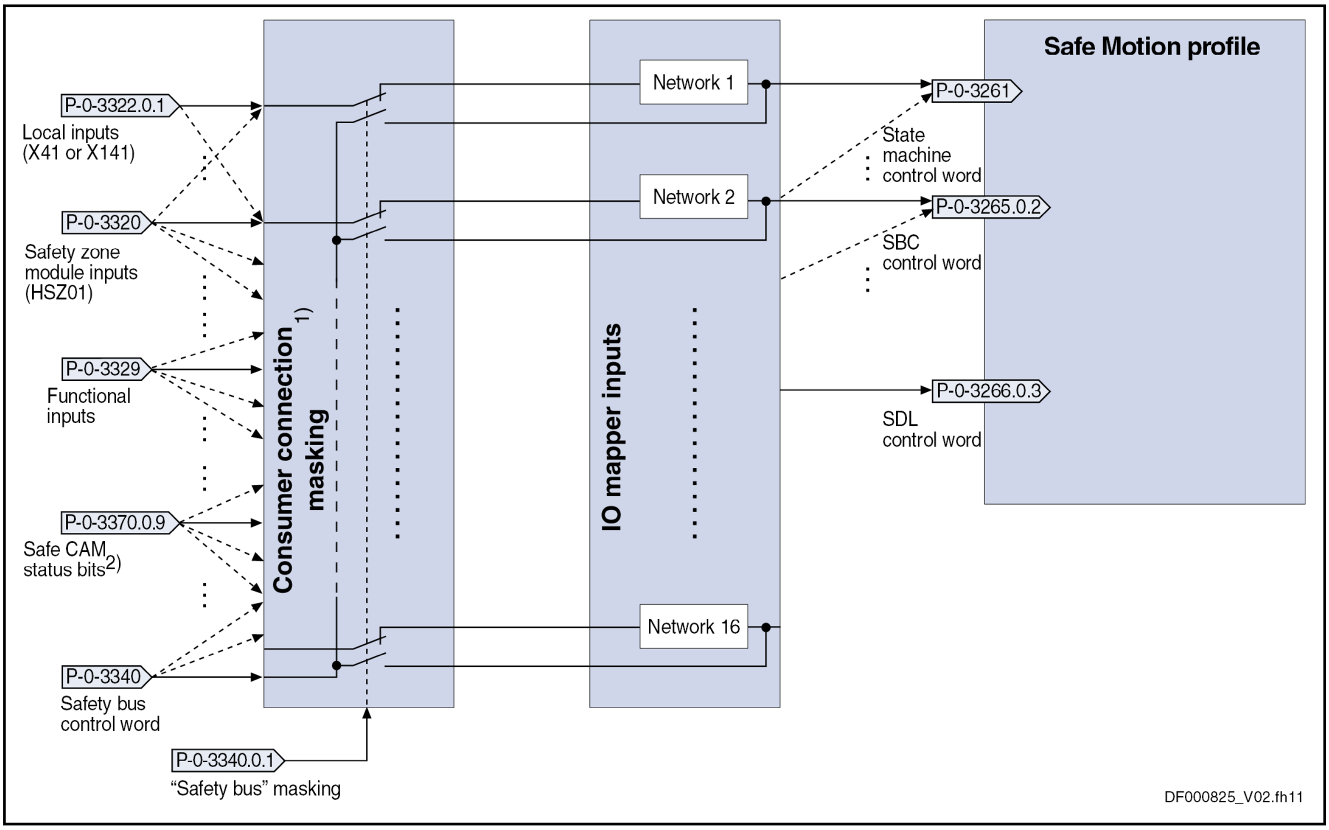
"Safe signals" are signals that are suitable for selecting or deselecting safety functions.

"Functional signals" are signals that are not suitable for selecting or deselecting safety functions since they do not transmit safe information.

Input signals of different sources (e.g. Safety bus communication and safety zone module) can be used for an IO mapper block. The input signals of the active Safe Motion profile (P-0-3261, P-0-3265.0.2 and P-0-3266.0.3) are assigned to the output signals of the IO mapper blocks (see "Safe Motion profiles").

If a predefined configuration is active, there is a direct, predefined linking of the control word of the Safety bus communication to target parameters of the Safe Motion profile (see "Safety bus communication"). "P-0-3340.0.1, SMO: Mask of control word, safety bus" can be used to mask input signals from the predefined configuration for a network. The IO mapper can then be freely defined for this network. The figure below shows, in schematic form, the signal sequence of the "IO mapper inputs":

Selection/acknowledgment



1) Only takes effect with active Safety bus communication

2) With MPx-20 and above

Fig. 7-9: IO mapper inputs

The IO mapper blocks are called and configured via dialogs in IndraWorks (see "Commissioning").

Depending on the selected IO mapper block type, a circuit diagram of the IO mapper block is displayed in the corresponding dialog of the network.

Selection/acknowledgment

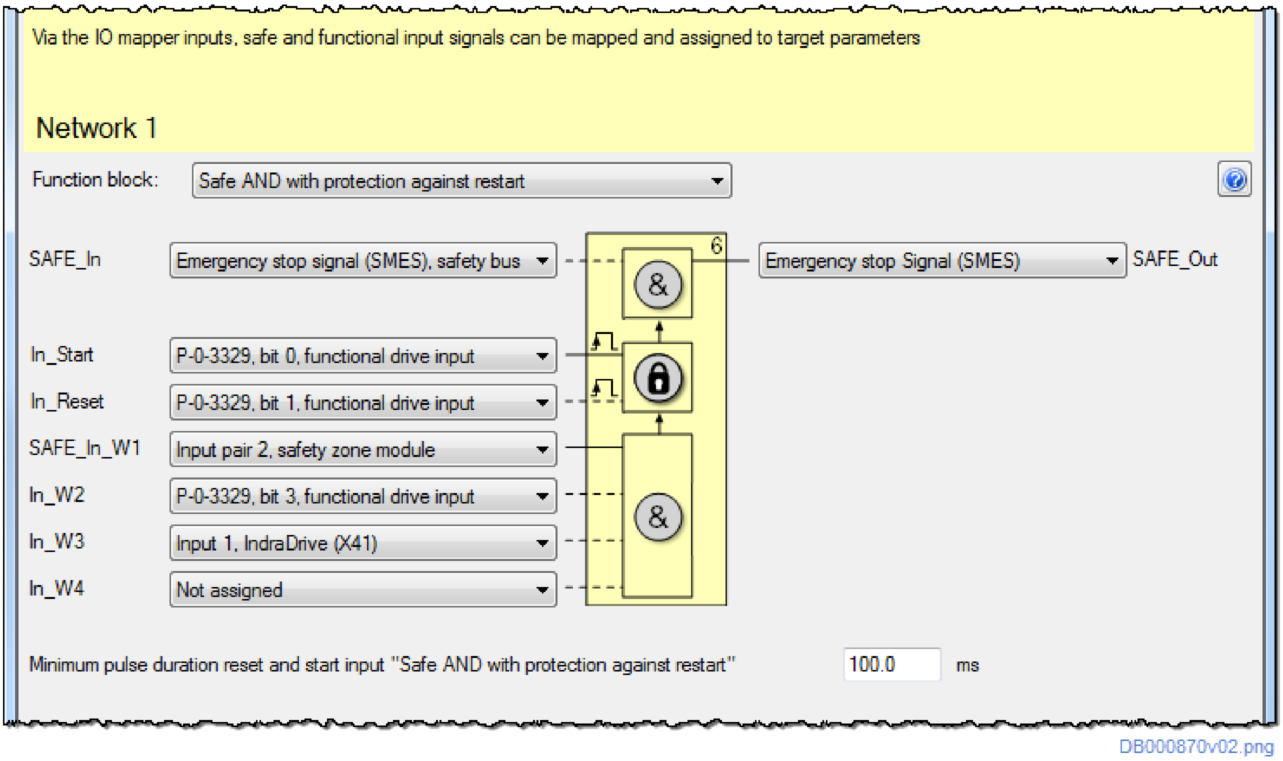


Fig. 7-10: Exemplary dialog: "IO mapper inputs"

The IO mapper blocks are assigned in the 16 so-called "networks".

The maximum number of IO mapper blocks is limited and preset by so-called "instances". If all instances of an IO mapper block are used, this IO mapper block is not provided any more.

If an IO mapper block has been assigned to a network, the name of the IO mapper block type is displayed in the Project Explorer; for example, "Network 1: Safe connector".

If the predefined configuration "Safety bus communication" has been pre-assigned to a network, the text of the corresponding branch is grayed out and "(predefined configuration)" is added to it; for example, "Network 2: Safe connector (predefined configuration)" (see "Safety bus communication").

Selection/acknowledgment

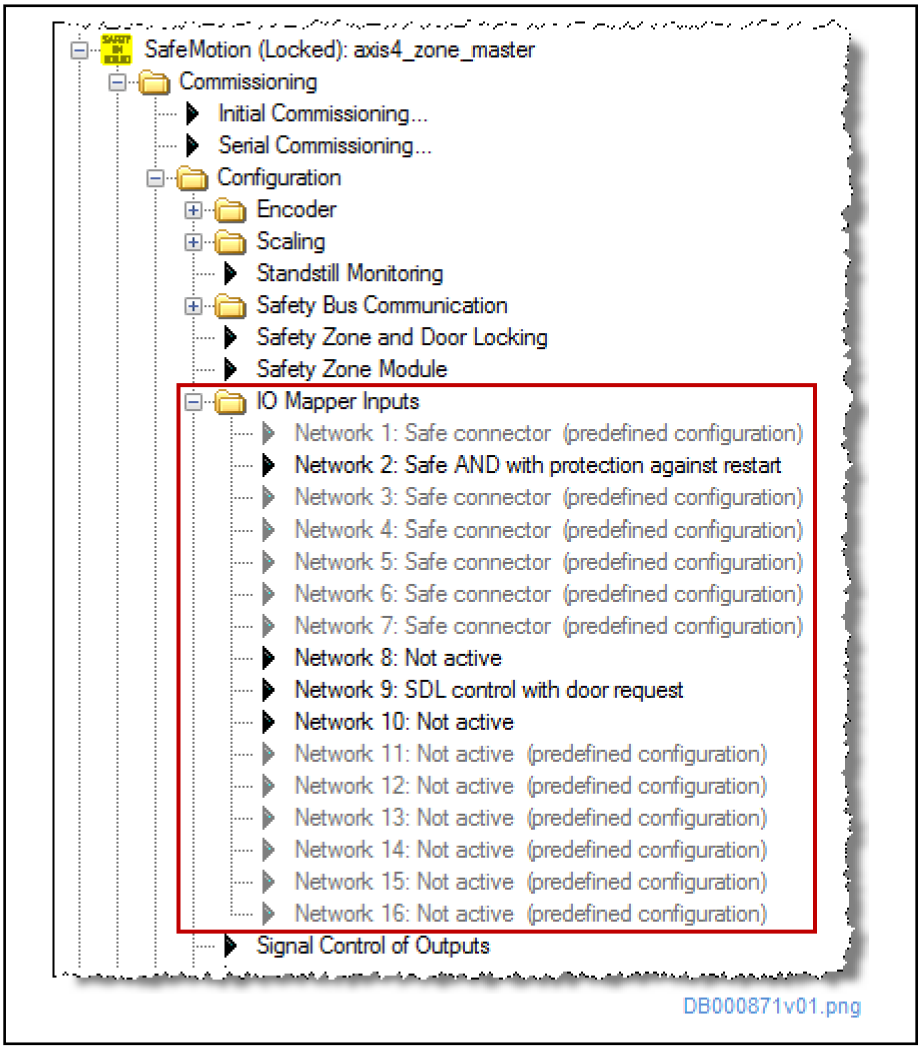


Fig. 7-11: "IO mapper inputs" function tree in the Project Explorer

- When the IO mapper block type is changed, the allowed input/output signals change in many cases. The signals that were set are not changed, but might possibly be displayed as invalid.
- Which input signals can be processed by an IO mapper block depends on the IO mapper block type.
- The multiple use of inputs is possible, because source signals can be simultaneously assigned to several networks.
- IO mapper blocks have at least one input at which a signal has to be applied. It is not necessary to apply a signal at optional inputs. If no signal has been applied to an optional input (the input is not used), S-0-0000 has to be configured as the source signal at the optional input.

The parameter [ident number (IDN)] and bit to which the result of an IO mapper block (output signal) can be assigned also depend on the IO mapper block type.

Pertinent parameters

The following parameters are used in conjunction with the "IO mapper inputs":

- P-0-3253, SMO: Safe homing procedure control word
- P-0-3261, SMO: State machine control word
- P-0-3265.0.2, SMO: Control word of safe braking and holding function
- P-0-3266.0.3, SMO: Control word of safe door locking
- P-0-3273.0.1, SMO: Status word, bit-coded SCA
- P-0-3320, SMO: Safe Input Signals, safety zone module
- P-0-3322.0.1, SMO: Functional input signals, local
- P-0-3329, SMO: Functional input signals, drive
- P-0-3330.x.1, SMO: IO mapper inputs, type
- P-0-3330.x.2, SMO: IO mapper inputs, IDN source
- P-0-3330.x.3, SMO: IO mapper inputs, bit source
- P-0-3330.x.4, SMO: IO mapper inputs, IDN target
- P-0-3330.x.5, SMO: IO mapper inputs, bit target
- P-0-3331.x.130, SMO: IO mapper block type, compact
- P-0-3332.0.1, SMO: IO mapper inputs, minimum pulse duration
- P-0-3340, SMO: Safety bus control word

Pertinent diagnostic messages

The following diagnostic messages can be generated in conjunction with the "IO mapper inputs":

- C8214 SMO: Incorrect configuration
- F3010 SMO: IO mapper inputs error

7.4.2 IO mapper block types

"Inactive"

Using the "inactive" IO mapper block (type 0), a logic block instance can be deactivated. No data are written to an output signal.

"Safe connector"

The IO mapper block "Safe connector" provides a direct 1:1 connection between the signal of a safe input and a target parameter.

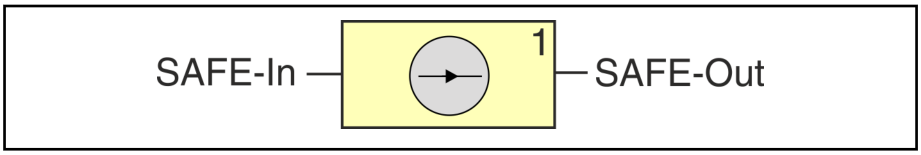


Fig. 7-12: IO mapper block "Safe connector" (type 1)

Variables of the IO mapper block

Input variable	Type of input
SAFE-In	Safe input

Tab. 7-7: Input variable of the IO mapper block "Safe connector"

Selection/acknowledgment

Output variable	Possible target IDNs	Possible target bits
SAFE-Out	P-0-3261, SMO: State machine control word	Bit 0 [mode selection signal (MS)] Bit 1 [emergency stop signal (SMES)] Bit 2 [enabling control signal (EC)] Bits 3...18 [SMMx signal (A_SSMx), x=1..16]
	P-0-3265.0.2, SMO: Control word of safe braking and holding function	Bit 0 (release holding system)
	P-0-3266.0.3, SMO: Control word of safe door locking	Bit 0 (unlock safety door request) Bit 1 (feedback contacts of safety door)

Tab. 7-8: Output variable of the IO mapper block "Safe connector"

Maximum number of instances: 16

"Safe inversion"

The IO mapper block "Safe inversion" safely connects a safe input to a target parameter and inverts the signal.

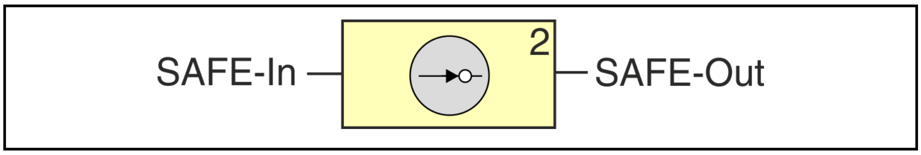


Fig. 7-13: IO mapper block "Safe inversion" (type 2)

Variables of the IO mapper block

Input variable	Type of input
SAFE-In	Safe input

Tab. 7-9: Input variable of the IO mapper block "Safe inversion"

Output variable	Possible target IDNs	Possible target bits
SAFE-Out	P-0-3261, SMO: State machine control word	Bit 2 [enabling control signal (EC)] Bits 3...18 [SMMx signal (A_SSMx), x=1..16]

Tab. 7-10: Output variable of the IO mapper block "Safe inversion"

Maximum number of instances: 16

"Safe constant selection"

With the IO mapper block "Safe constant selection", a target parameter can be safely, statically selected with logic "1".

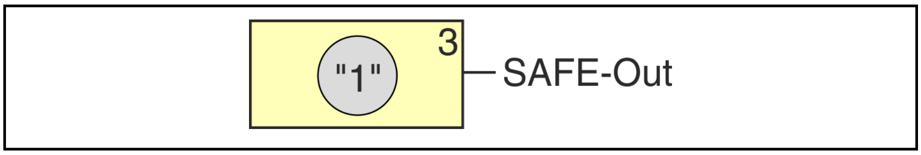


Fig. 7-14: IO mapper block "Safe constant selection" (type 3)

Variables of the IO mapper block

Output variable	Possible target IDNs	Possible target bits
SAFE-Out	P-0-3261, SMO: State machine control word	Bits 3...18 [SMMx signal (A_SSMx), x=1..16]

Tab. 7-11: Output variable of the IO mapper block "Safe constant selection"

Maximum number of instances: 16

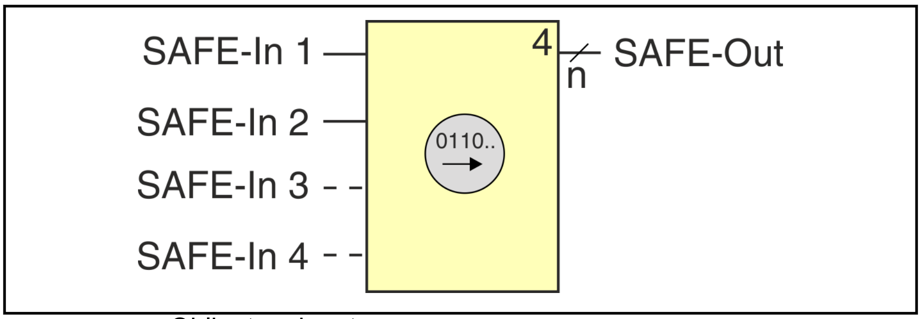
"Binary-to-bit decoder"

With the IO mapper block "binary-to-bit decoder", the binary-coded selection signals of the Safety bus communication can be decoded for the special mode "Safe motion".

As input variables, only selection signals of the Safety bus communication (P-0-3340, bits 3 to 15) and of the Safe CAM (P-0-3273) are allowed.

The decoding can be carried out for at least 2 bit, binary and a maximum of 4 bit, binary to 4-fold or 16-fold bit-coded for the selection of Safe motion.

Only the initial bit within the target parameter is required as the output signal. The other target bits are used implicitly in ascending, consecutive order. All source bits have to come from the same parameter.



____ Obligatory input
_ _ _ Optional input

Fig. 7-15: IO mapper block "binary-to-bit decoder" (type 4)

Variables of the IO mapper block

Input variable	Type of input
SAFE-In 1	Safe input
SAFE-In 2	Safe input
SAFE-In 3	Safe input
SAFE-In 4	Safe input

Tab. 7-12: Input variables of the IO mapper block "binary-to-bit decoder"

Output variable	Possible target IDNs	Possible target bits
SAFE-Out	P-0-3261, SMO: State machine control word	Bit 3 [SMM1 signal (A_SSM1)]

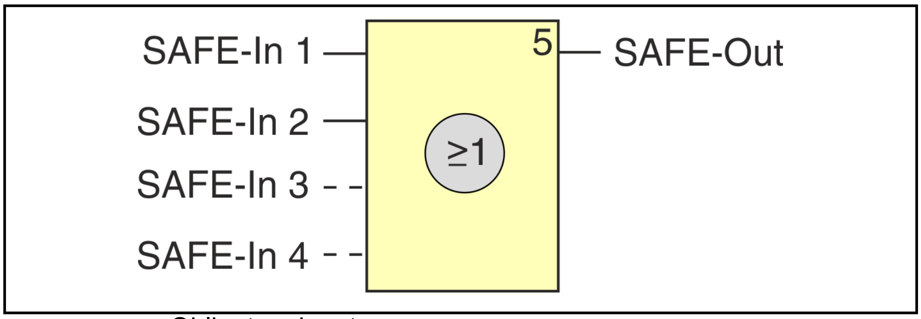
Tab. 7-13: Output variable of the IO mapper block "binary-to-bit decoder"

Maximum number of instances: 1

"Safe OR"

With the IO mapper block "Safe OR", the safe input signals of multiple enabling control devices can be processed in parallel. At least 2 inputs have to be used; a maximum of 4 input signals is allowed.

Selection/acknowledgment



____ Obligatory input

_ _ _ Optional input

Fig. 7-16: IO mapper block "Safe OR" (type 5)

Variables of the IO mapper block

Input variable	Type of input
SAFE-In 1	Safe input
SAFE-In 2	Safe input
SAFE-In 3	Safe input
SAFE-In 4	Safe input

Tab. 7-14: Input variable of the IO mapper block "Safe OR"

Output variable	Possible target IDNs	Possible target bits
SAFE-Out	P-0-3261, SMO: State machine control word	Bit 2 [enabling control signal (EC)]

Tab. 7-15: Output variable of the IO mapper block "Safe OR"

Maximum number of instances: 1

"Safe AND with protection against restart"

The IO mapper block "Safe AND with protection against restart" is used for the parallel processing of multiple emergency stop signals (ES) or multiple mode selection signals (MS), and for protection against restart by reset and start inputs or start input only.

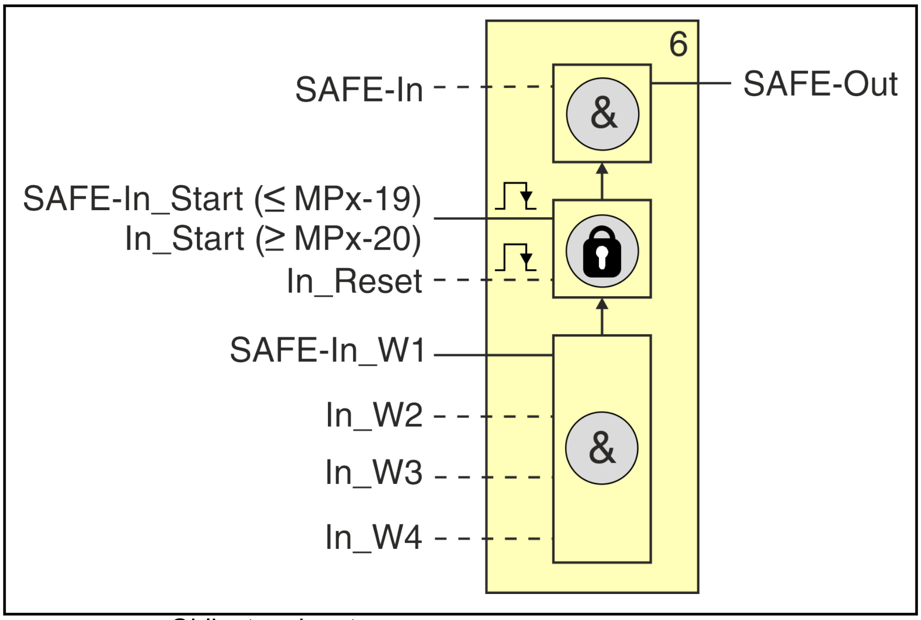
Function

The "SAFE-In_W1" and "In_W2" to "In_W4" inputs are ANDed. The result is connected with the input of the restart lockout block ().

When the AND operation of the "SAFE-In_W1" and "In_W2" to "In_W4" inputs provides logic "0", the output of the restart lockout block is set to logic "0". To set this output to logic "1" again, a negative edge first has to be detected at the "SAFE-In_Start" (MPx-19 and below) or "In_Start" (MPx-20 and above) input.

If the optional "In_Reset" input is used, a negative edge first has to be detected here and then at the "SAFE-In_Start" (MPx-19 and below) or "In_Start" (MPx-20 and above) input. When this has happened and stable logic "1" is still applied at the output of the AND operation, the output of the restart lockout block is logic "1".

If the optional safe input "SAFE_In" is used, it is ANDed with the result of the restart lockout block and the result is applied to the "SAFE-Out" output.



_____ Obligatory input
_ _ _ Optional input

Fig. 7-17: IO mapper block "Safe AND with protection against restart" (type 6)

Variables of the IO mapper block

Input variable	Type of input
SAFE-In_W1	Safe input
In_W2	Functional input
In_W3	Functional input
In_W4	Functional input
SAFE-In_Start (MPx-19 and below) In_Start (MPx-20 and below)	Safe input Functional input / Safe input[1)]
In_Reset	Functional input
SAFE-In	Safe input

1) depending on the source signal of "In_Start", a different performance level (PL) is achieved: **PL d** with **functional input signal** as source of "In_Start"; **PL e** with **safe input signal** as source of "In_Start"

Tab. 7-16: Input variable of the IO mapper block "Safe AND with protection against restart"

Output variable	Possible target IDNs	Possible target bits
SAFE-Out	P-0-3261, SMO: State machine control word	Bit 0 [mode selection signal (MS)] Bit 1 [emergency stop signal (ES)]

Tab. 7-17: Output variable of the IO mapper block "Safe AND with protection against restart"

Maximum number of instances: 2

There is pulse duration monitoring for the "SAFE-In_Start" (MPx-19 and below) or "In_Start" (MPx-20 and above) and "In_Reset" inputs with regard to the value defined in "P-0-3332.0.1, SMO: IO mapper inputs, minimum pulse

Selection/acknowledgment

duration". When the value falls below the minimum pulse duration, "F3010 SMO: IO mapper inputs error" is generated. When the maximum pulse duration of 30 seconds is exceeded, F3010 is also generated.

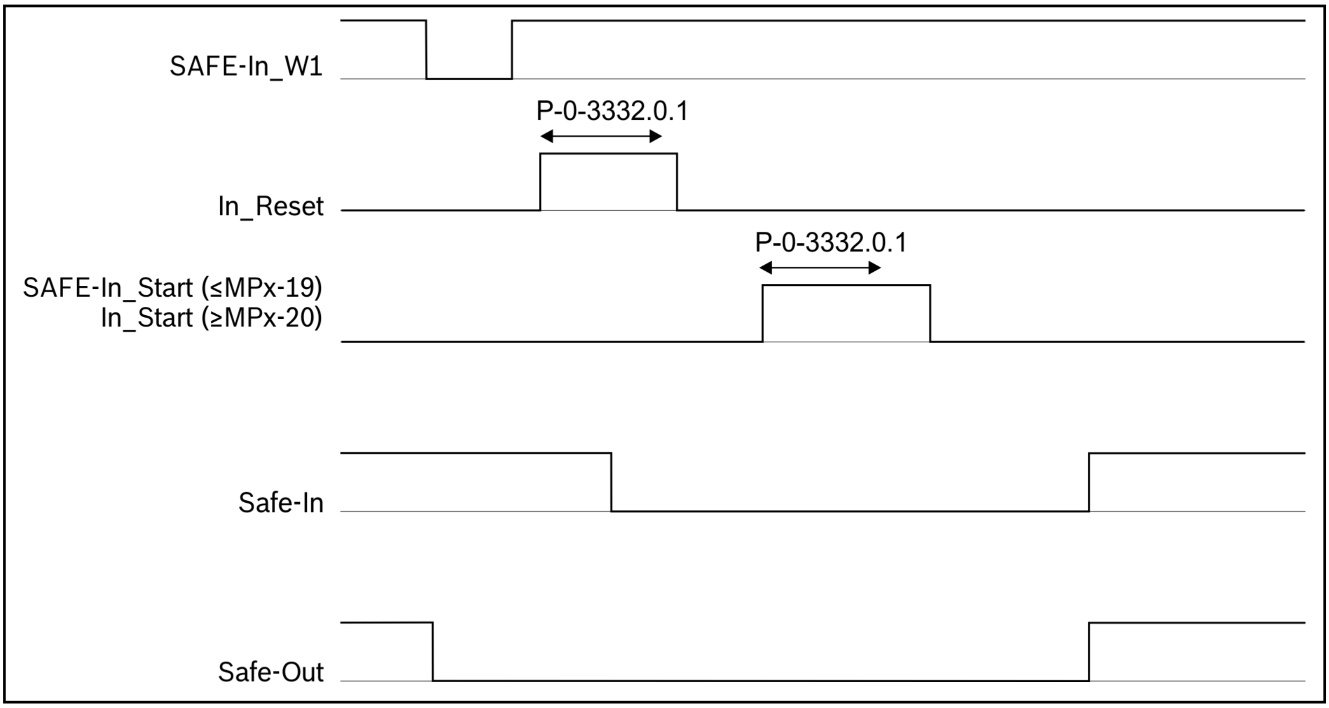


Fig. 7-18: Pulse duration complied with

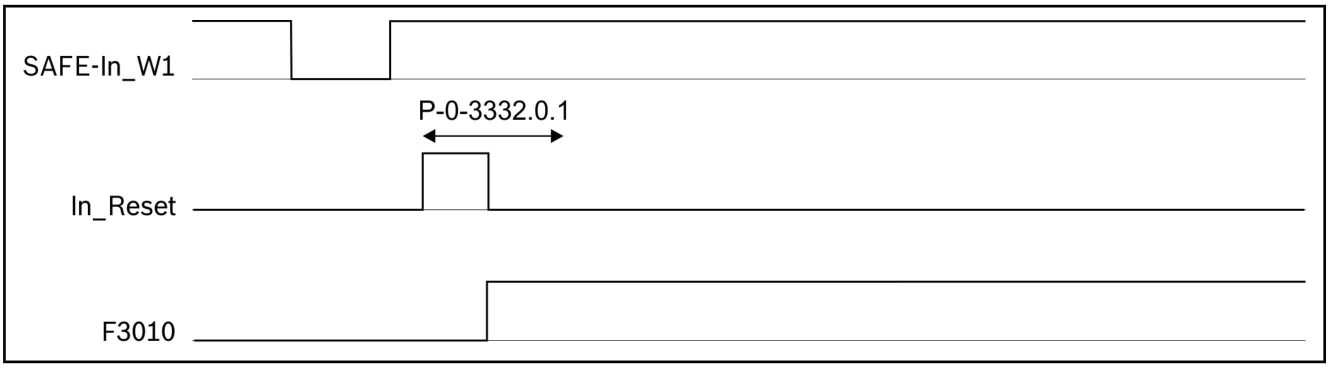


*Fig. 7-19: Pulse duration **not** complied with*

"SDL with door request"

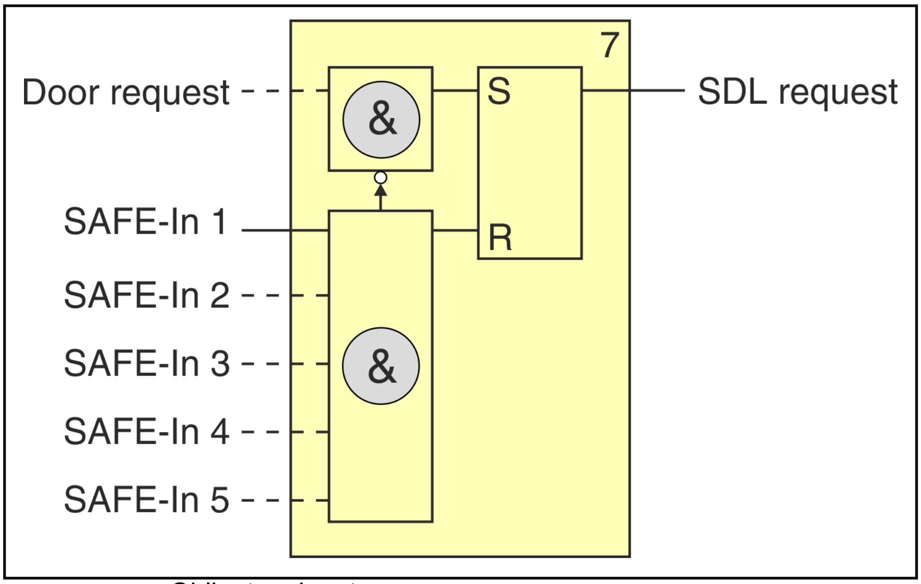
The IO mapper block "SDL with door request" allows multiple selection options for the special mode to be processed in conjunction with the control of a door locking device via SDL. Optionally, the door can be enabled in the special mode when the "door request" input is set.

Function

ANDing of the "SAFE-In 1" to "SAFE-In 5" inputs as a reset signal for the RS flip-flop.

ANDing of the "door request" with the inverted result of the AND operation of the "Safe-In" inputs to hereby set the RS flip-flop. The output controls the "SDL request".

☞ When the SDL function is used, the feedback contacts of the safety door locking device have to be connected to the corresponding parameter via a safe connector.



____ Obligatory input
_ _ _ Optional input

Fig. 7-20: "SDL with door request" (type 7)

Variables of the IO mapper block

Input variable	Type of input
SAFE-In 1	Safe input
SAFE-In 2	Safe input
SAFE-In 3	Safe input
SAFE-In 4	Safe input
SAFE-In 5	Safe input
Door request	Functional input

Tab. 7-18: Input variable of the IO mapper block "SDL with door request"

Output variable	Possible target IDNs	Possible target bits
SDL request	P-0-3266.0.3, SMO: Control word of safe door locking	Bit 0 ("unlock safety door" request); bit 0="0": lock; bit 0="1"; unlock

Tab. 7-19: Output variable of the IO mapper block "SDL with door request"

Maximum number of instances: 1

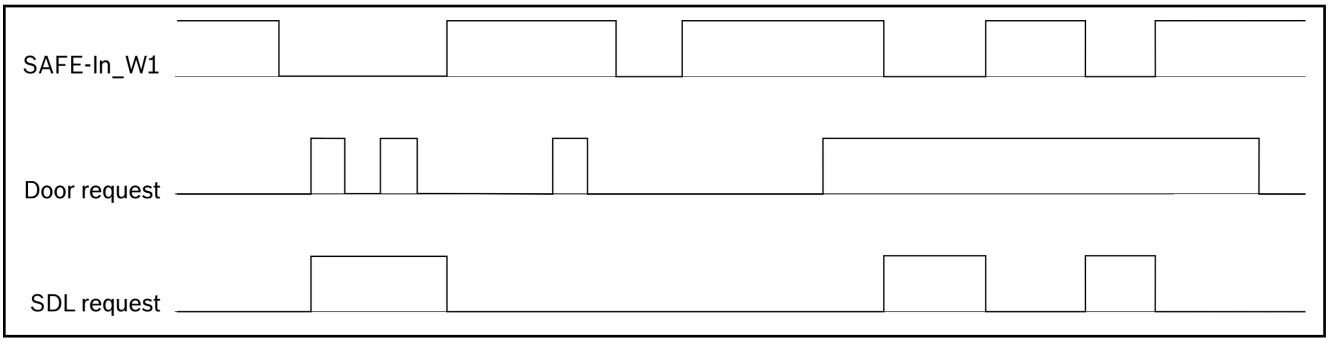


Fig. 7-21: SDL timing diagram

"Safe AND"

The IO mapper block "Safe AND" is available in the firmware MPx-20 and above.

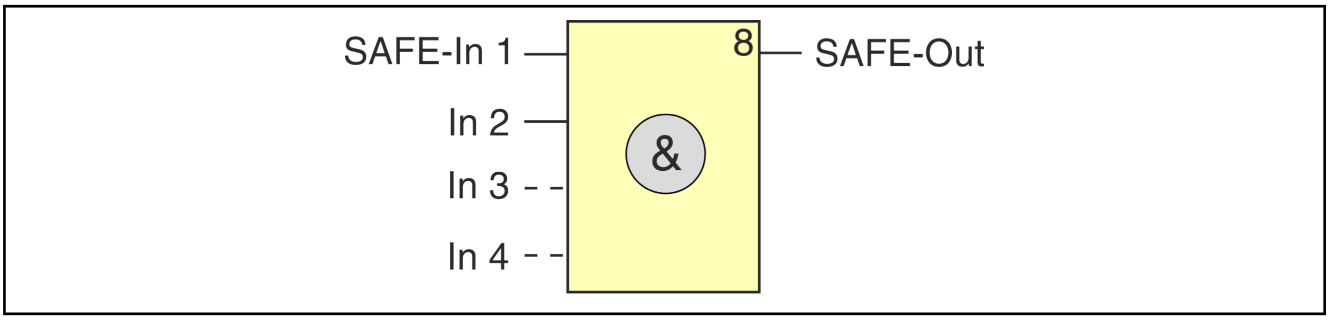
Selection/acknowledgment

The IO mapper block "Safe AND" is used to map additional activation signals [mode selection signal (MS), enabling control signal (EC), SMMx signal (A_SSMx)] to other, also functional, signals from the machine/installation.

The output of the block can be used to control the operating states [normal operation, Safe stop (SMST1 and SMST2), Safe motion (SMM1 to SMM16)], the holding brake and/or the locking of the safety door locking device.

In the example "Selection of special mode via external mode selector, special mode switching for loading/equipping and locking via safe cams, in parallel emergency stop pushbutton", the "Safe AND" block is used to evaluate the status of a safe cam: a "Safe motion x" can only be selected if the drive is within a defined range.

Function Logic AND operation of the inputs SAFE-In 1, In 2, In 3 and In 4. At least 2 inputs have to be used; apart from that, two optional inputs are available. The status TRUE is internally pre-assigned to optional inputs that are not used.



____ Obligatory input
_ _ _ Optional input

Fig. 7-22: IO mapper block "Safe AND" (type 8)

Variables of the IO mapper block

Input variable	Type of input
SAFE-In 1	Safe input
In 2	Functional input
In 3	Functional input
In 4	Functional input

Tab. 7-20: Input variables of the IO mapper block "Safe AND"

Output variable	Possible target IDNs	Possible target bits
SAFE-Out	P-0-3261, SMO: State machine control word	Bit 0 [mode selection signal (MS)] Bit 2 [enabling control signal (EC)] Bits 3...18 [SMMx signal (A_SSMx), x=1..16]
	P-0-3265.0.2, SMO: Control word of safe braking and holding function	Bit 0 (release holding system)
	P-0-3266.0.3, SMO: Control word of safe door locking	Bit 0 (unlock safety door request)

Tab. 7-21: Output variables of the IO mapper block "Safe AND"

Maximum number of instances: 16

"Functional connector"

The IO mapper block "Functional connector" is available in the firmware MPx-20 and above.

The IO mapper block "Functional connector" is used to map a reference signal at a functional input to the control word of the safety technology function "Safe homing procedure".

Function

The IO mapper block provides a direct 1:1 connection between the signal of a functional input and a target parameter.

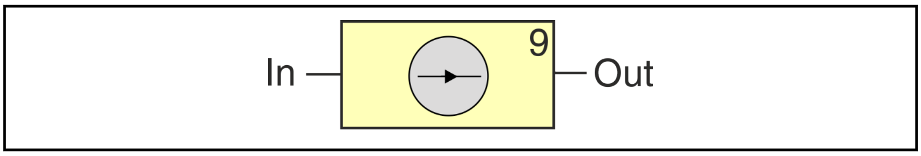


Fig. 7-23: IO mapper block "Functional connector" (type 9)

Variables of the IO mapper block

Input variable	Type of input
In 1	Functional input

Tab. 7-22: Input variable of the IO mapper block "Functional connector"

Output variable	Possible target IDNs	Possible target bits
Out	P-0-3253.0.0, SMO: Safe homing procedure control word	Bit 0 (SMO reference signal)

Tab. 7-23: Output variable of the IO mapper block "Functional connector"

Maximum number of instances: 1

Safe AND with ES bypass and protection against restart

The IO mapper block "Safe AND with ES bypass and protection against restart" is available in the firmware MPx-20 and above.

The IO mapper block "Safe AND with ES bypass and protection against restart" is used for parallel processing of multiple emergency stop signals (ES) and the protection against automatic restart. The individual emergency stop signals (ES) can be dynamically masked using bypass signals.

Function

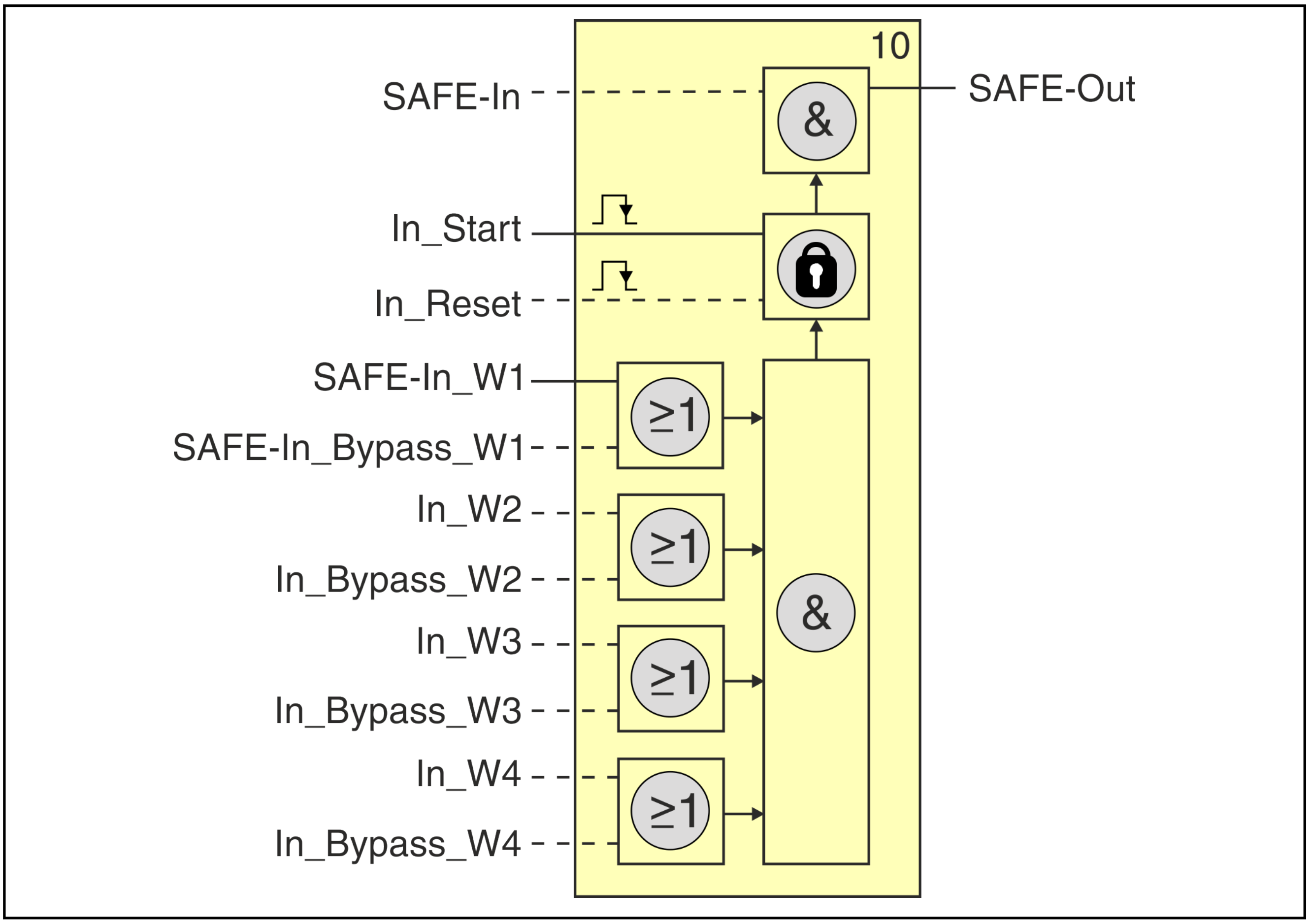
The "SAFE-In_W1" and "In_W2" to "In_W4" inputs are ANDed. Via the optional bypass inputs SAFE-In_Bypass_W1 and In_Bypass_W2 to In_Bypass_W4, these inputs can be masked for the AND operation. The result of the AND operation is connected with the input of the restart lockout block ().

If the AND operation of the inputs provides logic "0", the output of the restart lockout block is set to logic "0". To set this output to logic "1" again, a negative edge first has to be detected at the "In_Start" input.

If the optional "In_Reset" input is used, a negative edge first has to be detected here and then at the "In_Start" input. When this has happened and stable logic "1" is still applied at the output of the AND operation, the output of the restart lockout block is logic "1".

If the optional safe input "SAFE_In" is used, it is ANDed with the result of the restart lockout block and the result is applied to the "SAFE-Out" output.

Selection/acknowledgment



____ Obligatory input
_ _ _ Optional input

Fig. 7-24: IO mapper block "Safe AND with ES bypass and protection against restart" (type 10)

Variables of the IO mapper block

Input variable	Type of input
SAFE-In_W1	Safe input
SAFE-In_Bypass_W1	Safe input
In_W2	Functional input
In_Bypass_W2	Functional input
In_W3	Functional input
In_Bypass_W3	Functional input
In_W4	Functional input
In_Bypass_W4	Functional input
In_Start	Functional input / Safe input[1)]
In_Reset	Functional input
SAFE-In	Safe input

1) depending on the source signal of "In_Start", a different performance level (PL) is achieved: **PL d** with **functional input signal** as source of "In_Start"; **PL e** with **safe input signal** as source of "In_Start"

Tab. 7-24: Input variable of the IO mapper block "Safe AND with ES bypass and protection against restart"

Output variable	Possible target IDNs	Possible target bits
SAFE-Out	P-0-3261, SMO: State machine control word	Bit 1 [emergency stop signal (ES)]

Tab. 7-25: Output variable of the IO mapper block "Safe AND with ES bypass and protection against restart"

Maximum number of instances: 1

There is pulse duration monitoring for the inputs "In_Start" and "In_Reset" with regard to the value defined in "P-0-3332.0.1, SMO: IO mapper inputs, minimum pulse duration". When the value falls below the minimum pulse duration, "F3010 SMO: IO mapper inputs error" is generated. When the maximum pulse duration of 30 seconds is exceeded, F3010 is also generated.

Selection/acknowledgment

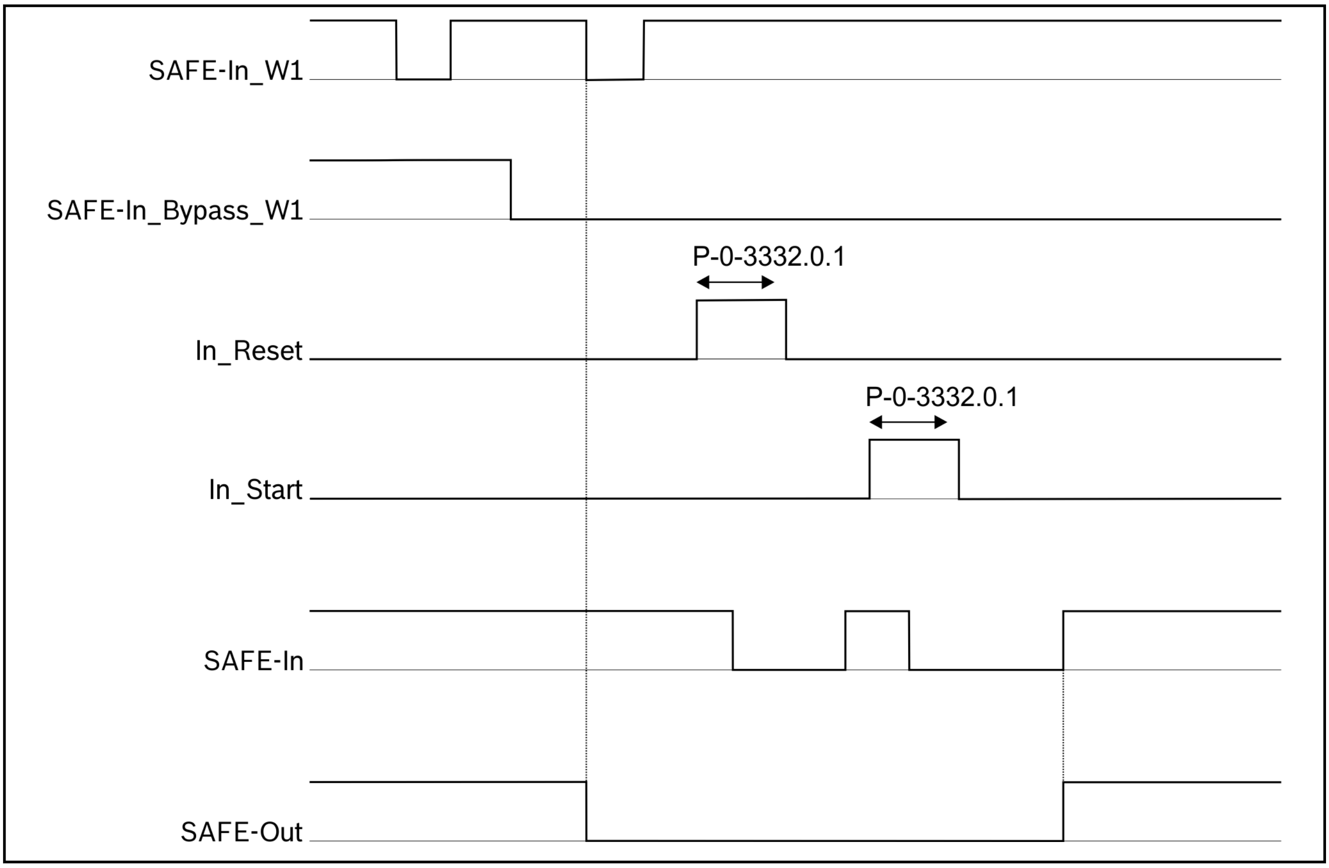


Fig. 7-25: Pulse duration complied with (in addition, the selection of "SAFE-In_W1" is masked via the signal "SAFE-In_Bypass_W1")

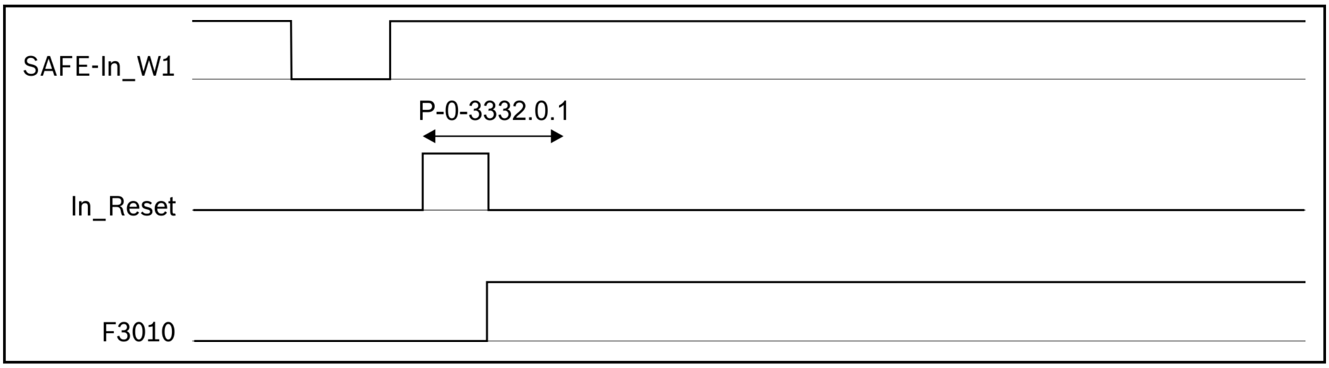


*Fig. 7-26: Pulse duration **not** complied with*

7.4.3 Exemplary applications for "IO mapper inputs"

Example:

Selection of special mode via external mode selector, special mode switching for loading/equipping, in parallel: emergency stop pushbutton with restart

- Mode selector [automatic (=1) / special mode (=0)]:

  Direct switching between normal operation and special mode "Safe motion"
- Special mode switch [loading (=1) / equipping (=0)]:

  Switching between SMM1 (loading) and SMM2 (equipping)
- Emergency stop [not active (=1) / active (=0)]:

Activation of emergency stop

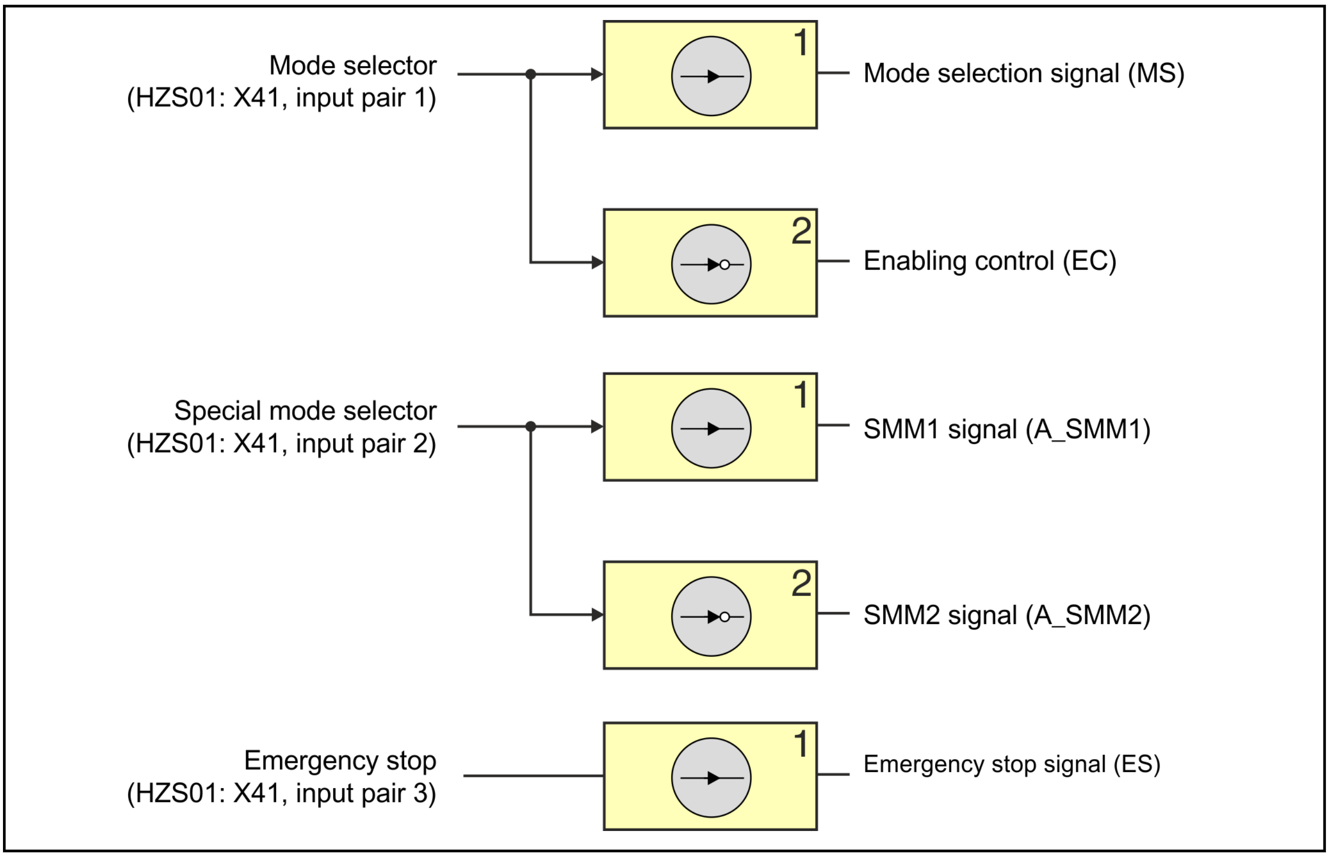


Fig. 7-27: Graphical representation of the networks

The operating states are described in the Safe Motion profile "Bosch Rexroth".

Selection/acknowledgment

Overview of parameterization

Network number	IO mapper block	Input signal	Type of input	Output signal
1	Type 1 "Safe connector"	Mode selector (safety zone module HZS01: input pair 1)	Safe input	Mode selection signal (MS)
2	Type 2: „Safe inversion“	Mode selector (safety zone module HZS01: X41, input pair 1)	Safe input	Enabling control signal (EC)
3	Type 1 "Safe connector"	Special mode selector switch (safety zone module HZS01: X41, input pair 2)	Safe input	SMM1 signal (A_SMM1)
4	Type 2: „Safe inversion“	Special mode selector switch (safety zone module HZS01: X41, input pair 2)	Safe input	SMM2 signal (A_SMM2)
5	Type 1 "Safe connector"	Emergency stop (safety zone module HZS01: X41, input pair 3)	Safe input	Emergency stop signal (ES)

Example:

Control word of safety bus system with predefined configuration type 2: "1-byte SMO control word, binary-coded SMM", local selection of emergency stop via protection against restart is present in parallel.

- Mode selector [automatic (=1) / special mode (=0)]:
  direct switching between normal operation and special mode "Safe motion"
- Emergency stop [not active (=1) / active (=0)]:
  Activation of emergency stop
- Enabling of restart [enabled (=1) / not enabled (=0)]:
  Enabling of restart after local emergency stop
- Enabling control device [active (=1) / not active (=0)]:
  Activation of the selected special mode "Safe motion"
- Special mode switch:
  Switching between SMM1 to SMM7
- Release brake [active (=1) / not active (=0)]:
  Manually releasing the motor brake

Selection/acknowledgment

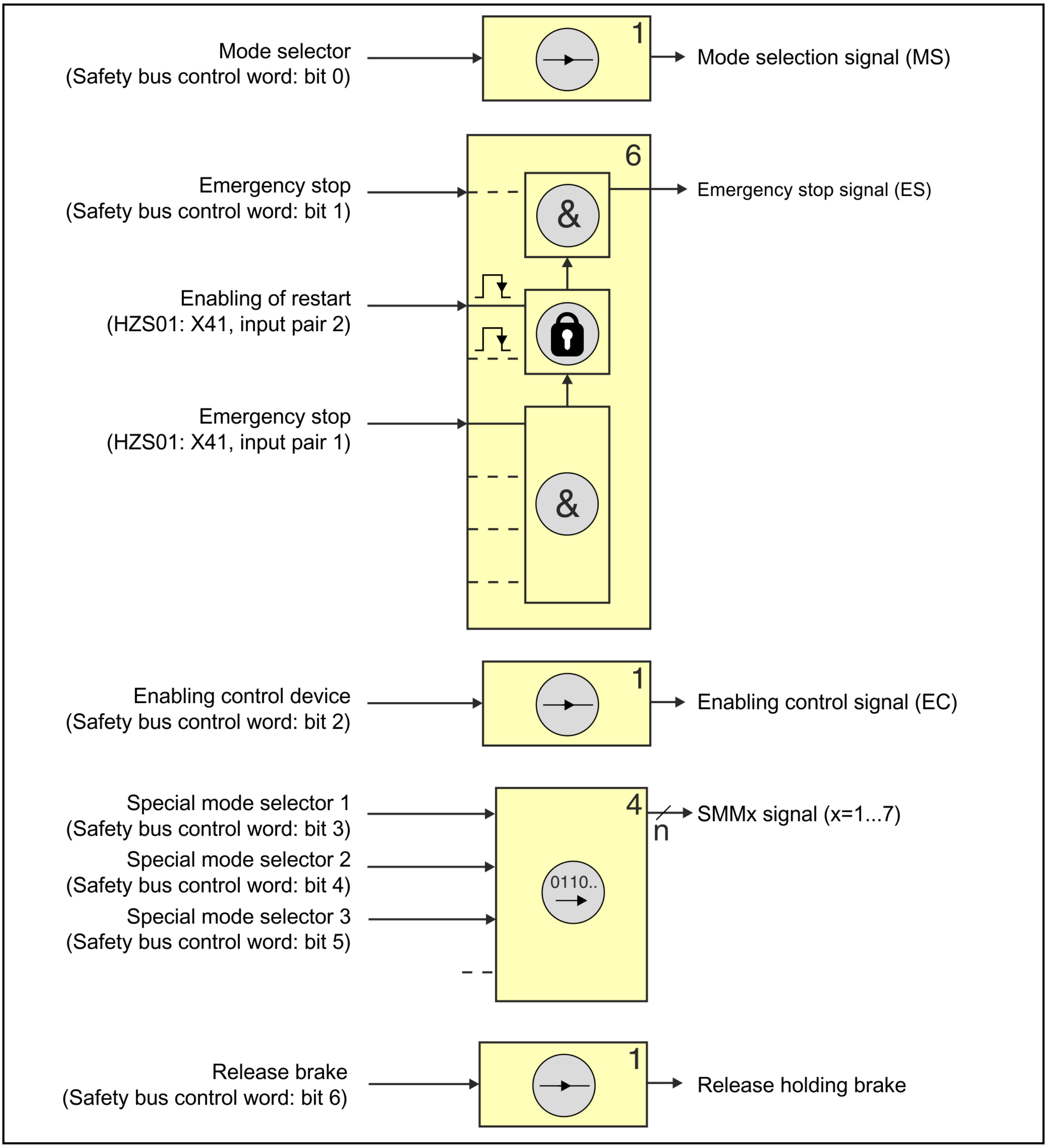


Fig. 7-28: Graphical representation of the networks

The operating states are described in the Safe Motion profile "Bosch Rexroth".

Selection/acknowledgment

Overview of parameterization

Network number	IO mapper block	Input number	Input signal	Type of input	Output signal
1	Type 1 "Safe connector"	1	Mode selector (control word of safety bus: bit 0)	Safe input	Mode selection signal (MS)
2	Type 6: "Safe AND with protection against restart"	1	Emergency stop (safety zone module HZS01: X41, input pair 1)	Safe input	Emergency stop signal (ES)
		2	Not assigned		
		3	Not assigned		
		4	Not assigned		
		5	Enabling of restart (safety zone module HZS01: X41, input pair 2)	Safe input	
		6	Not assigned		
		7	Emergency stop (control word of safety bus: bit 1)	Safe input	
3	Type 1 "Safe connector"	1	Enabling control device (control word of safety bus: bit 2)	Safe input	Enabling control signal (EC)
4	Type 4: "Binary-to-bit decoder"	1	Special mode selector switch 1 (control word of safety bus: bit 3)	Safe input	SMM1 signal
		2	Special mode selector switch 2 (control word of safety bus: bit 4)	Safe input	SMM2 signal
		3	Special mode selector switch 3 (control word of safety bus: bit 5)	Safe input	SMM3 signal
		4	Not assigned		SMM4 signal
		5	Not assigned		SMM5 signal
		6	Not assigned		SMM6 signal
		7	Not assigned		SMM7 signal
		8	Not assigned		SMM8 signal
5	Type 1 "Safe connector"	1	Release brake (control word of safety bus: bit 6)	Safe input	Release holding brake

Example:

Selection of special mode via external mode selector, special mode switching for loading/equipping and locking via safe cams, in parallel emergency stop pushbutton

- Mode selector [automatic (=1) / special mode (=0)]:

  Direct switching between normal operation and special mode "Safe motion"
- Special mode selector switch [loading (=1)]:

  Selection SMM1 (loading)
- Special mode selector switch [equipping (=1)]:

  Selection SMM2 (equipping)
- Emergency stop [not active (=1) / active (=0)]:

  Activation of emergency stop

Selection/acknowledgment

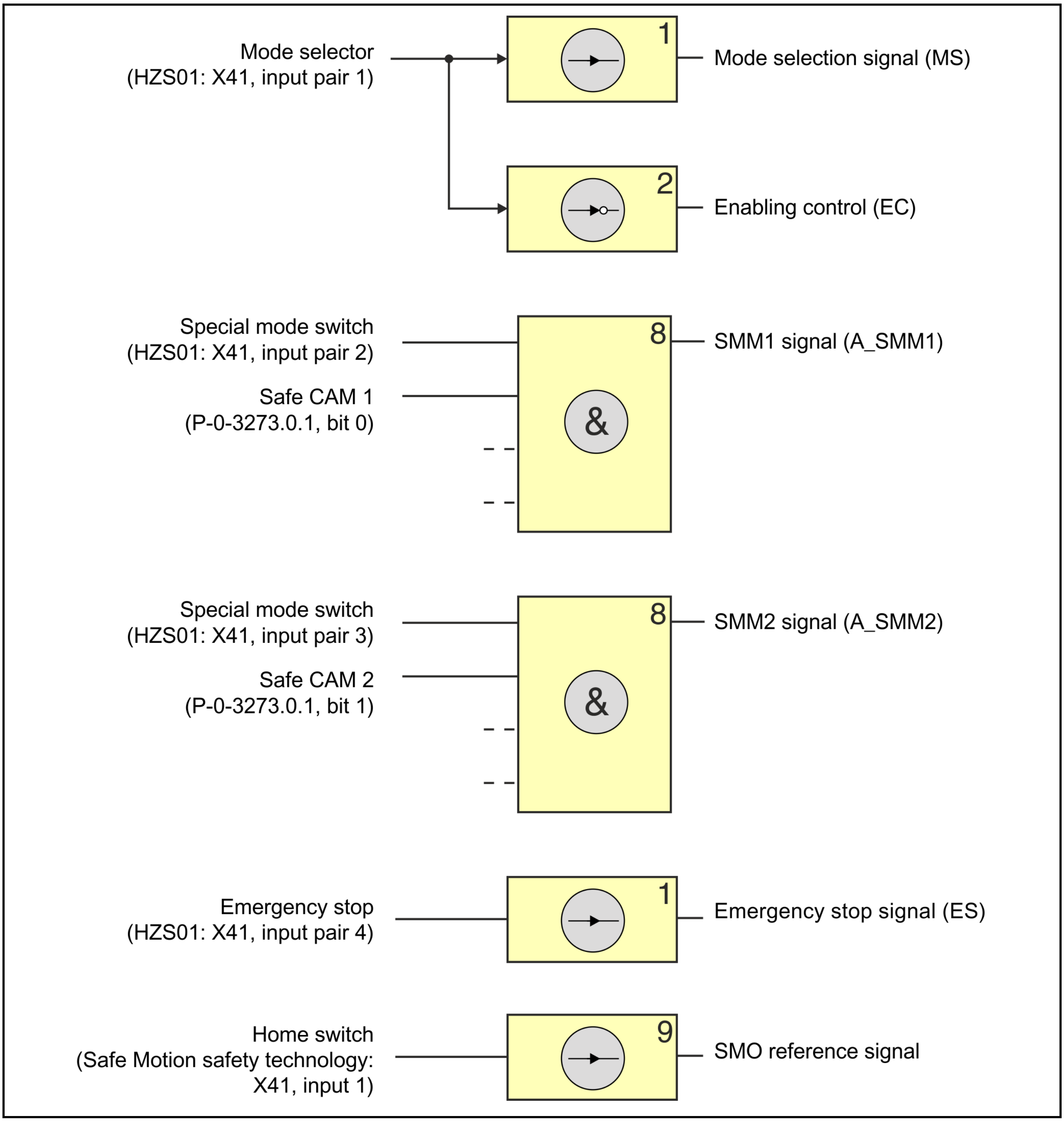


Fig. 7-29: Graphical representation of the networks

The operating states are described in the Safe Motion profile "Bosch Rexroth".

Overview of parameterization

Network number	IO mapper block	Input number	Input signal	Type of input	Output signal
1	Type 1 "Safe connector"	1	Mode selector (safety zone module HZS01: X41, input pair 1)	Safe input	Mode selection signal (MS)
2	Type 2: "Safe inversion"	1	Mode selector (safety zone module HZS01: X41, input pair 1)	Safe input	Enabling control signal (EC)
3	Type 8 "Safe AND"	1	Special mode selector switch (safety zone module HZS01: X41, input pair 2)	Safe input	SMM1 signal (A_SMM1)
		2	Safe CAM 1 (P-0-3273.0.1, bit 0)	Functional input	
			Not assigned	Functional input	
			Not assigned	Functional input	
4	Type 8: "Safe AND"	1	Special mode selector switch (safety zone module HZS01: X41, input pair 3)	Safe input	SMM2 signal (A_SMM2)
		2	Safe CAM 2 (P-0-3273.0.1, bit 1)	Functional input	
			Not assigned	Functional input	
			Not assigned	Functional input	
5	Type 1 "Safe connector"	1	Emergency stop (safety zone module HZS01: X41, input pair 4)	Safe input	Emergency stop signal (ES)
6	Type 9 "Functional connector"	1	Home switch (Safe Motion safety technology: X41, input 1	Functional input	SMO reference signal

7.5 Signal control of outputs

By means of the "signal control of outputs", it is possible to specify which signal is to be output via the safe local output [X41 (S4, S5) or X141 (S3, SD) at the optional safety technology module]. The safe local output is suitable for safety-relevant applications up to category 4, PL e according to EN ISO 13849-1 or up to SIL 3 according to IEC EN 62061.

Selection/acknowledgment

☞ The **achievable** safety level of the function depends on the signal that is to be output via the safe local output; the entire safety chain is to be considered.

Example: If the encoder standstill signal is connected to the output, the safety level is determined by the encoder version (usually category 3, PL d and/or SIL 2).

IndraWorks supports the "signal control of outputs" via the entry of the same name in the function tree of the Project Explorer, and within the scope of the wizard for initial commissioning. The dialog is described in detail in the chapter "Initial commissioning", "Signal control of outputs".

The parameters P-0-3335.0.1 and P-0-3335.0.2 can be used to determine which signal is to be output via the safe local output. The available status parameters and status bits are defined in the parameters P-0-3335.0.3 and P-0-3335.0.4.

☞ When the "signal control of outputs" is used, the power supply of the inputs/outputs must be wired at the connector X41 and/or X141 at the optional safety technology module. A missing 24V supply is diagnosed via the error "F3360 SMO: Local I/O system error".

Pertinent parameters

The following parameters can be used in conjunction with the "signal control of outputs":

- P-0-3335.0.1, SMO: Signal control for discrete outputs, IDN assignment
- P-0-3335.0.2, SMO: Signal control for discrete outputs, bit number
- P-0-3335.0.3, SMO: Signal ctrl for discrete outputs, possible source IDNs
- P-0-3335.0.4, SMO: Signal ctrl for discrete outputs, possible source bits

Pertinent diagnostic messages

The following diagnostic messages can be generated in conjunction with the "signal control of outputs":

- C8214 SMO: Incorrect configuration
- F3360 SMO: Local I/O system error

7.6 Safety zone acknowledge (SZA)

7.6.1 Brief description

If there are several axes in a danger zone at a machine, it is useful to combine them in a safety zone. The IndraDrive safety system allows combining up to 35 axes in a safety zone via discrete wiring. The zone setup is independent of the selection of the safety function (e.g. discrete or via the safe master communication) at the individual axes.

The safety of the entire safety zone is monitored by a zone master and can be acknowledged to a higher-level control unit via a safe output pair of the safety zone module "HSZ01". Alternatively, the zone master of the safety zone can directly control a safe door locking device connected to the safety zone module [see "Safe door locking (SDL)"].

Features

The safety function "Safety zone acknowledge" has the following features:

- Is suited for safety-relevant applications up to Category 4, PL e according to EN ISO 13849-1 or up to SIL 3 according to IEC EN 62061.

- The safety level achieved for the safety function "Safety zone acknowledge (SZA)" depends on the safety level achieved in the zone nodes. The zone node with the lowest safety level determines the safety level of the Safety zone acknowledge.
- The safety zone can consist of a maximum of 35 axes and the safety zone module.
- To set up a safety zone, a safety zone module (HSZ01) is always required.
- Only axes of the IndraDrive C/M/ML and Cs ranges, that have been equipped with the optional safety technology module "S4" or "S5" can be included in the safety zone.

Pertinent parameters

The following parameters can be used in conjunction with the safety function "Safety zone acknowledge":

- P-0-3266, SMO: Safety zone status word
- P-0-3266.0.1, SMO: Safety zone control word
- P-0-3266.0.2, SMO: Safety zone configuration

Pertinent diagnostic messages

The following diagnostic messages can be generated in conjunction with the safety function "Safety zone acknowledge":

- F3131 Control error, safe inputs of HSZ
- F3153 Safety zone module: SZE/SZA error
- F7035 Zone bus error

7.6.2 Safety function

Using the function

Setting up a discretely wired safety zone requires a safety zone module "HSZ01". All axes that are included in the safety zone (zone participants and zone master) must be equipped with the optional safety technology module "S4" or "S5". The safety zone module provides all zone participants (incl. zone master) with safe inputs for the selection of safety functions. The selection can be made individually for each zone node (incl. zone master) via discrete inputs (safety zone module or local inputs of the axis) or via the safety bus. The zone master of the safety zone cyclically generates the safety status of the zones and can acknowledge it via the following safe outputs of the safety zone module of the safety zone:

- One output pair (X44) to acknowledge the zone safety (SZA)
- One output pair (X44) to control the door locking magnet of a safe door locking device (SDL)

The safety zone module communicates with the zone nodes (incl. zone master) via the safety zone bus. All drives are connected in line and pass on the information, transmitted via the bus (output X43 → input X42), to the next node.

For diagnostic purposes, it is possible to read via "P-0-3266, SMO: Safety zone status word" what the zone participant receives from its predecessor and what it transmits to the next zone node.

A safety zone is set up by means of the wiring of the safety zone bus; i.e. all drives wired in the zone bus must be configured as zone node or zone master and must inform the zone of their safety states.

Selection/acknowledgment

☞ **It is not possible to loop the zone bus through axes that are not part of the safety zone!**

Axes within the safety zone with inactive safety technology or which have not been configured as zone node or zone master, generate the error message F8361 when receiving zone telegrams.

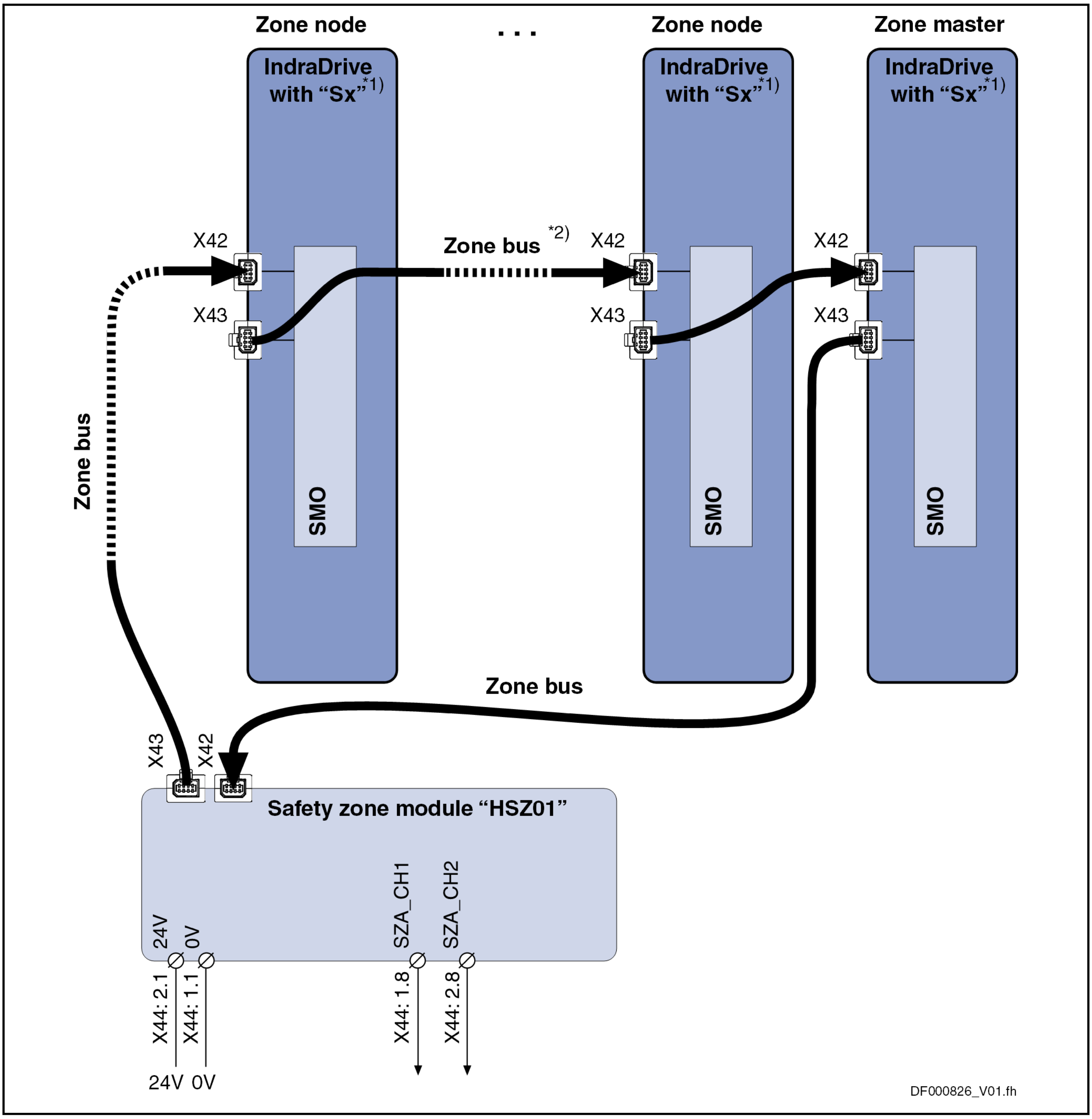
The last zone node before the safety zone module "HSZ01" must always assume the function of the zone master, because it must directly control the "HSZ01" via the zone bus. When it has been configured, the safety function "SZA" is active in the following SMO operating states:

- Operating mode (OM)
- Parameter mode (PM)

In the states "SMO configuration mode (SCM)" and with deactivated safety technology, the SZA function is not active; the outputs at "HSZ01" go to the "Safety Default" state.

☞ Zone nodes that are in the SMO configuration mode do not acknowledge safety, they do not transmit the zone telegrams of the previous zone node.

Selection/acknowledgment



*1)	"Sx" stands for the optional safety technology modules "S4" or "S5"
*2)	A maximum of 35 zone nodes can be integrated (including zone master)
Connection X42↔X43	See "Cables"

Fig. 7-30: Example of zone setup with zone acknowledgement via output pair "SZA"

Requirement for zone acknowledgement

To be able to acknowledge the state of the safety zone, the zone master gets the following pieces of information from the zone bus:

- States of the safe inputs of the safety zone module
- States of the feedbacks of the zone nodes (safe or unsafe)

Selection/acknowledgment

- Status of HSZ01 (error-free or error)
- States of the feedback inputs for the safety door locking device at HSZ01 (only applies to "SDL" configuration)

From its input information, the zone master generates the zone status (safe or not safe) of the safety zone. The zone master acknowledges the safety of the zone under the following conditions:

- The zone master has detected a valid safety selection **and**
- the zone master is in the safe stated **and**
- all zone nodes acknowledge a safe state via the zone bus **and**
- "HSZ01" does not signal any error **and**
- the feedback inputs for the safety door locking device at "HSZ01" signal the same status as the output signal (only applies to "SDL" configuration).

As soon as one of the mentioned conditions is no longer fulfilled, the zone master generates the zone status "not safe" for the safety zone.

7.6.3 Notes on commissioning

To set up a zone, the zone nodes must be configured accordingly. Axes operated at a safety zone with "HSZ01" must be configured as **zone nodes**.

For the acknowledgment of the safety state of the safety zone, the **last axis before the safety zone module (HSZ01) must be configured as zone master**.

The safety zone module does not need to be configured; it makes available its safe input signals to the zone nodes via the zone bus for evaluation, independent of the configuration. The status, too, is always transmitted to all zone nodes via the zone bus.

☞ For zone acknowledgement it is irrelevant whether the zone nodes are in one or several master communication rings.

It is recommended to commission the safety zone in the following order:

1. Only connect the safety zone module (HSZ01) and the zone master via the zone bus (X42/X43) (without any other zone node) and commission them.
2. Check whether the selection and acknowledgment via the safety zone module work without error.
3. Loop first zone node into the safety zone at X43 of the safety zone module and commission it.
4. Loop second zone node into the safety zone between the first zone node and the zone master and commission it.
5. Loop third zone node into the safety zone between the second zone node and the zone master and commission it.
6. ...
7. Loop last zone node into the safety zone between the penultimate zone node and the zone master and commission it.

If a safety technology error is present at a zone node, this node only acknowledges **safety** via the zone bus under the following requirements:

- The node has reached a safe state **and**
- the previous nodes of the zone acknowledge safety **and**

- HFT[1] ="1" can still be maintained (i.e. the safe state is not endangered by the occurrence of another error, e.g. error in output stage switch-off, encoder error, etc.).

If a zone participant or the zone master is switched to the "SMO configuration mode" (SCM) state in a safety zone, all other zone participants are decelerated due to the system with the error "F7035 Zone bus error". When the drive is switched from "SMO configuration mode" (SCM) to "parameterization level 1" (OM), the error clearing procedure (C0500) should therefore be executed at all zone nodes and the zone master.

7.7 Safe zone error (SZE)

7.7.1 Brief description

If there are several axes in a danger zone at a machine, it is useful to combine these axes in a safety zone. The IndraDrive safety system allows combining up to 35 axes in a safety zone via discrete wiring [see also "Safety zone acknowledge (SZA)"].

By means of the "Safe zone error" (SZE) function, it is possible for zone nodes (incl. zone master) to quickly signal locally present safety technology errors (errors of the categories F3xxx, F7xxx or F83xx) to all zone nodes via the zone bus. Depending on their configuration, the zone nodes react to the zone error or not (for reaction times see chapter "Performance").

Using the "Safe zone error" (SZE) function requires a safety zone with a safety zone module "HSZ01" and accordingly configured drives.

A pending zone error is signaled via the corresponding safe output pair at the connection point X44 of the safety zone module "HSZ01". This output pair can be used, for example, to signal the zone error to a higher-level control unit by means of discrete wiring.

Features

The safety function "Safe zone error" (SZE) has the following features:

- Is suited for safety-relevant applications up to Category 4, PL e according to EN ISO 13849-1 or up to SIL 3 according to IEC EN 62061.
- The safety level achieved for the safety function "Safe zone error" (SZE) depends on the safety level achieved in the zone nodes. The zone node with the lowest safety level determines the safety level of the Safe zone error.
- Using the safety function "Safe zone error" (SZE) always requires a safety zone module (HSZ01).
- The safety function "Safe zone error" (SZE) can only be used in axes of the IndraDrive C/M/ML and Cs ranges equipped with the optional safety technology module "S4" or "S5".
- The safety function "Safe zone error" (SZE) can only be used in conjunction with the safety function "Safety zone acknowledge (SZA)".
- Quick transmission of safety technology error messages within the safety zone.
- Free configuration option as regards error messages and error acknowledgment.

[1] *Minimum hardware error tolerance*

Selection/acknowledgment

Pertinent parameters

The following parameters can be used in conjunction with the safety function "Safe zone error":

- P-0-3266, SMO: Safety zone status word
- P-0-3266.0.1, SMO: Safety zone control word
- P-0-3266.0.2, SMO: Safety zone configuration

Pertinent diagnostic messages

The following diagnostic messages can be generated in conjunction with the safety function "Safe zone error":

- F3131 Control error, safe inputs of HSZ
- F3153 Safety zone module: SZE/SZA error
- F7035 Zone bus error
- E8300 SMO: Error within the safety zone

7.7.2 Safety function

Configuration

To use the safety function "Safe zone error" (SZE), it must be configured via the parameter "P-0-3266.0.2, SMO: Safety zone configuration" during the commissioning of the safety technology. The following configurations can be set individually for each zone node (incl. zone master):

- Zone node signals zone error and reacts to zone error (type 1)
- Zone node only signals zone error (type 2)
- Zone node only reacts to zone error (type 3)
- Zone node does not signal any zone error and does not react to zone error either (type 4)

Monitoring function

According to the configuration, the zone nodes (incl. zone master) react differently to their own errors and zone errors:

- Type 1

  When a safety technology error is present at a zone node of type 1 (zone node signals zone error and reacts to zone error), it signals a zone error to the next zone node via the zone bus.

  When the zone node is error-free, it takes the zone error status from the previous zone node and passes it on to the next zone node.

  When the zone participant gets signaled a zone error via the zone bus and is not in a safety technology error itself, it acknowledges this error with the warning "E8300 SMO: Error within the safety zone" and initiates the configured error reaction. As long as the zone error is signaled via the zone bus, the warning "E8300" remains active.
- Type 2

  When a safety technology error is present at a zone node of type 2 (zone node only signals zone error), it signals a zone error to the next zone node via the zone bus.

  When the zone node is error-free, it takes the zone error status from the previous zone node and passes it on to the next zone node.

  When the zone node gets signaled a zone error via the zone bus, it does not react to the zone error.
- Type 3

  When a safety technology error is present at a zone node of type 3 (zone node only reacts to zone error), it does **not** signal any zone error via the zone bus.

It **always** takes the zone error status from the previous zone node and passes it on to the next zone node.

When the zone participant gets signaled a zone error via the zone bus and is not in a safety technology error itself, it acknowledges this error with the warning "E8300 SMO: Error within the safety zone" and initiates the configured error reaction. As long as the zone error is signaled via the zone bus, the warning "E8300" remains active.

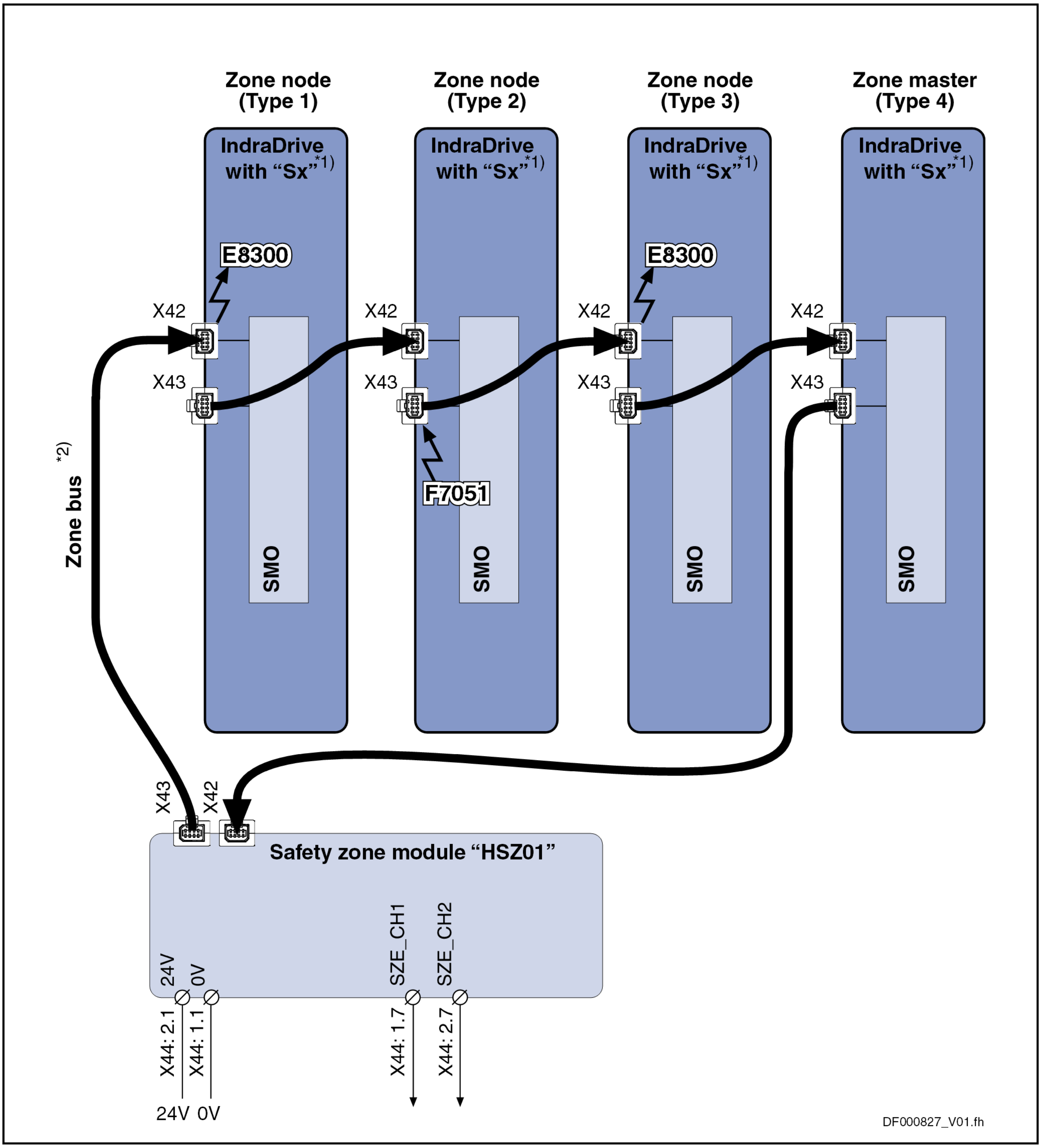
- Type 4

  When a safety technology error is present at a zone node of type 4 (zone node does not signal any zone error and does not react to zone error either), it does not signal any zone error via the zone bus.

  It **always** takes the zone error status from the previous zone node and passes it on to the next zone node.

  When the zone node gets signaled a zone error via the zone bus, it does not react to this zone error.

Selection/acknowledgment



*1)	"Sx" stands for the safety engineering option module "S4" or "S5"
*2)	A maximum of 35 zone nodes can be integrated (including zone master)
Connection X42↔X43	See "Cables"

Fig. 7-31: Example of zone setup with zone error reaction

Selection/acknowledgment

When a safety zone signals a zone error, the error remains active until the safety technology error has been cleared at all axes currently signaling a zone error via the zone bus. All zone nodes that currently only signal the zone error (E8300 active) automatically go to regular operation again, as soon as there are no more zone errors signaled via the zone bus.

A pending zone error is signaled via the corresponding safe output pair at the connection point X44 of the safety zone module "HSZ01". This output pair can be used, for example, to signal the zone error to a higher-level control unit by means of discrete wiring.

7.8 Safe door locking (SDL)

7.8.1 Brief description

By means of the safety function "Safe door locking", the locking device of an interlocking guard (e.g., safety door) can be directly controlled via two channels. The safety door is unlocked whenever the user requests this accordingly, e.g. via a pushbutton (optional), or automatically as soon as the Safe zone acknowledgment signals safety. The safety technology safely monitors the position of the locking device in operation.

The "Safe door locking" can only be use in conjunction with a safety zone. The safety zone must consist of at least one drive (zone master) and one safety zone module "HZS01" [see also "Safety zone acknowledge (SZA)"]. Via the safety zone module, the required outputs and inputs for the "Safe door locking" or for the assignment of the signals are made available at the IO mapper block "SDL with door request".

The position monitoring ("door open" / "door closed") of the interlocking guard is nevertheless required.

Features

The safety function "Safe door locking" has the following features:

- Is suitable for safety-relevant applications up to category 4, PL e according to EN ISO 13849-1 or up to SIL 3 according to IEC EN 62061.

  If breakage of the door lock cannot be excluded, maximally category 1, PL c according to EN ISO 13849-1 is achieved for the "Safe door locking (SDL)" function.
- The safety level to be achieved for the Safe door locking depends on the safety level achieved in the zone nodes and on the locking device for the safety door that is used. The component (zone node, locking device) with the lowest safety level determines the safety level of the Safe door locking.
- Using the safety function "Safe door locking" (SDL) always requires a safety zone module (HSZ01).
- The safety function "Safe door locking" (SDL) can only be used in axes of the IndraDrive C/M/ML and Cs ranges equipped with the optional safety technology module "S4" or "S5".
- The safety function "Safe door locking" (SDL) can only be used in conjunction with the safety function "Safety zone acknowledge (SZA)".

Pertinent parameters

The following parameters can be used in conjunction with the safety function "Safe door locking":

- P-0-3266, SMO: Safety zone status word
- P-0-3266.0.1, SMO: Safety zone control word

- P-0-3266.0.2, SMO: Safety zone configuration
- P-0-3266.0.3, SMO: Control word of safe door locking
- P-0-3266.0.4, SMO: Tolerance time for Safe door locking

Pertinent diagnostic messages

The following diagnostic messages can be generated in conjunction with the safety function "Safe door locking":

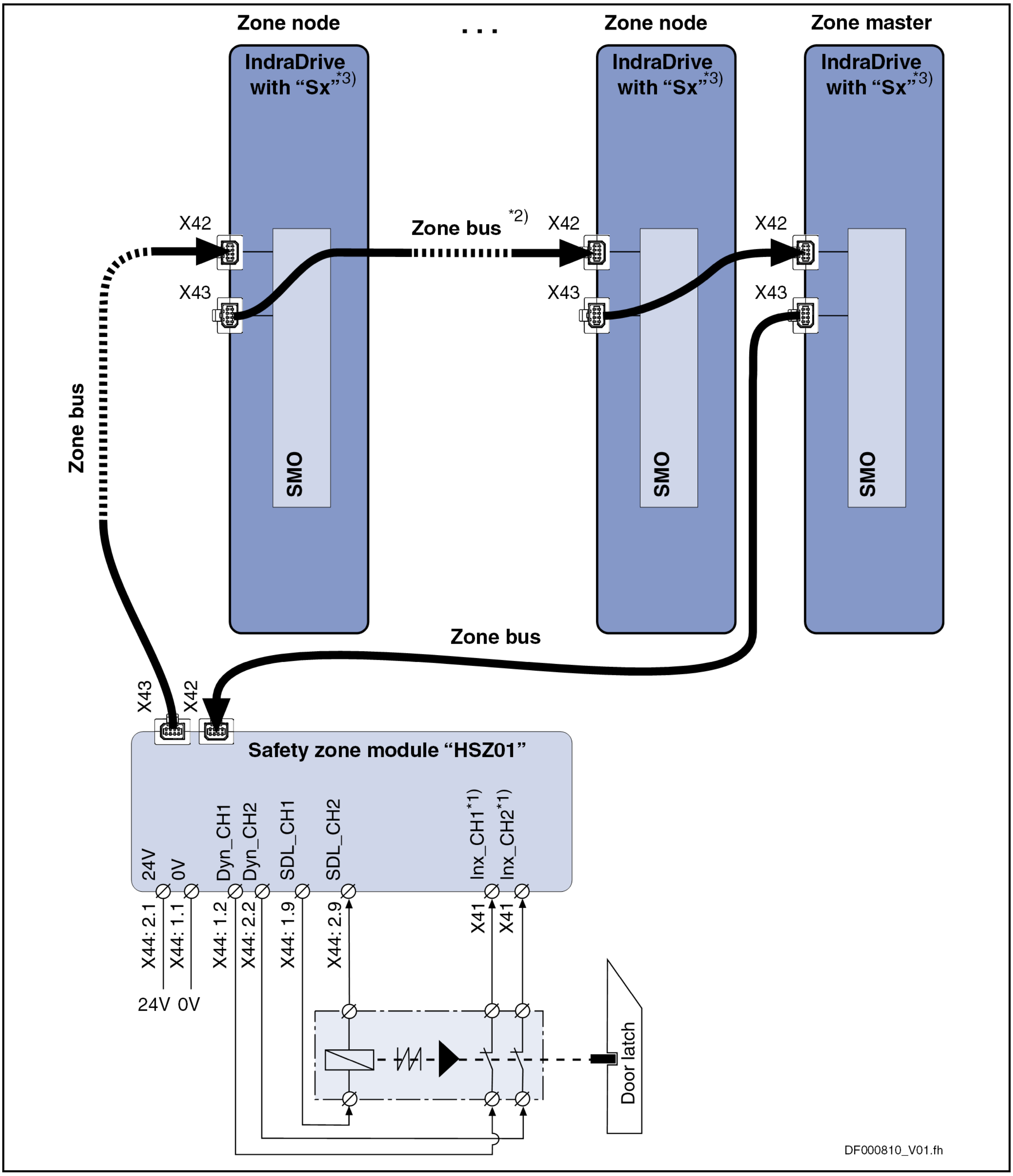
- F3132 SDL validation error
- F7032 Forced zone safety
- F7034 Safety zone module: SDL error

7.8.2 Safety function

Configuration and selection

To use the "Safe door locking" function, a safety zone must be set up via the safety zone module "HSZ01". All drives of the safety zone must be equipped with the optional safety technology module "S4" or "S5". The zone participants must be parameterized according to their use in the safety zone [see also "Safe zone acknowledge (SZA)"].

Selection/acknowledgment



*1)	"Inx_CH1" / "Inx_CH2": "x" represents an arbitrary input pair
*2)	A maximum of 35 zone nodes can be integrated (including zone master)
*3)	"Sx" stands for the safety engineering option module "S4" or "S5"

Selection/acknowledgment

Connection X42↔X43 See "Cables"

Fig. 7-32: Example of zone setup with door locking

The locking device is controlled via the safe output pair ("SDL_Ch1" / "SDL_Ch2") of the safety zone module.

The position monitoring of the locking device is always required; it is read back via a safe input pair (to be selected as desired) and safely monitored. Two isolated safe N/C contacts must be used for the position monitoring of the locking device. These contacts are supplied via the dynamization outputs of the safety zone module.

> ☞ If a short circuit against 24 V and between the N/C signals can be excluded (fault exclusion in the risk evaluation), the N/C contacts can be supplied with non-dynamized 24 V.

The setting and configuration for the "Safe door locking" are made in the zone master (last drive before the safety zone module "HSZ01").

By means of the IO mapper block "SDL with door request", the selection signals for controlling the locking device must be configured in the "IO mapper inputs" of the zone master. At least 1 safe input is necessary for the selection. A maximum of 5 safe inputs can be configured. For the selection it is reasonable to use the same signals (e.g. MS, ES) as for the selection of the corresponding special mode. In addition, it is possible to configure whether the safety door will be automatically unlocked when changing into the special mode or whether it will be unlocked in the special mode by means of a 0-1-signal at the optional functional input "door request". If the safety door is to be unlocked automatically, this optional input does not need to be wired. The output signal of the IO mapper block must be assigned to bit 0 ("Unlock safety door request") of parameter "P-0-3266.0.3, SMO: Control word of safe door locking".

The input signals of the position monitoring of the locking device must be assigned to bit 1 ("feedback contacts of the safety door") of the parameter P-0-3266.0.3 by means of an IO mapper block "Safe connector" (type 1). From MPx-20V12, the time can be set in "P-0-3266.0.4, SMO: Tolerance time for Safe door locking" within which the feedback contacts have to acknowledge the safe door locking status; in previous firmware versions, the time is fixed to 1 second.

When the "Safe door locking" function is used, **position monitoring of the safety door** must be included (in addition to the monitoring of the locking device) in the selection of the corresponding safety functions.

The position monitoring of the safety door can be included "externally" by the corresponding wiring in series, e.g. of the mode selector; i.e. normal operation cannot be selected as long as the safety door is open. As an alternative, the position monitoring can be read in separately via safe inputs and included in the selection of the special mode via the "IO mapper inputs".

Monitoring function

When it has been configured, the safety function "Safe door locking" is only active in the following SMO operating states:

- SMO operating mode
- SMO parameter mode

In the SMO configuration mode state and with deactivated safety technology, the safety function "Safe door locking" is not active; the outputs at the safety zone module go to the "Safety Default" state and lock the safety door.

When a request to unlock the safety door is made via the IO mapper block "SDL with door request", the zone master checks whether the following conditions have been complied with:

- When configuring the zone master, the "Control and monitoring of a safety door locking device via the safety zone module" has been activated.
- The zone master is in a special mode.
- The zone is in a safe state.
- The safety zone module does not signal any error.
- The feedback contacts of position monitoring of the locking device signal the same status as the output signal.

When all conditions have been fulfilled, the zone master unlocks the safety door (via the safe output pair "SDL_Ch1" / "SDL_Ch2") and monitors whether the feedback inputs ["Inx_CH1" / "Inx_CH2" ("x" represents an arbitrary input pair)] are switching accordingly and keep providing a verisimilar value.

When the safety door has been unlocked, the zone master locks the switching to normal operation for all zone nodes. When the special mode is deselected for a zone node (incl. zone master) with normal operation locked, the zone node remains in the last selected special mode.

When a request to lock the safety door is made via the IO mapper block "SDL with door request", the zone master locks the safety door and monitors whether the feedback inputs are switching accordingly and keep providing a verisimilar value. As long as the safety door is not locked, the zone master locks the switching to normal operation for all zone nodes. The zone nodes remain in the last selected special mode until normal operation is enabled.

When the zone master via the feedback inputs detects an inadmissible state of the locking device (an inadmissible state of the feedback contacts will be tolerated for 10 ms) or more than 1 second passes between controlling the safety door and the feedback, and/or P-0-3266.0.4 (from MPx-20V12), it signals the error "F3132 SDL validation error" and locks the normal operation for all zone participants. If at this point, the zone participants are in normal operation, they react to the locked normal operation with the error "F7032 Forced zone safety"; otherwise, they remain in the last selected special mode.

Commissioning

☞ Within the scope of the safety assessment, the residual risk must be taken into consideration for cases in which the zone master cannot lock the door and one or several zone nodes cancel their safety.

Under the following requirements, the locking by the zone master is controlled via the zone bus or the safety zone module "HSZ01":

Selection/acknowledgment

<table>
<tr><th>SMO operating status</th><th>Selection 1)</th><th>Safety door request 1)</th><th>SDL control 2)</th><th>Zone status</th><th>Safety door 3)</th></tr>
<tr><td>Not active</td><td rowspan="2">x</td><td rowspan="2">x</td><td rowspan="4">Lock door</td><td rowspan="4">x</td><td rowspan="5">Locked</td></tr>
<tr><td>SMO configuration mode</td></tr>
<tr><td rowspan="5">SMO parameter mode or SMO operating mode</td><td>Normal operation</td><td>x</td></tr>
<tr><td rowspan="4">Special mode</td><td>Opening of safety door not requested</td></tr>
<tr><td rowspan="2">Opening of safety door requested4)</td><td rowspan="3">Unlock door</td><td>Not safe</td></tr>
<tr><td rowspan="2">Safe</td><td rowspan="2">Unlocked</td></tr>
<tr><td>Not used 5)</td></tr>
</table>

1) Inputs at IO mapper block "SDL with door request"
2) Outputs at IO mapper block "SDL with door request"
3) Status of safe output pair "SDL" at HSZ01
4) "Safety door request" does not need to be permanently present, signal is maintained internally
5) "Safety door request" is optional. If not configured, this signal is generated at the corresponding selection by the drive firmware.
x Not relevant

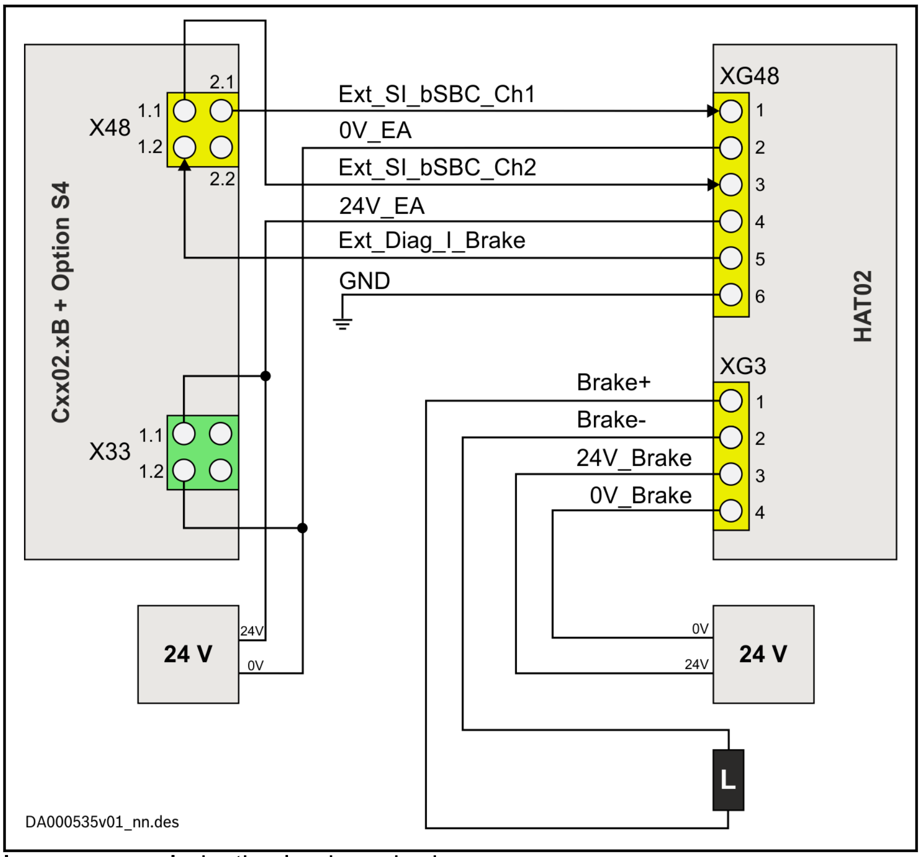
Tab. 7-26: Input and output signals for controlling the locking device of a safety door

The "SDL_Ch1" and "SDL_Ch2" outputs are highly resistive in normal operation (safety door closed and locking device of safety door closed).

In the controlled state (locking device of safety door open), "SDL_Ch1" provides high level(s) and "SDL_Ch2" provides low level(s); the coil of a locking device thus can be directly controlled.

8 Examples of application

8.1 Using the control unit "HAT02.1-002" for the safe control of an external inductive load



L Inductive load, e.g brake

Fig. 8-1: Wiring as 1st inductive load

Optional module "S4", connection point X48, pin	Signal name	Control unit "HAT02.1-002", connection point XG48, pin
1.1	Ext_SI_bSBC_Ch2	3
1.2	Ext_Diag_I_Brake	5
2.1	Ext_SI_bSBC_Ch1	1
2.2	-	n.c.

Tab. 8-1: Interconnection "optional module "S4", connection point X48" ↔ "control unit "HAT02.1-002", connection point XG48"

⚠ WARNING **In the case of error, injury and property damage due to inadmissibly high voltage!**

For selection and the 24 V supply of devices with integrated safety technology, use a 24 V power supply unit with protection by **SELV**[1)] in accordance with IEC 60950-1 or **PELV**[2)] in accordance with IEC 60204-1.

☞ For "24V_EA" and "24V_Brake" and/or "0V_EA" and "0V_Brake", a joint voltage supply may be used. It has to be noted that the voltage tolerances to be complied with for the voltage supply of the brake may be lower than for the "HAT02" control unit.

8.2 Safety zone with control of a door locking device

The following application example shows a simple setup of a safety zone with control of a safety door locking device. Corresponding drives with safety engineering option module "S4" or "S5" are required. The safety engineering must be activated and parameterized accordingly in all drives of the safety zone. The settings with regard to the Safety door locking device (SDL) are made in the zone master of the safety zone. The parameter setting for Safe motion is not addressed in this example.

Scope of functions:

In this example, the following safety engineering functions are used:

- SMST1 or SMST2 (can be parameterized)
- SMES
- Safety door locking device SDL
- SMM1 (optional)

Procedure:

- Establish the cabling of the drives according to fig. 8-5 "Example of zone setup with door locking" on page 280 (prerequisite: approved motors/measuring systems already connected to drives).
- Establish the engineering connection to the drive and load the default values, including safety engineering parameters.
- Commission all drives with IndraWorks by means of the commissioning wizard.

  Wire and parameterize the commissioning steps "safety zone", "safety zone module" and "IO mapper" according to these instructions.
- In the "Safety zone and Safety door locking device" dialog, the zone master (last drive in the zone network in front of the safety zone module, as shown in fig. 8-5 "Example of zone setup with door locking" on page 280) is to be configured as zone master and a check mark is to be provided at **Controlling and monitoring a safety door locking device via the safety zone module**.

1) *Safety Extra Low Voltage*

2) *Protective Extra Low Voltage*

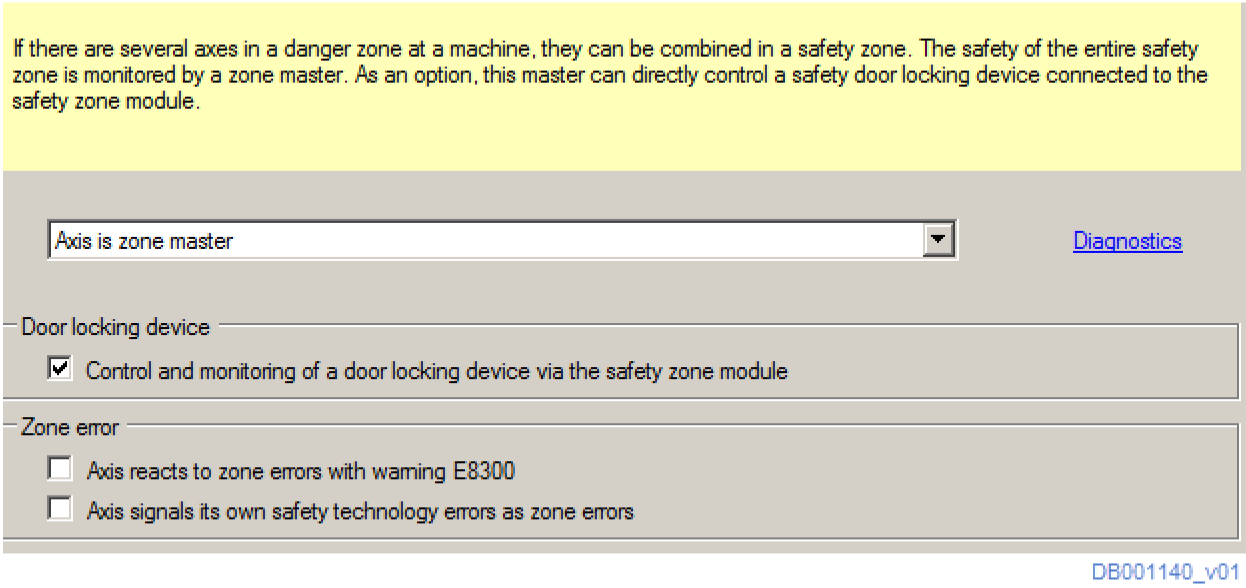


Fig. 8-2: Parameterizing the zone master

Parameterize the zone slaves as zone nodes:

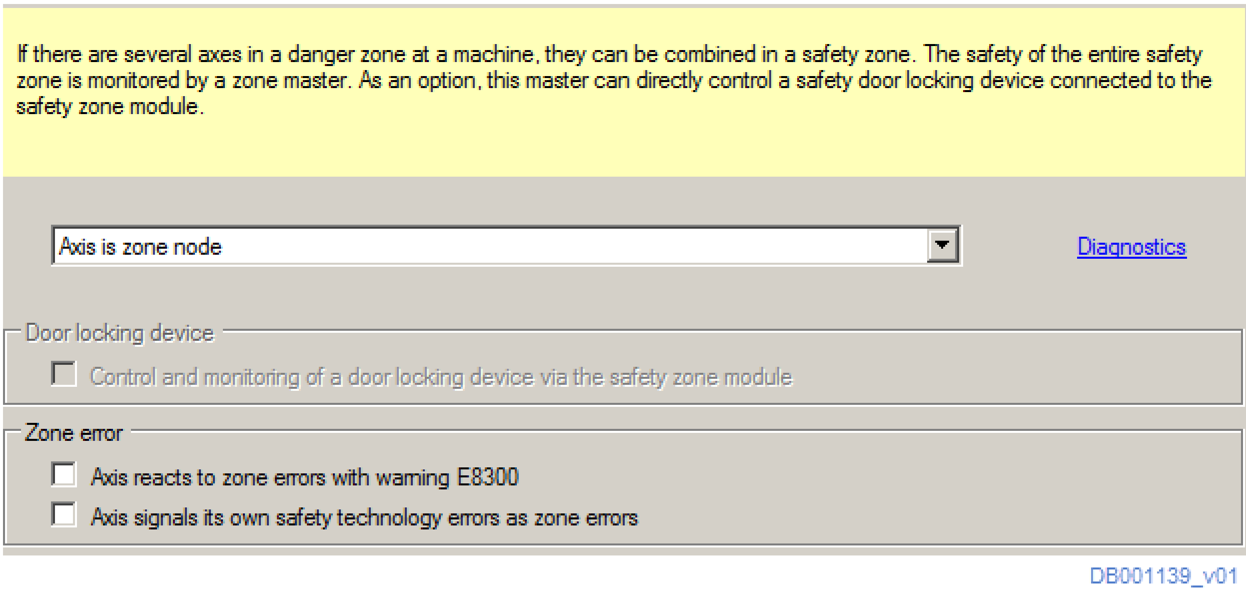


Fig. 8-3: Parameterizing the zone slaves

- The IO mapper networks min the zone master must be assigned as shown in the following diagram:

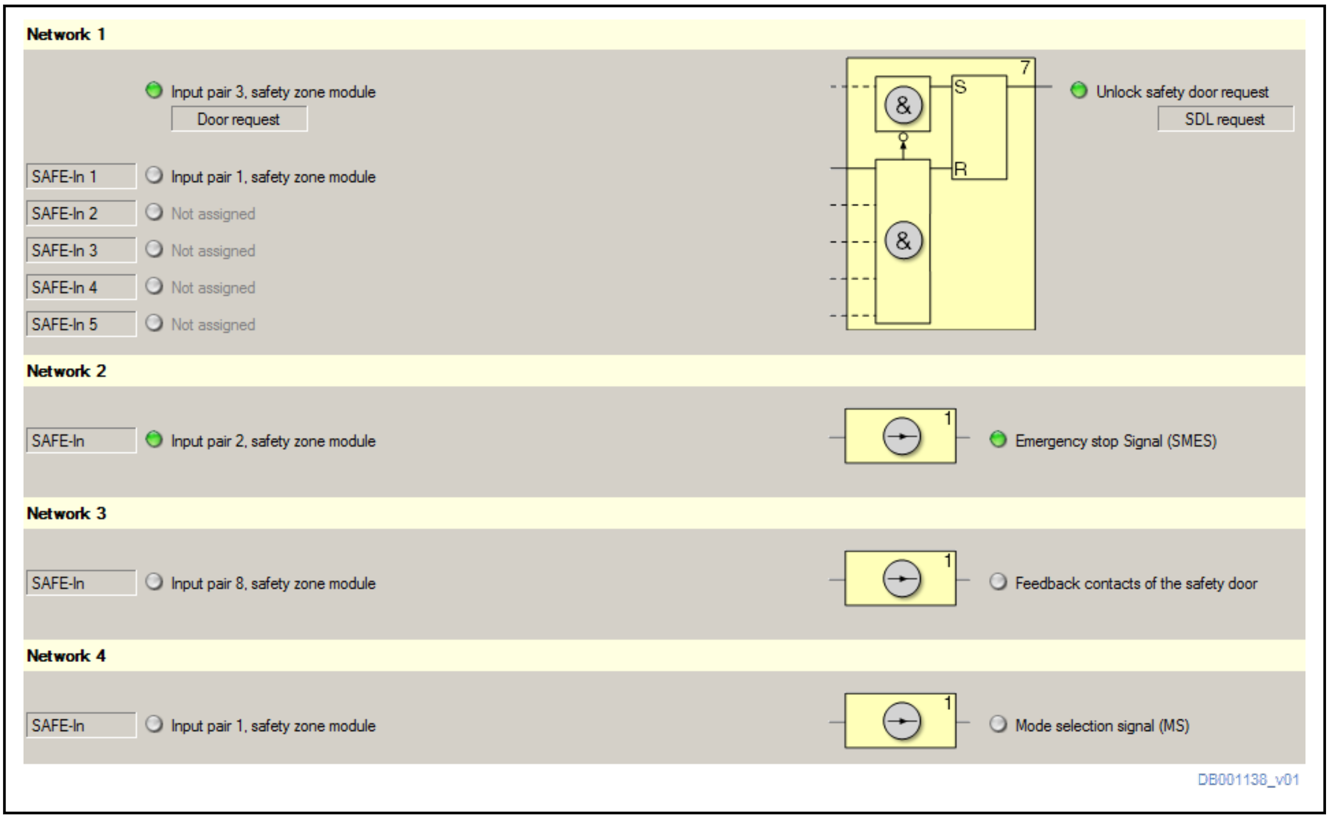


Fig. 8-4: Assignment of the networks in the zone master

- In the slave axes, at least the "SMES" signal as well as the "ModeSel" must be linked to the internal signals by means of a safe connector.

☞ Master and slave must be parameterized differently! fig. 8-4 "Assignment of the networks in the zone master" on page 278 only shows the zone master parameterization.

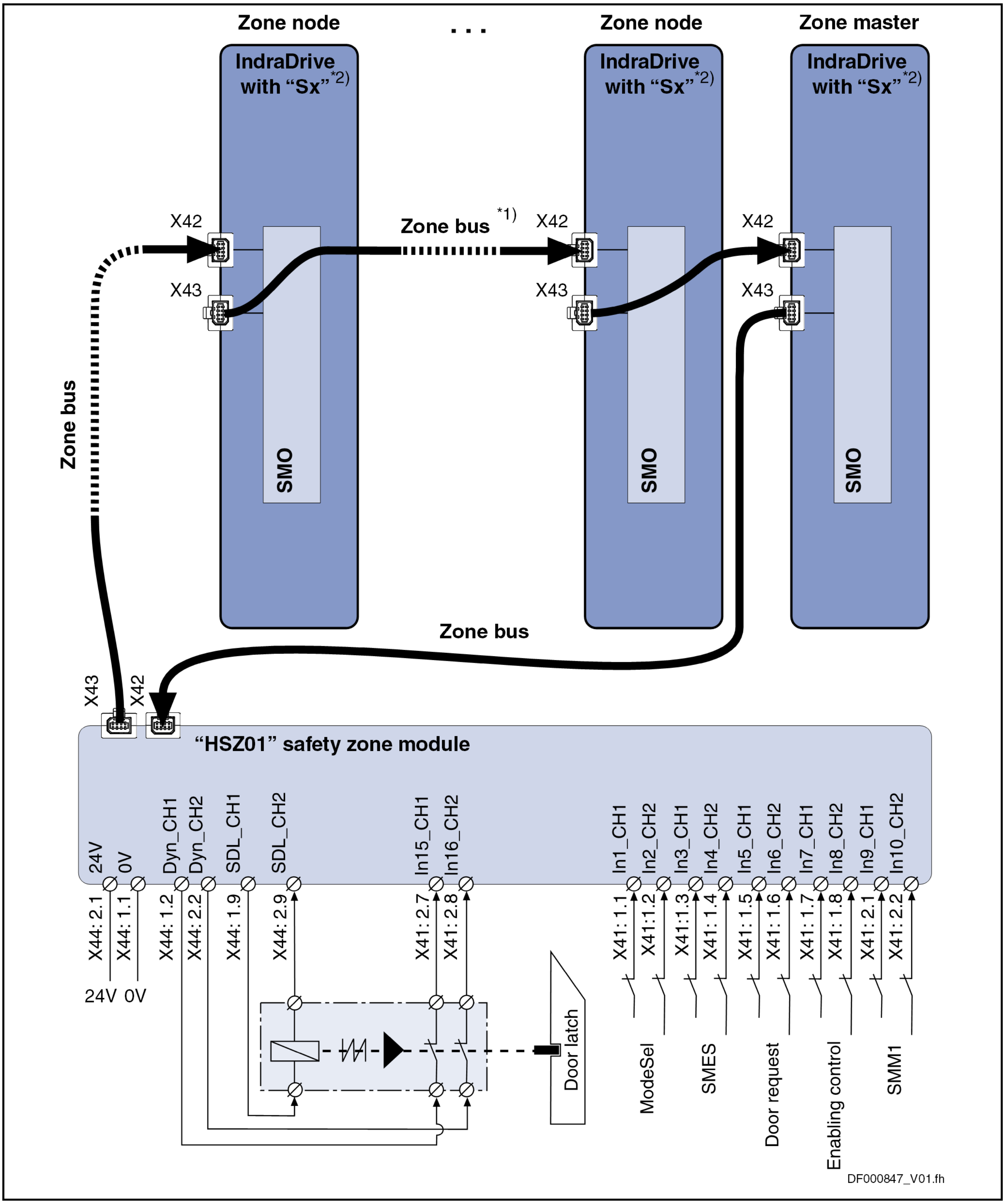
- If the "Safe safety door locking device" function is used, position monitoring of the safety door must be included (in addition to the monitoring of the locking device) in the selection of the corresponding safety functions. The position monitoring of the safety door can be included "externally" by the corresponding wiring in series, e.g. of the mode selector; i.e. normal operation cannot be selected as long as the safety door is open. As an alternative, the position monitoring can be read in separately via safe inputs and included in the selection of the special mode via the "IO mapper inputs". In the example, an "external" wiring of the position monitoring is assumed.

Behavior of the zone:

- SMES == 1 and ModeSel == 1: Zone is in normal operation
- SMES == 1 and ModeSel == 0: Zone is in SMST1/SMST2, the safety door can be opened by means of a 0-1-edge to "Request safety door".
- SMES == 0 and ModeSel == 0: Zone is in SMES, safety door remains open and/or can be opened via "Request safety door".
- SMES == 1 and ModeSel == 1: Zone may change back into normal operation if the safety door is closed (in the example externally locked).

- SMES == 0 and ModeSel == 1: Zone is in SMES, safety door cannot be opened via "Request door".

Examples of application



*1)	A maximum of 35 zone nodes can be integrated.
*2)	"Sx" stands for the safety engineering option module "S4" or "S5"

Fig. 8-5: Example of zone setup with door locking

9 Commissioning

9.1 Risk assessment

Before a machine can be placed on the market, the manufacturer of the machine must carry out a risk assessment in accordance with the Machinery Directive 2006/42/EC in order to determine the hazards associated with the use of the machine.

The risk assessment is a multi-level, iterative process. The procedure is described in detail in "ISO 12100" - "General principles for design - Risk assessment and risk reduction". This documentation can only give you short overview on the subject of risk assessment; users of integrated safety technology are obliged to intensively study the respective standards and legal status.

The risk assessment carried out provides you the requirements for determining the category for safety-related control units according to the valid C-standard the safety-relevant parts of the machine control have to comply with.

☞ For more detailed information on the required Safety Integrity Levels (SIL), Performance Levels (PL) and Categories, please refer to the applied component- and machine-relevant standards in "Safety-relevant standards and regulations".

Procedure

To obtain the highest possible degree of safety, the machine manufacturer when choosing the solutions has to apply the following basic principles in the indicated order:

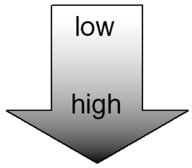
1. Eliminate or minimize the hazards by construction measures.
2. Take the required protective measures against hazards that cannot be eliminated.
3. Document the remaining risks and inform the user of these risks.

Simplification by use of integrated safety technology

When using integrated safety technology, the machine manufacturer will benefit from the following simplifications:

- The safety-related parts of the "IndraDrive" range with the "Safe Motion" option are suited for applications up to SIL 2 (**encoder-dependent** safety functions) or SIL3 (safety functions **independent of an encoder**) of IEC 62061.
- The safety functions integrated in IndraDrive were certified by TÜV Rheinland®; this guarantees the user that the solution complies with the state-of-the-art / the conformity of the components in accordance with the Machinery Directive 2006/42/EC is ensured.

Safety Integrity Level (SIL): relation between the SILs of IEC 62061 and the Performance Level (PL) of EN ISO 13849-1

Performance Level (PL)	Average probability of dangerous failure [1/h] (PFH)	Safety Integrity Level (SIL)	Risk
a	$\geq 10^{-5}$...$< 10^{-4}$	-	
b	$\geq 3 \cdot 10^{-6}$...$< 10^{-5}$	1	
c	$\geq 10^{-6}$...$< 3 \cdot 10^{-6}$	1	
d	$\geq 10^{-7}$...$< 10^{-6}$	2	
e	$\geq 10^{-8}$...$< 10^{-7}$	3	

Tab. 9-1: Safety Integrity Level: failure limit values for a safety function of a PDS(SR)

Risks

Some safety functions and measures of "Safe Motion" must be taken into account separately in the risk assessment. Amongst others, this includes the following risks:

Activation time of enabling control

The monitoring of the activation time of enabling control becomes inactive when the value "0" has been set in the parameter "P-0-3290.x.6, SMO: Maximum activation time of enabling control" (x=1...16).

> It is possible to do without the monitoring of the activation time, if it is not common practice to use an enabling control signal of an enabling control in an industrial sector and if constant motion does not represent any danger. The machine manufacturer is responsible for the monitoring of the activation time and their risk analysis has to show their responsibility. Too long monitoring times cause hazards, too. The machine manufacturer must carry out an application-related risk analysis.

The maximum configurable value of the activation time of enabling control in the parameter "P-0-3290.x.6, SMO: Maximum activation time of enabling control" is not limited by Safe Motion. The allowed value must be defined for the respective special mode in the risk assessment. Too high values increase the risk of not being able to detect a fault in the enabling control in time (e.g. jamming in the activated state).

Safe parking axis

The requirement for using the "Safe parking axis" function is an appropriate risk assessment with the result that the axis does not cause any danger to persons, when it has been parked. Using the function for axes with long coasting times (grinding wheels, spindles, rolls, ...) must be excluded.

Safe door locking

Within the scope of the safety assessment of the installation, the residual risk must be taken into consideration if the zone master cannot lock the door locking device and one or several zone nodes do not signal safety.

9.2 Initial commissioning

9.2.1 Safety instruction

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

Do not commission the installation without having it checked by a qualified person!

Before an installation with integrated safety technology is commissioned for the first time, the installation must be checked and approved in documented form by a qualified person.

Check the danger zone!

- Before commissioning, make sure that nobody is staying in the danger zone.
- Check the danger zone and secure it against access by persons (e.g., put up warning signs, install barriers or the like).

  Observe the applicable laws and local regulations.

9.2.2 Introduction

The integrated safety technology "Safe Motion" is a dual-channel system in which two processors redundantly carry out the safety-related monitoring functions and monitor each other with regard to validation and correctness. When a processor detects a problem or the cross data comparison is inconsistent, the axis is safely decelerated. The behavior of the safety technology is based on the configuration of the scaling and encoder settings, as well as on the parameterization of the safety functions.

After the machine acceptance test has been successfully carried out, the safety technology parameters must not be changed any more.

All safety technology parameters must be verified by the user during parameterization.

Changes in the encoder and scaling settings (configuration parameters) require that the axis be validated again and the machine acceptance test be repeated.

Changes in the safety technology parameterization require that the machine acceptance test be repeated.

☞ For commissioning the safety technology, you should always use the current release of the corresponding firmware version and of the IndraWorks commissioning software.

Otherwise, take the corresponding manufacturer information on detected and solved problems into account and verify their relevance for the machine application.

For information on the current release and the manufacturer information, please refer to the "eBusiness Portal" under http://www.boschrexroth.com/portal.

9.2.3 Prerequisites for using integrated safety technology

General

The IndraDrive system (axis / spindle / roll) consists of the components control section, power section and motor. In the case of devices of the IndraDrive Cs (HCS01) and IndraDrive Mi (KMS02/KMS03) types, the control section and power section are combined. In the case of devices of the IndraDrive Mi (KSM02) type, the control section, power section and motor are combined.

By the interaction of hardware and software components, IndraDrive provides the "Integrated Safety Technology".

☞ The mechanical parts of power transmission, such as gearbox, motor, and those of the safety devices (brakes, fall-down protection, arresting device, ...) shall be designed to withstand the occurring static and dynamic stresses (e.g., dual weight of the load).

The safety factor and the sizing are application-specific and have to be defined by the system and/or machine manufacturer.

For the maximum gear input torque, too, a safety factor in relation to the maximum motor torque has to be taken into account. This also applies to motor-gearbox combinations by Bosch Rexroth. (See also documentation of the respective gearbox.)

⚠ WARNING **In the case of error, injury and property damage due to inadmissibly high voltage!**

For selection and the 24 V supply of devices with integrated safety technology, use a 24 V power supply unit with protection by **SELV**[1)] in accordance with IEC 60950-1 or **PELV**[2)] in accordance with IEC 60204-1.

Required drive firmware

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

The integrated safety functions can be used in accordance with IEC 61508 as of the following firmware versions:

- "Safe Motion" (S3):
  - IndraDrive Mi (KMS02.x): MPB-18V08 and above
  - IndraDrive Mi (KSM02.x): MPB-18V08 and above
- "Safe Motion" (S4):
  - IndraDrive Cs (HCS01.1): MPx-18V08 and above
  - IndraDrive C (control sections Cxx02.x): MPx-18V08 and above
  - IndraDrive M (control sections Cxx02.x): MPx-18V08 and above
  - IndraDrive ML (Cxx02.5 control sections): MPx-19V02 and above
- "Safe motion" (S5):
  - IndraDrive Cs (HCS01.1): MPx-20V04 and above
  - IndraDrive C (control sections Cxx02.x): MPx-20V04 and above

1) *Safety Extra Low Voltage*

2) *Protective Extra Low Voltage*

  - IndraDrive M (control sections Cxx02.x): MPx-20V04 and above
  - IndraDrive ML (Cxx02.5 control sections): MPx-20V04 and above
- "Safe Motion Bus" (SB):
  - IndraDrive Cs (HCS01.1): MPx-20V04 and above
  - IndraDrive C (control sections Cxx02.x): MPx-20V04 and above
  - IndraDrive M (control sections Cxx02.x): MPx-20V04 and above
  - IndraDrive ML (Cxx02.5 control sections): MPx-20V04 and above
- "Safe Motion" (SD):
  - IndraDrive Mi (KSM02.x): MPB-20V04 and above
  - IndraDrive Mi (KMS02.x): MPB-20V04 and above
  - IndraDrive Mi (KMS03.x): MPB-20V04 and above

☞ With the firmware version MPx-20VRS and above, the functional scope of "Safe Motion" can be extended, if necessary, by using firmware options (FWS). The following firmware options are available:

- "SAFETY-PLUS"
- "SIL3-MOTION"
- "SIL3-PLUS"

See also "Firmware options for Safe Motion"

Required controller configuration

General

To use the integrated safety technology of Rexroth IndraDrive controllers, the drive controller has to be configured/equipped with the corresponding optional safety technology module.

CSos - CIP Safety on sercos

Using CSos - CIP Safety on sercos requires an optional safety technology module "Sx", as well as sercos III as the master communication.

See also "Project Planning Manual for Control Section"

☞

- For the IndraDrive Cs "BASIC", IndraDrive C/M "single-axis BASIC" (CSB02.1B) and IndraDrive M "double-axis BASIC" (CDB02.1B) control sections / devices, the "PROFIBUS DP"- or "CANopen"- option must not be available, because otherwise the Multi-Ethernet function is not available any more.
- Using the integrated safety technology requires one optional module "Safe Motion" (Sx) **per axis** in conjunction with the firmware component and one master communication module Multi-Ethernet (ET)/Sercos (only possible with CSoS).

For pin assignments and technical data of the optional safety technology module "Sx", please refer to the chapter "Project Planning".

FSoE - FailSafe over EtherCAT

Using FSoE - FailSafe over EtherCAT (MPx-20V04 and above) requires an optional safety technology module "Sx", as well as EtherCAT as master communication.

See also "Project Planning Manual for Control Section"

- For the IndraDrive Cs "BASIC", IndraDrive C/M "single-axis BASIC" (CSB02.1B) and IndraDrive M "double-axis BASIC" (CDB02.1B) control sections / devices, the "PROFIBUS DP"- or "CANopen"- option must not be available, because otherwise the Multi-Ethernet function is not available any more.
- Using the integrated safety technology requires one optional module "Safe Motion" (Sx) **per axis** in conjunction with the firmware component and one master communication module Multi-Ethernet (ET)/Sercos (only possible with CSoS).

For pin assignments and technical data of the optional safety technology module "Sx", please refer to the chapter "Project Planning".

PROFIsafe on PROFINET

Using PROFIsafe on PROFINET (MPx-20V12 and above) requires an optional safety technology module "Sx", as well as PROFINET as master communication.

See also "Project Planning Manual for Control Section"

- For the IndraDrive Cs "BASIC", IndraDrive C/M "single-axis BASIC" (CSB02.1B) and IndraDrive M "double-axis BASIC" (CDB02.1B) control sections / devices, the "PROFIBUS DP"- or "CANopen"- option must not be available, because otherwise the Multi-Ethernet function is not available any more.
- Using the integrated safety technology requires one optional module "Safe Motion" (Sx) **per axis** in conjunction with the firmware component and one master communication module Multi-Ethernet (ET)/Sercos (only possible with CSoS).

For pin assignments and technical data of the optional safety technology module "Sx", please refer to the chapter "Project Planning".

Safety zone module (HSZ01)

Selection via a safety zone module (HSZ01) requires the optional safety technology module "S4"/"S5".

See also "Additional Components and Accessories Project Planning Manual"

Using the integrated safety technology requires one optional module "Safe Motion" (S4/S5) **per axis** in conjunction with the firmware component.

For pin assignments and technical data of the optional safety technology module "S4"/"S5", please refer to the chapter "Interfaces of the optional modules".

Control module for inductive loads (HAT02)

The following units require one "control module for inductive loads (HAT02)" **per axis** for the safe disconnection of inductive loads with the optional safety technology module "S4"/"S5"/"SB":

- IndraDrive C (HCS02.1E-W00xx-A-03-xNN**N** and
  HCS03.1E-W0xxx-A-05-xxx**N**) with CSB**02** or CSH**02** control section
- IndraDrive M (HMS01, HMS02) with CSB**02** or CSH**02** control section
- IndraDrive M (HMD01) with CDB**02** control section
- IndraDrive ML (HMU05.1) with CSB**02.5** or CSH**02.5** control section

See also "Additional Components and Accessories Project Planning Manual"

Using the integrated safety technology requires one optional module "Safe Motion" (S4/S5/SB) **per axis** in conjunction with the firmware component.

For pin assignments and technical data of the optional safety technology module "S4"/"S5"/"SB", please refer to the chapter "Interfaces of the optional modules".

Optional Safety Technology Module "Safe Motion" (S3)

The optional safety technology module "S3" is exclusively available for "IndraDrive Mi":

- Motor-integrated servo drive "KSM02"
- Near motor servo drive "KMS02"

Servo drives of the IndraDrive Mi type equipped with the optional safety module "S3" may only be operated at the drive connection box of the "KCU02" or "KMV03" type.

Using the integrated safety technology requires one optional module "Safe Motion" (S3) **per axis** in conjunction with the firmware component.

For pin assignments and technical data of the optional safety technology module "S3", please refer to the chapter "X141, Safe Motion safety technology".

Optional Safety Technology Module "Safe Motion" (S4)

The optional safety technology module "S4" can be ordered for the following controllers:

- IndraDrive Cs Basic (HCS01.1E-W00**-A0*-**B**)
- IndraDrive Cs Advanced (HCS01.1E-W00**-A0*-**A**)
- IndraDrive C (HCS02.1E-W00xx-A-03-xNN**N** and
  HCS03.1E-W0xxx-A-05-xxx**N**) with CSB**02** or CSH**02** control section
- IndraDrive M (HMS01, HMS02) with CSB**02** or CSH**02** control section
- IndraDrive M (HMD01) with CDB**02** control section

Cxx02.x control sections of the "IndraDrive C"/"IndraDrive M" ranges are only supported by power sections produced in 2007 and later [see "FD" data on the power section type plate (example: 07W49 means year 2007, week 49)].

- IndraDrive ML (HMU05.1) with CSB**02.5** or CSH**02.5** control section

Parallel operation is only allowed for universal inverters (HMU05.1) of the same performance (up to 8 HMU05.1 are possible). Parallel operation of universal inverters (HMU05.1) with different performances is forbidden.

In case of parallel operation, one HMU05.1 must be equipped with an optional module "Safe Motion" (S4) and configured as master.

For pin assignments and technical data of the optional safety technology module "S4", please refer to the chapter "Interfaces of the optional modules".

For more information on the parallel operation, please refer to the Project Planning Manual "Rexroth IndraDrive ML, Drive Systems with HMU05".

Optional safety technology module "Safe Motion" (S5)

The optional safety technology module "S5" can be ordered for the following controllers:

- IndraDrive Cs Basic (HCS01.1E-W00**-A0*-**B**)
- IndraDrive Cs Advanced (HCS01.1E-W00**-A0*-**A**)
- IndraDrive C (HCS02.1E-W00xx-A-03-xNN**N** and HCS03.1E-W0xxx-A-05-xxx**N**) with CSB**02** or CSH**02** control section
- IndraDrive M (HMS01, HMS02) with CSB**02** or CSH**02** control section
- IndraDrive M (HMD01) with CDB**02** control section

Cxx02.x control sections of the "IndraDrive C"/"IndraDrive M" ranges are only supported by power sections produced in 2007 and later [see "FD" data on the power section type plate (example: 07W49 means year 2007, week 49)].

- IndraDrive ML (HMU05.1) with CSB**02.5** or CSH**02.5** control section

Parallel operation is only allowed for universal inverters (HMU05.1) of the same performance (up to 8 HMU05.1 are possible). Parallel operation of universal inverters (HMU05.1) with different performances is forbidden.

In case of parallel operation, one HMU05.1 must be equipped with an optional module "Safe Motion" (S5) and configured as master.

For pin assignments and technical data of the optional safety technology module "S5", please refer to the chapter "Interfaces of the optional modules".

For more information on the parallel operation, please refer to the Project Planning Manual "Rexroth IndraDrive ML, Drive Systems with HMU05".

Optional safety technology module "Safe Motion" (SB)

The optional safety technology module "SB" can be ordered for the following controllers:

- IndraDrive Cs Basic (HCS01.1E-W00**-A0*-**B**)
- IndraDrive Cs Advanced (HCS01.1E-W00**-A0*-**A**)
- IndraDrive C (HCS02.1E-W00xx-A-03-xNN**N** and HCS03.1E-W0xxx-A-05-xxx**N**) with CSB**02** or CSH**02** control section
- IndraDrive M (HMS01, HMS02) with CSB**02** or CSH**02** control section

- IndraDrive M (HMD01) with CDB**02** control section

> Cxx02.x control sections of the "IndraDrive C"/"IndraDrive M" ranges are only supported by power sections produced in 2007 and later [see "FD" data on the power section type plate (example: 07W49 means year 2007, week 49)].

- IndraDrive ML (HMU05.1) with CSB**02.5** or CSH**02.5** control section

> Parallel operation is only allowed for universal inverters (HMU05.1) of the same performance (up to 8 HMU05.1 are possible). Parallel operation of universal inverters (HMU05.1) with different performances is forbidden.

> In case of parallel operation, one HMU05.1 must be equipped with an optional module "Safe Motion" (SB) and configured as master.
>
> For pin assignments and technical data of the optional safety technology module "SB", please refer to the chapter "Interfaces of the optional modules".
>
> For more information on the parallel operation, please refer to the Project Planning Manual "Rexroth IndraDrive ML, Drive Systems with HMU05".

Optional safety technology module "Safe Motion" (SD)

The optional safety technology module "SD" is exclusively available for "IndraDrive Mi":

- Near motor servo drive "KMS02"/"KMS03"
- Motor-integrated servo drive "KSM02"

Servo drives of the IndraDrive Mi type equipped with the optional safety module "SD" may only be operated at the drive connection box of the "KCU02" or "KMV03" type.

> Using the integrated safety technology requires one optional module "Safe Motion" (SD) **per axis** in conjunction with the firmware component.
>
> For pin assignments and technical data of the optional safety technology module "SD", please refer to the chapter "X141, Safe Motion safety technology".

Required Motors and Measuring Systems

☞ It is recommended to configure and commission the encoder which is analyzed in "Safe Motion" in the functional part of the drive first. This ensures that all functions necessary for the operation of the encoder (e.g. encoder supply voltage, terminating resistors for the encoder signals, etc.) are activated.

Rexroth motors

In conjunction with the optional safety technology module "Safe Motion" (Sx), the following **motors / motor-integrated servo drives** by Rexroth can be used:

⚠ DANGER **Lethal injury and/or property damage caused by variations in the position detection**

If a sine/cosine resolver is used as safety technology encoder, linearity errors in the absolute position detection of the Safe Motion of up to 90° relating to one division period cannot be discovered. These linearity errors may lead to an undetected positional variation between detected and actual position with all safety functions of the safe absolute position; this is to be considered in the risk assessment of the machine.

Motor series	Motor type code (placeholders "EE"/"E" and "B", see legend)	Encoder (placeholders "EE"/"E", see legend)	$PFH_{encoder}$ 2)	$SIL_{encoder}$ 3)	$PL_{encoder}$ 3)	Mission Time	Brake (placeholder "B", see legend)	λ_{brake} 4)	Suited for "Safe Motion"
IndraDyn S: MSK, MKE									
MSK	MSKxxxx-xxxx-NN-**EE**-Ux**B**-xxxx	S1, M1	10×10^{-9} 1/h (at a DC of 90%)	2	d	175,200 h (20 years)	0, 1, 2, 3	40×10^{-9} 1/h	All (with/without safety technology label[1])
		S2, M2	30×10^{-9} 1/h (at a DC of 90%)						Only with safety technology label[1]
MKE	MKExxxx-xxx-**E**x**B**-xxxN	A, C	10×10^{-9} 1/h (at a DC of 90%)				0, 1		All (with/without safety technology label[1])
		B, D	30×10^{-9} 1/h (at a DC of 90%)						Only with safety technology label[1]
IndraDyn A: MAD, MAF									
MAF	MAFxxxx-xxxx-xx-**EE**-xx**B**-xx-xx	S2, M2, C0	30×10^{-9} 1/h (at a DC of 90%)	2	d	175,200 h (20 years)	0, 1, 2, 3	40×10^{-9} 1/h	Only with safety technology label[1]
MAD	MADxxxx-xxxx-xx-**EE**-xx**B**-xx-xx								
MAx Ex	MAFxxxx-xxxx-x**6**-**EE**-xx**B**-xx-xx MADxxxx-xxxx-x**6**-**EE**-xx**B**-xx-xx	S6, M6							
IndraDyn S: MS2N									
MS2N[5]	MS2Nxx-xxxxx-**EE**-xx**B**-xxxxx-xx	CS[6], CM[6], DS[6], DM[6]	1.5×10^{-9} 1/h (at a DC of 95%)	2	d	175,200 h (20 years)	0, 1, 2	40×10^{-9} 1/h	Only with safety technology label[1]
		BS, BM	10×10^{-9} 1/h (at a DC of 90%)						

x — "Don't care" positions in motor type code irrelevant for the requirements of integrated safety technology according to IEC61508

EE/E — Placeholders for position in type code at which encoder type is encoded

B — Placeholder for position in type code at which brake type is encoded

1) — The safety technology label is to be found on the type plate

Commissioning

2) The specified value is PFH_d, i.e. the probability of dangerous failures
3) In conjunction with the IndraDrive system, the encoders installed in the motors are suitable for encoder-dependent safety functions for applications up to the specified Performance Level (PL)/Safety Integrity Level (SIL)
4) Probability of **all failures** of the brake, **not only the number of dangerous failures**
5) With firmware version MPx20V08 and above
6) ACURO®link encoders with a **safe position resolution** of **9 bits**

Series	Type code (placeholders "EE" and "B", see legend)	Encoder (placeholders "EE" see legend)	$PFH_{encoder}$ 2)	$SIL_{encoder}$	$PL_{encoder}$	Mission Time	Brake (placeholder "B", see legend)	λ_{brake} 3)	Suited for "Safe Motion"
IndraDrive Mi									
KSM02	KSM02xxx-xxxx-xxx-**EE**-xx**B**-xx-xx-xx-xx-xx	S1, M1	10×10^{-9} 1/h (at a DC of 90%)	2	d	175,200 h (20 years)	0, 2	40×10^{-9} 1/h	All (with/without safety technology label1))

x "Don't care" positions in type code irrelevant for the requirements of integrated safety technology according to IEC61508
EE Placeholders for position in type code at which encoder type is encoded
B Placeholder for position in type code at which brake type is encoded
1) The safety technology label is to be found on the type plate
2) The specified value is PFH_d, i.e. the probability of dangerous failures
3) Probability of **all failures** of the brake, **not only the number of dangerous failures**

Fig. 9-1: Example of "SI" label on type plate

"Mission Time" and "Proof Test" interval

- The "Mission Time" of all components used has to be observed and complied with. After the "Mission Time" of a component has elapsed, the component has to be discarded or replaced. It is not allowed to continue operating the component!
- After the component was discarded ("Mission Time" has elapsed), it has to be ensured that the component cannot be reused (e.g., by disabling it).
- If a component (with valid "Mission Time") is decommissioned, the "Mission Time" has to be recorded and continued when the component is commissioned again.
- The "Proof Test" has not been specified for Rexroth motors. Therefore, the "Mission Time" cannot be reset by a "Proof Test".

Third-party motors/optional measuring systems

In conjunction with the optional safety technology module "Safe Motion", the requirements on the **measuring system** used which are mentioned below must be complied with for **third-party motors/optional measuring systems** so that the measuring system can be used as a safety technology encoder:

If it is not a motor encoder but an optional encoder which has been connected to the optional slot X4 [X4.1 and X4.2 for double-axis devices; X104 for IndraDrive Mi (KMS02)], this encoder must comply with the requirements below.

Please observe that the encoder can also be evaluated by the corresponding encoder option (EC) (see "Project Planning Manual for the control section").

When using the optional safety technology module "Sx", it is **always** the encoder at the optional slot **X4** [X4.1 and X4.2 for double-axis devices; X104 for IndraDrive Mi (KMS02)] which is evaluated for the safety functions.

Sine/cosine encoder

Sine/cosine encoders have to comply with the following requirements so that they can be used as safety technology encoders in safety-related applications up to SIL 2 or Category 3, PL d:

- **Signal generation:** The analog position signals (sin, cos) have to be generated and processed in analog form. Synthetic signal generation is not allowed.
- **Signal transmission:** The analog position signals (sin, cos) have to be transmitted in differential form. The differential signal amplitude levels have to be between 0.55 V_{pp} and 1.4 V_{pp}.
- **Resolution:** It is only allowed to use rotary encoders with a resolution of 1..65536 DP/rev. or linear encoders with a resolution of 1 µm..1000 mm.
- **Cut-off frequency (-3 dB):** The frequency of the encoder signals should not be higher than a maximum of 300 kHz.
- **Dynamic response:** The frequency slope of the encoder signals should not exceed 100 kHz/ms.

- **Mechanics:** The connection of encoder shaft and motor shaft or encoder housing and motor housing, and the fixing device of the reading head of linear encoders has to be dimensioned such that accidental loosening or breakage of the connection can be excluded (e.g., 20-fold overdimensioning).

☞ Take remaining risks into consideration: see marginal note "Important instructions regarding inadequate connections of encoder shaft and motor shaft or encoder housing and motor housing".

- **Reliability:** The "Mission Time" and the "Proof Test Interval" of the encoder have to be complied with. After the "Mission Time" has elapsed, the encoder has to be decommissioned. When the "Proof Test Interval" is over, a "Proof Test" has to be carried out with the encoder **or** it has to be decommissioned.
- **Wiring "encoder - IndraDrive":** The encoder has to be **directly** connected to the optional slot X4 [X4.1 and X4.2 for double-axis devices; X104 for IndraDrive Mi (KMS02)] (additional mere plug-in connectors are allowed). **Branches** to other evaluation devices, a third-party supply, interconnecting active units or switching between encoders **are not allowed**.

⚠ DANGER **Lethal injury and/or property damage caused by variations in the position detection**

If a sine/cosine resolver is used as safety technology encoder, linearity errors in the absolute position detection of the Safe Motion of up to 90° relating to one division period cannot be discovered. These linearity errors may lead to an undetected positional variation between detected and actual position with all safety functions of the safe absolute position; this is to be considered in the risk assessment of the machine.

Resolver

☞ Using a resolver as a safety technology encoder for Safe Motion is possible with firmware version MPx20V08 and above, and only in conjunction with the optional safety technology modules "S5" or "SB".

Resolvers have to comply with the following requirements so that they can be used as safety technology encoders in safety-related applications up to SIL 3 or Category 4, PL e:

- **Necessary encoder properties:**
  - Supply voltage: 10 V_{pp} or 7 V_{rms} (±10 %)
  - Excitation frequency: 8 kHz (±4 %)
  - Coupling factor: 0.5 (±10 %)
  - Output impedance Z_{pp}: ≤ 700 Ω at 8 kHz[3)]
  - Phase shift: 90° between signal A and B
- **Signal generation:** The analog position signals have to be generated and processed in analog form. Synthetic signal generation or any further signal processing is not allowed. Only the excitation voltage generated by the drive may be used.

3) *With values outside the specified range, examination of the individual case is necessary.*

- **Signal transmission:** The analog position signals have to be transmitted in differential form. The differential signal amplitude levels have to be between 3 V_{pp} and 6 V_{pp} (related to an excitation voltage of 10 V_{pp} (±10%) at 8 kHz (±4%)].
- **Cut-off frequency:** The frequency of the encoder signals should not be higher than a maximum of 600 kHz.
- **Mechanics:** The connection of encoder shaft and motor shaft or encoder housing and motor housing, and the fixing device of the reading head of linear encoders has to be dimensioned such that accidental loosening or breakage of the connection can be excluded (e.g., 20-fold overdimensioning).

☞ Take remaining risks into consideration: see marginal note "Important instructions regarding inadequate connections of encoder shaft and motor shaft or encoder housing and motor housing".

- **Reliability:** The "Mission Time" and the "Proof Test Interval" of the encoder have to be complied with. After the "Mission Time" has elapsed, the encoder has to be decommissioned. When the "Proof Test Interval" is over, a "Proof Test" has to be carried out with the encoder **or** it has to be decommissioned.
- **Wiring "encoder - IndraDrive":** The encoder has to be **directly** connected to the optional slot X4 [X4.1 and X4.2 for double-axis devices; X104 for IndraDrive Mi (KMS02)] (additional mere plug-in connectors are allowed). **Branches** to other evaluation devices, a third-party supply, interconnecting active units or switching between encoders **are not allowed.**

⚠ DANGER **Lethal injury and/or property damage caused by variations in the position detection**

If a resolver is used as safety technology encoder, linearity errors in the absolute position detection of the Safe Motion of up to 60° relating to one division period cannot be discovered. These linearity errors may lead to an undetected positional variation between detected and actual position with all safety functions of the safe absolute position. This must be considered in the risk assessment of the machine.

ACURO®link encoder

☞ Using an ACURO®link encoder as a safety technology encoder for Safe Motion is possible with firmware version MPx-20V08 and above. The encoder has to be configured in the standard firmware as "encoder 1"/"motor encoder".

ACURO®link encoders have to comply with the following requirements so that they can be used as safety technology encoders in safety-related applications up to SIL 3 or Category 4, PL e:

- **Necessary encoder properties:**
  - **Baud rate:** 10 MBaud in cyclic operation
  - **Resolution:** Only rotational encoders with a resolution which is a multiple of 2^n may be used.
- **Cut-off frequency:** The encoder speed should not exceed the value of 15,000 rpm in the application.

- **Mechanics:** Only rotational encoders are supported. The connection of encoder shaft and motor shaft or encoder housing and motor housing has to be dimensioned such that accidental loosening or breakage of the connection can be excluded (e.g., 20-fold overdimensioning).

☞ Take remaining risks into consideration: see marginal note "Important instructions regarding inadequate connections of encoder shaft and motor shaft or encoder housing and motor housing".

- **Reliability:** The "Mission Time" and the "Proof Test Interval" of the encoder have to be complied with. After the "Mission Time" has elapsed, the encoder has to be decommissioned. When the "Proof Test Interval" is over, a "Proof Test" has to be carried out with the encoder **or** it has to be decommissioned.
- **Wiring "encoder - IndraDrive":** The encoder has to be **directly** connected to the optional slot [X4 (and/or X4.1 and X4.2 for double-axis devices; X104 for IndraDrive Mi (KMS02)]; mere plug-in connectors are allowed. **Branches** to other evaluation devices, a third-party supply, interconnecting active units or switching between encoders **are not allowed**.

⚠ DANGER **Lethal injury and/or property damage caused by variations in the position detection**

If an ACURO®link encoder is used as safety technology encoder, the **Safe** position resolution of the encoder may be lower than the actual encoder resolution. This may lead to an undetected positional variation between detected and actual position with all safety functions of the safe position. This must be considered in the risk assessment of the machine.

Important instructions regarding inadequate connections of encoder shaft and motor shaft or encoder housing and motor housing

If it cannot be excluded that the connection of encoder shaft and motor shaft or encoder housing and motor housing accidentally loosens or breaks, take the following **remaining risks** into consideration:

- **Combination "rotary or linear encoder with synchronous motor"**: Possible incorrect orientation of the commutation can cause positive feedback of the current control loop. In this case, the velocity can inadmissibly increase before the monitoring function triggers.
- **"Optional load-side encoder" or combination "rotary encoder with asynchronous motor":** The encoder can move with the shaft by an angle limited by the connection cable which causes an angle offset. This can result in dangerous movements.

  Loosening of the material measure (e.g., encoder shaft breakage) should not cause any allowed signals; if this error cannot be excluded, take the following residual risk into consideration: The motor shaft can move at maximum slip speed.

Allowed motor holding brakes

Using the "Safe brake control (SBC)" function, a motor holding brake can be switched off safely. The following requirements must have been fulfilled for using the safety function:

- **IndraDrive Cs**
  - Optional safety technology module "S4"/"S5"/"SB"
  - Brake has to be connected to X6 of the controller
- **IndraDrive C/M/ML**

  - Optional safety technology module "S4"/"S5"/"SB"
  - Brake has to be connected via the control module for inductive loads (HAT02)
- IndraDrive Mi
  - Optional safety technology module "SD"
  - Brake has to be connected to X156 (KMS02) and/or XG3 (KMS03)

When the safe brake control is used, the brake connected to the controller has to comply with the following requirements:

- Control: The brake must have been designed is such a way that the holding torque of the brake takes effect in the de-energized state (e.g., electrically releasing friction surface brake).
- Electrical connection:
  - The electrical connections of the brake should not have ground reference.
  - The voltage range of the brake has to correspond to that of the supply voltage.
  - The output voltage of the power supply has to stay within the range specified for the brake, even in the case of an error. The safety function does not provide any protection against overvoltage!
  - The brake current in the activated state has to be between 0.1 A and 1.25 A (IndraDrive Cs) / 1 A (KMS02) / 1.29 A (KMS03) / 6 A (HAT02).
- Mechanics: Only friction surface brakes are allowed as motor holding brakes. It is not allowed to operate form-fitting brakes as motor holding brakes. The static holding torque of the brake has to be dimensioned such that the maximum load due to weight of the axis can be safely held. If necessary, the brake has to be cyclically tested for proper functioning.

  For more detailed information on the dimensioning of the brake, please refer to the corresponding C-standard.

☞ In addition to the static holding torque of the brake, the required dynamic braking torque of the brake has to be considered. The dynamic braking torque of the brake has a direct influence on the behavior of the axis in the case of error and needs to be taken into account in the risk analysis.

- Reliability: The brake must have been authorized for ambient temperatures from 0 to 40°C.
- Testing: The brake has to tolerate test pulses (brake voltage switched off) ≤ 1 ms without switching.

Required commissioning tools

The following IndraWorks version is required for commissioning an optional safety technology module "Safe Motion":

	MPx-18	MPx-20
IndraDrive Cs	IndraWorks 13V10	IndraWorks 14V16
IndraDrive Mi		
IndraDrive C and M		
IndraDrive ML	IndraWorks 13V14	

Tab. 9-2: IndraWorks version required for commissioning an optional safety technology module "Safe Motion"

☞ The commissioning is only possible with corresponding hardware; offline simulation is not possible.

9.2.4 Commissioning steps

Overview

The safety technology has to be commissioned using the safety technology wizard in the IndraWorks commissioning software.

☞ The following commissioning steps describe the commissioning using the safety technology wizard on the basis of IndraWorks 14V16.

The commissioning is only possible with corresponding hardware; offline simulation is not possible.

☞ For commissioning the safety technology, you should always use the current release of the corresponding firmware version and of the IndraWorks commissioning software.

Otherwise, take the corresponding manufacturer information on detected and solved problems into account and verify their relevance for the machine application.

For information on the current release and the manufacturer information, please refer to the "eBusiness Portal" under http://www.boschrexroth.com/portal.

Step 0:		Condition as supplied
		▼
Step 1:	Connection	Connecting and wiring the inputs and outputs
		▼
		Safe Motion has been wired
		▼
Step 2:	Activation	Activating the Safe Motion
		▼
		Safe Motion is active
		▼
Step 3:	Parameterization	Entering the SMO axis identifier
		▼
Step 4:	Parameterization	Configuring the system behavior
		▼
Step 5:	Parameterization	Parameterizing the safety functions
		▼
		Safe Motion has been configured and is active
		▼
Step 6:	Completion	Validating the axis
		▼
Step 7:	Completion	Acceptance test of the machine
		▼
		Safe Motion is active and passed the acceptance test. The drive is safe

Tab. 9-3: Overview - commissioning steps of Safe Motion

Step 0: Condition as supplied

Establishing the condition as supplied

In the condition as supplied, Safe Motion is not active and the drive is in the "Safety Default" state. "Safe state" (Safety Default) means:

- Output stage is locked (drive torque has been disabled)
- Brake output is deactivated, electrically releasing brake is applied
- Safety status: "Axis not safe"
- Safe outputs set to "0"

☞ If "Safe Motion" had already been activated, the condition as supplied has to be reestablished before initial commissioning by loading the SMO default values (S-0-0262 / P-0-4090).

Via the menu item "Load defaults procedure for SMO" in the context menu of the SafeMotion branch, the following dialog can be called. This dialog assists you with the loading of the SMO default values:

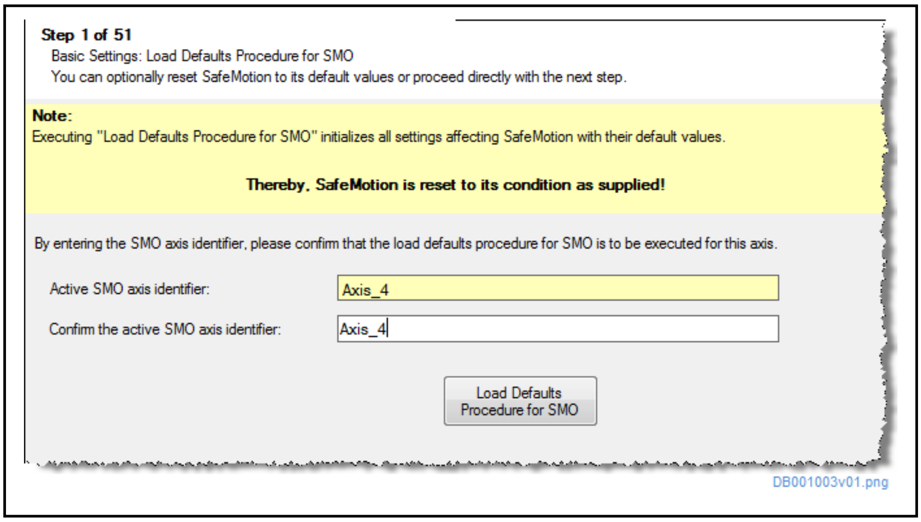


Fig. 9-2: Dialog for loading the SMO default values

Before the **Load defaults procedure for SMO** command is started, the SMO axis identifier has to be entered for confirmation. This ensures that Safe Motion is not deactivated at the wrong axis. After the SMO default values have been loaded, the safety parameters are at their default values and the parameters are **write-protected**. "INDRASAVE" has been entered as the default password in "P-0-3230.0.1, SMO: Password".

In the condition as supplied, the safety parameters, too, can be loaded from a parameter image (for copying drive configurations) (see chapter "Serial commissioning").

After the booting process, the drive system is in the "Safety Default" state. This is signaled by the "SAFE" display.

Functional commissioning

If the axis is to be functionally commissioned before Safe Motion is activated, the axis can go from the "Safety Default" state to "functional commissioning". The functional commissioning is activated via the "Functional enabling" dialog. The dialog can be called via the IndraWorks function tree **SafeMotion ▸ Commissioning ▸ Functional enabling**. It is only displayed as long as Safe Motion has not been activated yet.

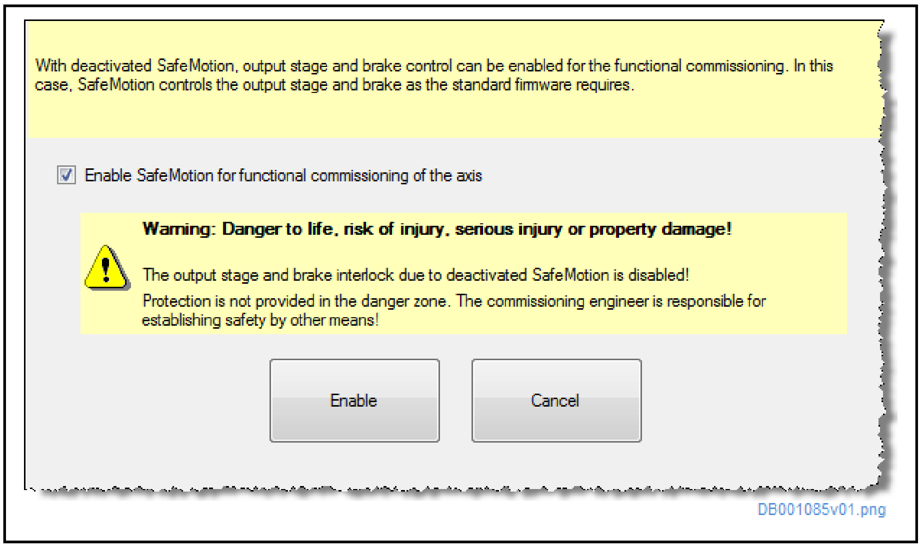


Fig. 9-3: Dialog for functional enabling

The bit for the functional commissioning "P-0-3201, SMO: Configuration of functional commissioning" has to be selected in the dialog. This disables the output stage interlock and brake interlock and the axis can be moved. In this mode, too, the safety status is "Axis not safe" and digital local outputs remain set to "0".

⚠ DANGER

Danger to life, risk of injury, serious injury or property damage! With functional enabling of the drive, the output stage and brake interlock are disabled by inactive Safe Motion! Protection is not provided in the danger zone.

The commissioning engineer is responsible for establishing safety by other means.

Step 1: Connecting and wiring the inputs and outputs

The connection or wiring of the safety functions (selection, acknowledgment, safety zone, safe door locking...) depends on the options used for selection and acknowledgment and on the configuration of the device. There are the following wiring options:

- Selection and acknowledgment via the safety bus
- Selection via digital I/Os at the safety zone module
- Selection and acknowledgment via the safety bus and I/Os at the safety zone module
- Local I/Os at the drive (no selection option)
- Safe door locking via zone bus and safety zone module
- Safe brake/actuator control via control module for inductive loads (HAT02)

☞ For axes connected to a safety zone module via the zone bus, the zone bus should only be wired (X42, X43) immediately before Safe Motion is activated. Otherwise, the error "F7035 Zone bus error" will be permanently generated and the axis cannot be operated.

Step 2: Activating the Safe Motion

Starting the commissioning wizard

☞ Before the wizard is called, the functional commissioning of the axis should have been completed to the point that the axis can be operated under control.

The wizard for initial commissioning is started via the IndraWorks function tree **SafeMotion ▸ Commissioning ▸ Initial commissioning.** The following chapters describe the commissioning procedure with the commissioning wizard. Using the commissioning wizard ensures that all steps and dialogs required for configuring and parameterizing the axis are followed.

(Alternatively, the commissioning procedure can be conducted by calling individual dialogs. In this case, the user must make sure that they have parameterized, during the commissioning procedure, all dialogs relevant to the axis. The individual dialogs can be accessed via the IndraWorks function tree **SafeMotion ▸ Commissioning.**)

Load defaults procedure for SMO

After the commissioning wizard has been started, the dialog for loading the default values of Safe Motion is provided. Before the axis is parameterized, Safe Motion can be reset to its default values using this dialog (see "Establishing the condition as supplied").

Afterwards, go to the next commissioning dialog using the **Next >>** button.

Assigning the safety technology password

The safety technology is activated and unlocked by entering the safety technology password (P-0-3230.0.1, SMO: Password) and subsequently confirming it using the **Activate** button.

In this state, it is possible to change the safety technology parameters without entering the password.

Via the "Lock SMO" and "Change SMO password" menu items in the context menu of the Safe Motion branch, the safety technology parameters can be write protected (locked) and the password can be changed.

When the drive is switched off, safety technology is automatically locked.

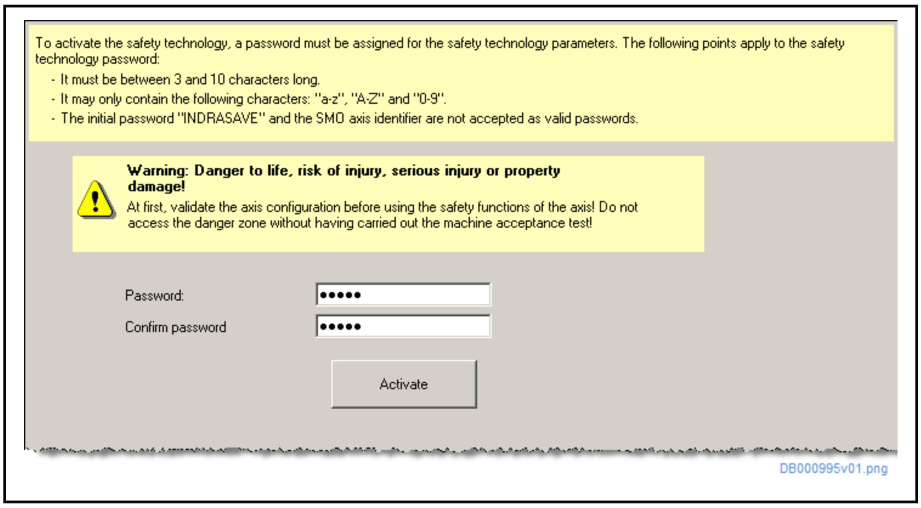


Fig. 9-4: Assigning the safety technology password

Afterwards, go to the next commissioning dialog using the **Next >>** button.

Step 3: Entering the SMO axis identifier

Using the dialog below, the SMO axis identifier can be assigned to the axis. The SMO axis identifier (P-0-3235.0.1) is an unequivocal identifier in the entire safety-related installation. It is used to unequivocally relate parameterization actions to the corresponding machine axis. Therefore, an SMO axis identifier may only be assigned once in each machine.

The SMO axis identifier cannot be simultaneously assigned at several axes. This has to be ensured by the machine manufacturer through organizational measures.

The SMO axis identifier can only be assigned once after the SMO default values have been loaded. To reassign the SMO axis identifier, the condition as supplied has to be reestablished.

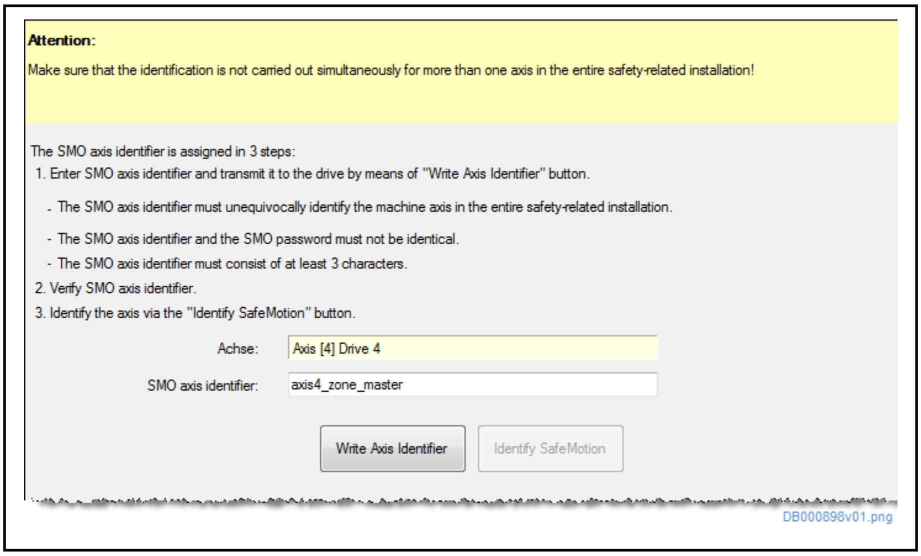


Fig. 9-5: Dialog for assigning the SMO axis identifier

After the SMO axis identifier was entered, it has to be transmitted to the drive. This is done by clicking the **Write axis identifier** button. Afterwards, the SMO axis identifier has to be verified.

With the parameter verification, it is necessary to check / verify whether the parameterization active in the drive complies with the parameters intended or configured for this axis.

The parameter verification is carried out in IndraWorks via the bottom sections of the Safe Motion dialogs ("Verification display").

All parameter values of the dialog are displayed which were changed but have not yet been verified. For this purpose, the corresponding parameter content is read from the drive and displayed. In the main section of the dialog, the entered value of the parameter is still displayed. Changed and unverified parameter settings are marked with a yellow "!" in the dialog.

Parameter values that were written have to be verified by visual control and confirmation (**Apply** button). This, too, applies when the parameter is written again with the same value, because safety technology cannot distinguish whether the same value is actually to be written, or whether the user had entered a different value that was altered during transmission.

If more parameters need to be verified than can be displayed, the **Apply** button is grayed out. The button only becomes active again when the user has compared all parameter values by using the scrollbar.

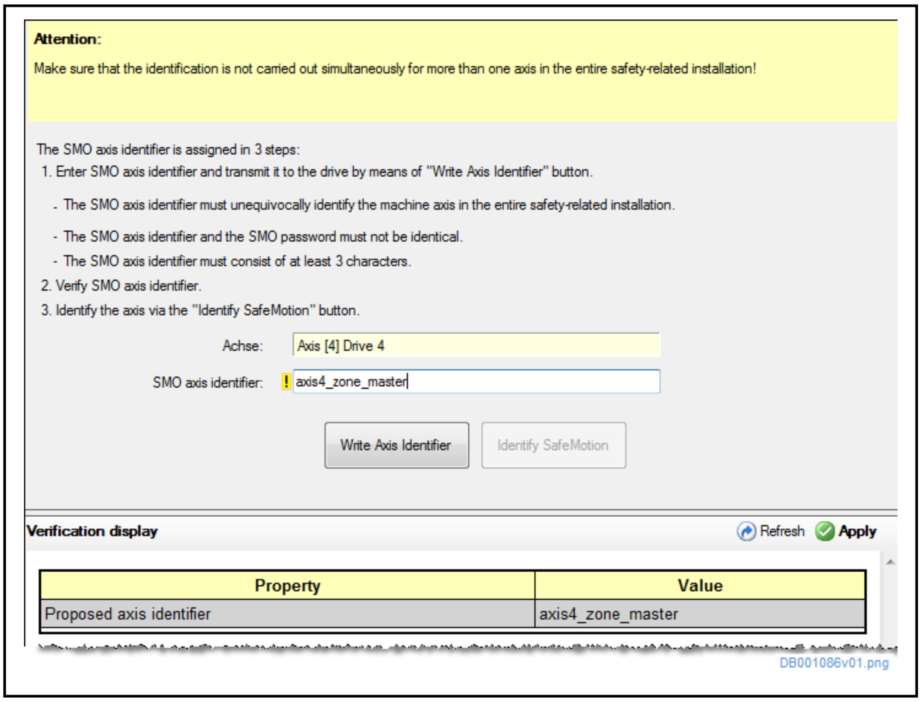


Fig. 9-6: Parameter verification

After the axis identifier was verified, the identification of the axis can be carried out. After the **Identify SafeMotion** button was clicked, the diagnostic LEDs H25 and H26 at the "Safe Motion" option are flashing at the connected drive for which the axis identifier is set, with the flashing pattern "red - green - green - red". In addition, the display of the control panel shows the `Confirm SMO-Identification?` message.

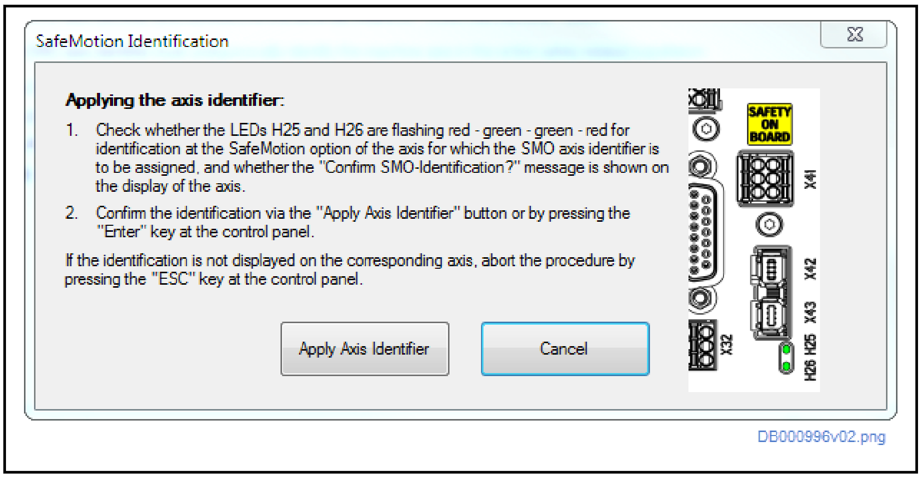


Fig. 9-7: Dialog for applying the axis identifier

The axis identifier has to be confirmed by pressing the <Enter> key at the control panel or by clicking the **Apply axis identifier** button in the dialog provided for applying the axis identifier.

By pressing the <ESC> key at the control panel or by clicking the **Cancel** button, the assignment of the axis identifier can be aborted.

☞ For devices of the "IndraDrive Mi" range, the axis identifier can only be confirmed using the **Apply axis identifier** button in the corresponding dialog.

Pertinent parameters

- P-0-3235.0.2, SMO: Proposed axis identifier
- P-0-3235.0.3, C8500 SMO: Command Apply identification data
- P-0-3235.0.4, SMO: Axis identification: Control word

Afterwards, go to the next commissioning dialog using the **Next >>** button.

Step 4: Configuring the system behavior

Configuring the SMO encoder

Overview (SMO encoder evaluation)

The "Overview" dialog for the SMO encoder evaluation shows the states of the connected encoder and of the encoder evaluation.

Via the **Apply encoder data from standard firmware to SMO...** button, the encoder data of the encoder connected to the optional slot X4 [X4.1 and X4.2 for double-axis devices; X104 for IndraDrive Mi (KSM02)] can be applied from the standard firmware to the SMO parameters (C8400 SMO: Command Apply encoder configuration).

Not all encoders are approved for "safe encoder evaluation". Therefore, only the data of approved encoder types are applied. If the encoder configuration cannot be applied, a command error (C8401, C8402) is generated.

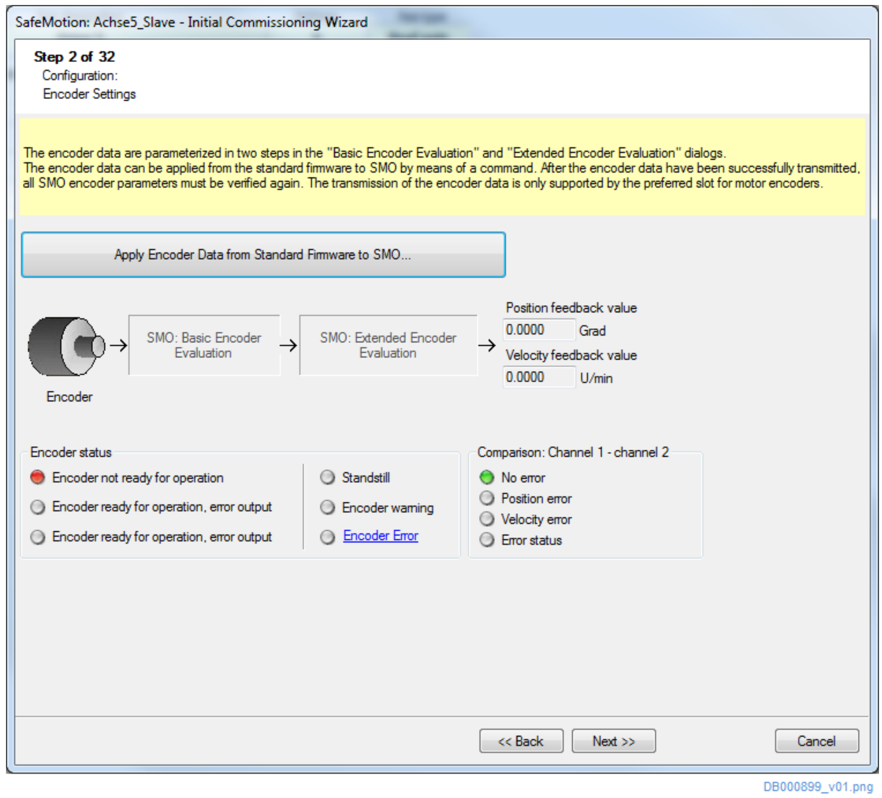


Fig. 9-8: "SMO Encoder" Overview

☞ After they were applied from the standard firmware, the SMO encoder parameters have to be verified in the following dialogs.

☞ It is recommended that you use the same encoder settings in the standard firmware and SafeMotion for the encoder connected to the optional slot X4 [X4.1 and X4.2 for double-axis devices; X104 for IndraDrive Mi (KSM02)]. Only in this way is it possible to compare the command values and actual values of both systems.

Afterwards, go to the next commissioning dialog using the **Next >>** button.

Basic encoder evaluation

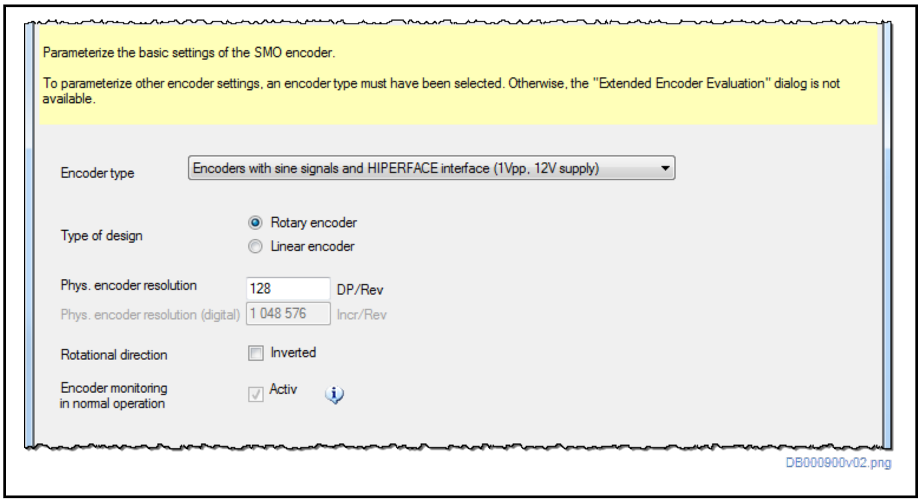


Fig. 9-9: Basic settings of the SMO encoder

The basic encoder properties are set in this dialog:

- In the "Encoder type" field, select the type of encoder, with regard to the signal shape and, if necessary, the communication interface (EnDat etc.) (P-0-3242.0.1, SMO: Phys. encoder type). If SMO is to be operated without encoder evaluation, set the encoder type to "No encoder".
- Via the encoder property "Type of design", set whether the encoder used is a rotary encoder or a linear encoder (P-0-3242.0.2, SMO: Phys. encoder properties).
- In the "Phys. encoder resolution (analog)" / "Phys. encoder resolution (digital)" fields, enter the physical resolution of the encoder [P-0-3242.0.3, SMO: Phys. encoder resolution (analog) / P-0-3242.0.4, SMO: Phys. encoder resolution (digital)].
- In the "Rotational direction" field, set whether the rotational direction of the encoder is inverted or not with regard to the rotational direction of the motor (P-0-3242.0.2).
- With MPx-20V08 and above, monitoring of the SMO encoder can be deactivated for normal operation in the **Encoder monitoring in normal operation** field.

☞ Disabling the encoder monitoring in normal operation is not recommended. It should only be switched off in normal operation, if the encoder monitoring would trigger due to the process. The effects of the deactivation have to be considered in the risk analysis for the machine.

Afterwards, the settings that were made have to be verified. (If the SMO encoder parameters were applied from the standard firmware using the command, they only need to be verified in this dialog.)

With the parameter verification, it is necessary to check / verify whether the parameterization active in the drive complies with the parameters intended or configured for this axis.

The parameter verification is carried out in IndraWorks via the bottom sections of the Safe Motion dialogs ("Verification display").

Go to the next commissioning dialog via the **Next >>** button.

Extended encoder evaluation

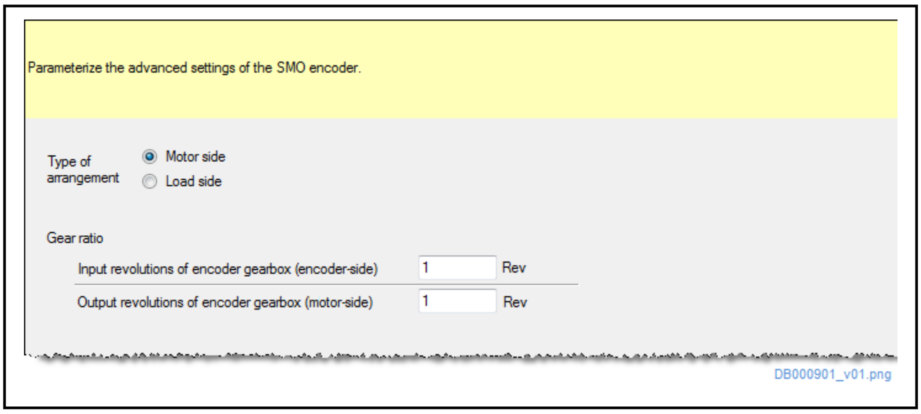


Fig. 9-10: Extended settings of the SMO encoder

The "Extended encoder evaluation" dialog is only displayed when an encoder was configured for the safety technology.

The extended encoder properties are set in this dialog:

- In the "Type of arrangement" field, parameterize whether the SMO encoder has been mounted on the motor side or on the load side (P-0-3252.0.2, SMO: Mounting position).
- Under the "Gear ratio" item, an encoder gearbox can be parameterized, if available. For this purpose, enter the gear ratio via the values "Input revolutions of encoder gearbox (encoder-side)" (P-0-3252.0.3, SMO: Gearbox input revolutions) and "Output revolutions of encoder gearbox (motor-side)" (P-0-3252.0.4, SMO: Gearbox output revolutions). If no encoder gearbox is used, set both values to "1".

Afterwards, the settings that were made have to be verified. (If the SMO encoder parameters were applied from the standard firmware using the command, they only need to be verified in this dialog.)

With the parameter verification, it is necessary to check / verify whether the parameterization active in the drive complies with the parameters intended or configured for this axis.

The parameter verification is carried out in IndraWorks via the bottom sections of the Safe Motion dialogs ("Verification display").

Go to the next commissioning dialog via the **Next >>** button.

Scaling

Overview (SMO scaling)

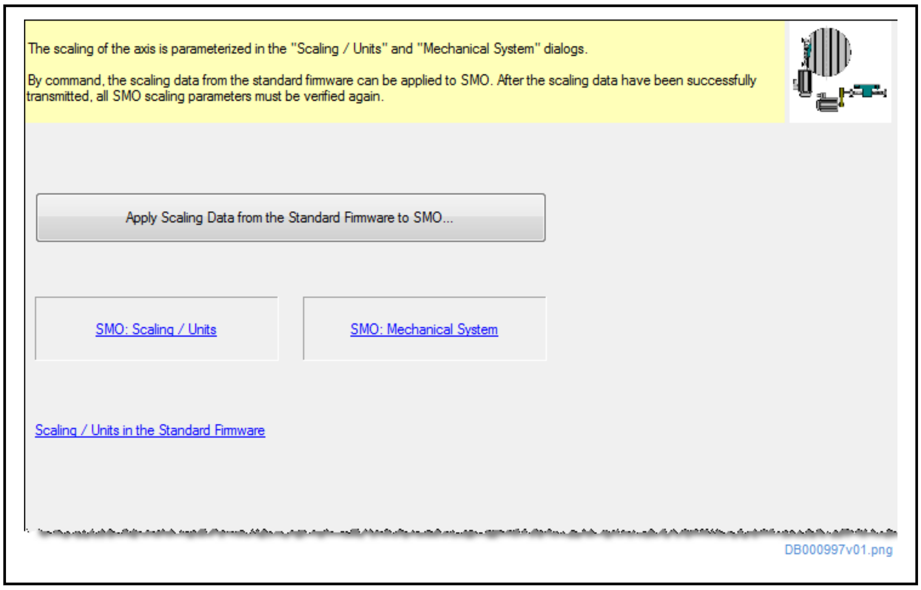


Fig. 9-11: Applying scaling data from the standard firmware to Safe Motion

☞ The "SMO Scaling" dialog is only displayed when an encoder was configured for the safety technology.

In the "Overview" dialog for the SMO scaling, the scaling settings, the settings of the units and the settings of the mechanical system can be applied from the standard firmware to the SMO parameters by using a command (C8000 SMO: Command Apply scaling). The settings are applied via the **Apply scaling data from the standard firmware to SMO…** button.

☞ It is recommended that you use the same scaling settings in the standard firmware and SafeMotion. Only in this way is it possible to compare the command values and actual values of both systems.

☞ In case the scaling settings are changed, all acceleration, velocity and position thresholds are marked as unverified and have to be verified again. During commissioning, it is recommended to first parameterize the scaling and then the monitoring threshold of the safety functions.

The "Scaling / units in the standard firmware" link opens a dialog in which you can have a look at the scaling / units of the standard firmware and, if necessary, change them before applying them:

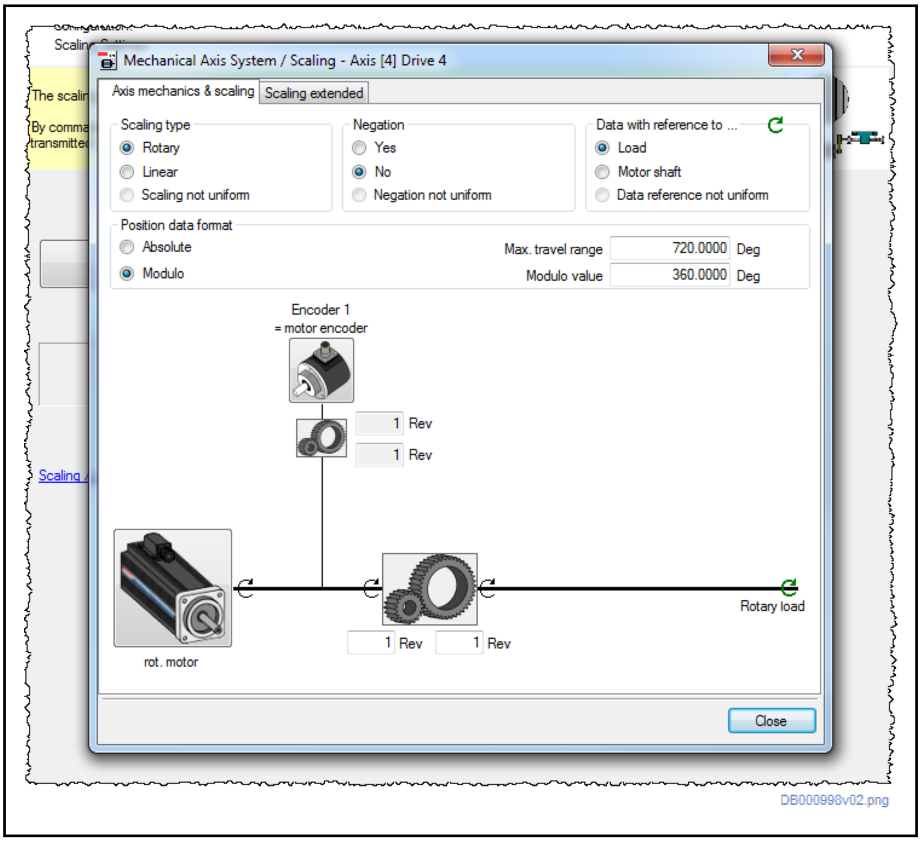


Fig. 9-12: Scaling / units of the standard firmware

☞ After they were applied from the standard firmware, the SMO scaling parameters have to be verified in the following dialogs.

Afterwards, go to the next commissioning dialog using the **Next >>** button.

Setting the scaling and units

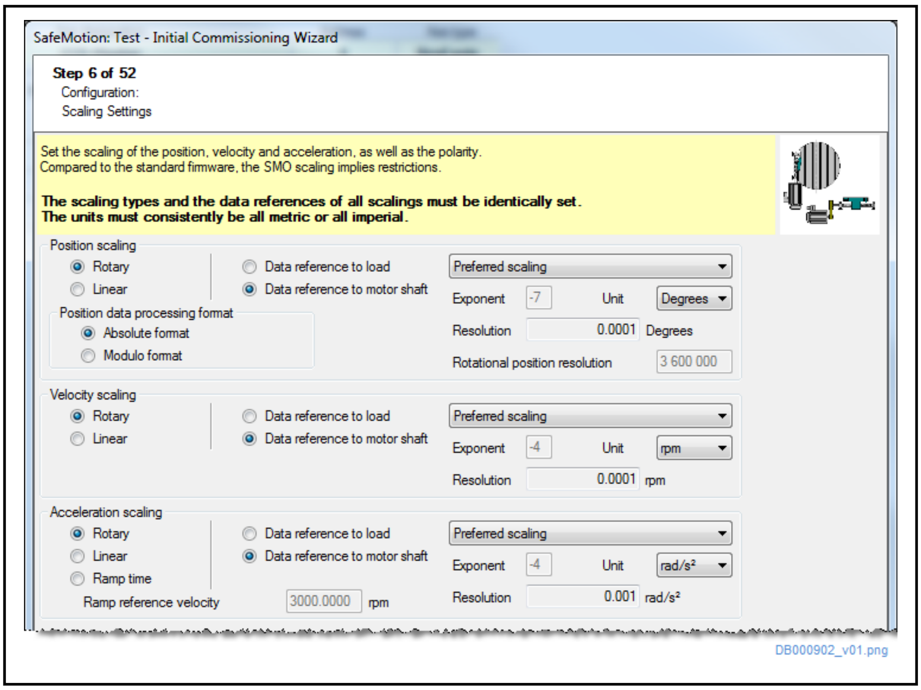


Fig. 9-13: Scaling / units

☞ The "Scaling and units" dialog is only displayed when an encoder was configured for the safety technology.

In this dialog, set the scalings and units.

Position scaling

For the position data scaling type, set either linear or rotary scaling. Besides the data reference and the processing format, set whether the data are available in preferred scaling or user-defined scaling (parameter scaling).

With **preferred scaling**, only the unit needs to be parameterized (exponent and rotational position resolution are grayed out).

With **rotary parameter scaling**, only the rotational position resolution and the unit take effect, the exponent is grayed out.

With **linear user-defined scaling**, the exponent and the unit can be input and the rotational position resolution is only displayed.

Pertinent parameters

- P-0-3222.0.1, SMO: Position data scaling type
- P-0-3222.0.2, SMO: Linear position data scaling exponent
- P-0-3222.0.3, SMO: Rotational position resolution

Velocity scaling

For the velocity scaling, all edit fields can be edited, except for the exponent that can only be changed with user-defined scaling.

Pertinent parameters

- P-0-3223.0.1, SMO: Velocity data scaling type
- P-0-3223.0.2, SMO: Velocity data scaling exponent

Acceleration scaling

For the acceleration scaling, the "ramp time" scaling type can be set besides the linear and rotary scaling types. Only when the ramp time has been set can a value for the ramp reference velocity be input. All other edit fields can always be selected, except for the exponent that can only be edited with user-defined scaling.

Pertinent parameters

- P-0-3224.0.1, SMO: Acceleration data scaling type
- P-0-3224.0.2, SMO: Acceleration data scaling exponent
- P-0-3224.0.3, SMO: Ramp reference velocity for acceleration data

☞ The following restrictions have to be observed for the parameter setting:

- Data reference at the motor shaft with load encoder: not permitted
- The data reference (motor or load) has to be the same for SMO scaling types position, velocity and acceleration

Afterwards, the settings that were made have to be verified. (If the SMO encoder parameters were applied from the standard firmware using the command, they only need to be verified in this dialog.)

☞ With the parameter verification, it is necessary to check / verify whether the parameterization active in the drive complies with the parameters intended or configured for this axis.

The parameter verification is carried out in IndraWorks via the bottom sections of the Safe Motion dialogs ("Verification display").

Go to the next commissioning dialog via the **Next >>** button.

Setting the mechanical system

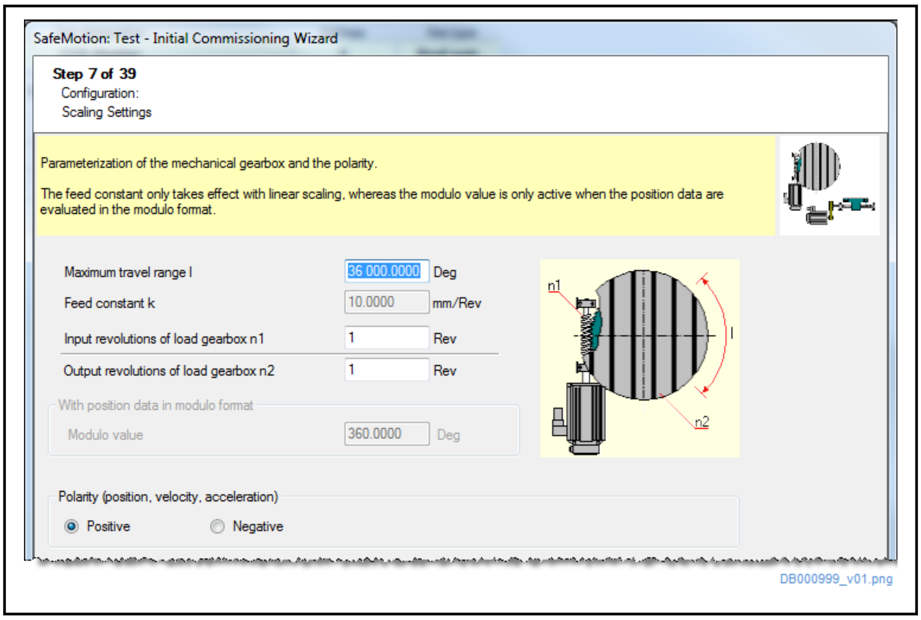


Fig. 9-14: Parameterizing the mechanical properties of the axis

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☞ The "Setting the mechanical system" dialog is only displayed when an encoder was configured for the safety technology.

The mechanical properties of the axis are set in this dialog:

- In the "Maximum travel range" (P-0-3221.0.7) field, parameterize the maximum possible travel range of the axis. According to the "Position data processing format" that has been set, modulo format or absolute format (see scaling dialog), the input is a unipolar value (modulo format) or bipolar value (absolute format).
- In the "Feed constant" (P-0-3221.0.4) field, specify the distance traveled by the axis when the gear output shaft or motor shaft makes one revolution.

  The field is only active with linear axes driven by a rotary motor.
- In the "Input revolutions of load gearbox" (P-0-3221.0.2) and "Output revolutions of load gearbox" (P-0-3221.0.3) fields, parameterize a gearbox present between motor and load. For this purpose, enter the gear ratio by using the number of integral motor revolutions (input revolutions) and the corresponding number of integral gear output revolutions (output revolutions). If no encoder gearbox is used, set both values to "1".

  The field is only active with a rotary motor.
- In the "Modulo value" (P-0-3221.0.6) field, specify at which numerical value the position data overflow to "0" in the modulo mode. The entered

value has to be smaller than the value entered in "Maximum travel range".

The field is only active, when the "Position data processing format" has been set to "modulo format" (see scaling dialog).

- In the "Polarity (position, velocity, acceleration)" (P-0-3221.0.1) dialog section, set the appropriate polarity for the machine axis depending on the mounting situation.
  - **This applies to rotatory motors:** Clockwise rotation of motor output shaft (with view to the motor output shaft) causes positive velocity feedback value (positive polarity).
  - **This applies to linear motors:** Motion of primary part in the direction of the cable connection side causes positive velocity feedback value (positive polarity).

  The polarity can only be set consistently for all scaling types (position, velocity, acceleration).

Afterwards, the settings that were made have to be verified. (If the SMO encoder parameters were applied from the standard firmware using the command, they only need to be verified in this dialog.)

> ☞ With the parameter verification, it is necessary to check / verify whether the parameterization active in the drive complies with the parameters intended or configured for this axis.
>
> The parameter verification is carried out in IndraWorks via the bottom sections of the Safe Motion dialogs ("Verification display").

Go to the next commissioning dialog via the **Next >>** button.

Standstill monitoring

In the Standstill monitoring dialog, set the velocity threshold (P-0-3255) below which Safe Motion is to detect and signal standstill. Set the value so high that the encoder noise does not exceed the value when the axis is at standstill.

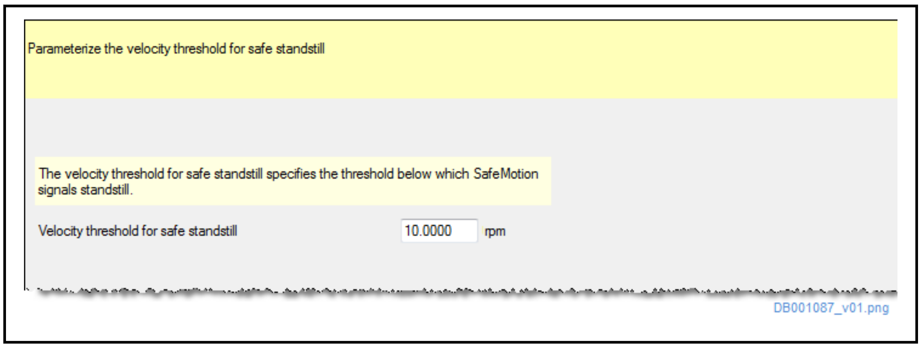

Fig. 9-15: Standstill monitoring

Afterwards, the value that was set has to be verified.

> ☞ With the parameter verification, it is necessary to check / verify whether the parameterization active in the drive complies with the parameters intended or configured for this axis.
>
> The parameter verification is carried out in IndraWorks via the bottom sections of the Safe Motion dialogs ("Verification display").

Go to the next commissioning dialog via the **Next >>** button.

Safe homing procedure

In the "Safe homing procedure" dialog, configure the homing procedure which is the prerequisite for using safety functions with safe absolute position.

To use this safety function, it has to be activated via the **Safe homing procedure** check box. The safe homing procedure is a homing procedure during normal operation with an additional home switch for safely determining the reference position.

The safety function is available in MPx-20V08 and above. In older firmware versions the dialog is not displayed.

The Safe homing procedure can only be activated on drives equipped with one of the following firmware options (FWS) for Safe Motion.

- "SAFETY-PLUS"
- "SIL3-PLUS"

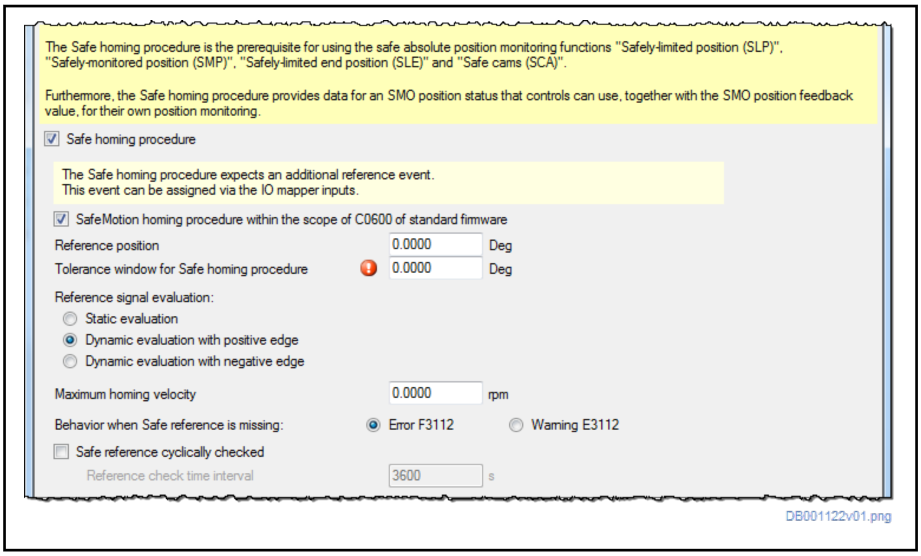

Fig. 9-16: Safe homing procedure

After the Safe homing procedure has been activated, the following fields have to be configured:

- If the **SafeMotion homing procedure within the scope of C0600 of standard firmware** check box is activated, the command "C4000 SMO: Safe homing procedure command" is automatically started with the start of the command "C0600 Drive-controlled homing procedure command" and the Safe reference is established.
- In the **Reference position** field, the position of the second reference has to be parameterized. The reference position for the first reference has to be parameterized in the standard firmware in the "Position data reference encoder x" dialog.
- In the **Tolerance window for safe homing procedure** window, set the maximum allowed deviation of the actual position values from the first and second reference during the execution of the "C4000 SMO: Safe homing procedure command" command.
- Next, determine whether the reference signal for the second reference is to be evaluated statically or dynamically. In the case of dynamic eval-

uation (home switch), the evaluation can refer to the positive or negative edge.

☞ Dynamization must not be carried out for the home switch / the cam!

- In the **Maximum homing velocity**, parameterize the maximum velocity at which the axis may be moved without safe reference (e.g., after switching on).
- Afterwards, determine whether Safe Motion is to signal the missing safe reference as an error (F3112) or as a warning (E3112).

☞ If a special mode Safe Motion (with configured safe absolute position) is selected without safe reference, error "F3112 Safe reference missing" will always be generated.

- Use the **Safe reference cyclically checked** check box to parameterize whether during operation, the safe reference will be automatically verified when the second reference position is passed. For a successful check, the second reference has to be passed with a velocity lower than the "maximum homing velocity". For the cyclic check, define a time interval within which the check has to be successful (**Reference check time interval** field).

Afterwards, the defined values have to be verified.

☞ With the parameter verification, it is necessary to check / verify whether the parameterization active in the drive complies with the parameters intended or configured for this axis.

The parameter verification is carried out in IndraWorks via the bottom sections of the Safe Motion dialogs ("Verification display").

Go to the next commissioning dialog via the **Next >>** button.

Safety bus communication

To use the Safety bus communication for the axis, it has to be "enabled" via the **Safety bus communication** drop down list (P-0-3345). It is possible to choose between the following Safety bus systems:

- "SafeMotion with Safety bus communication CIP Safety on SERCOS (CSos)"
- MPx-20V08 and above:"SafeMotion with Safety bus communication FailSafe over EtherCAT (FSoE)"
- MPx-20V12 and above: "SafeMotion with Safety bus communication PROFIsafe"

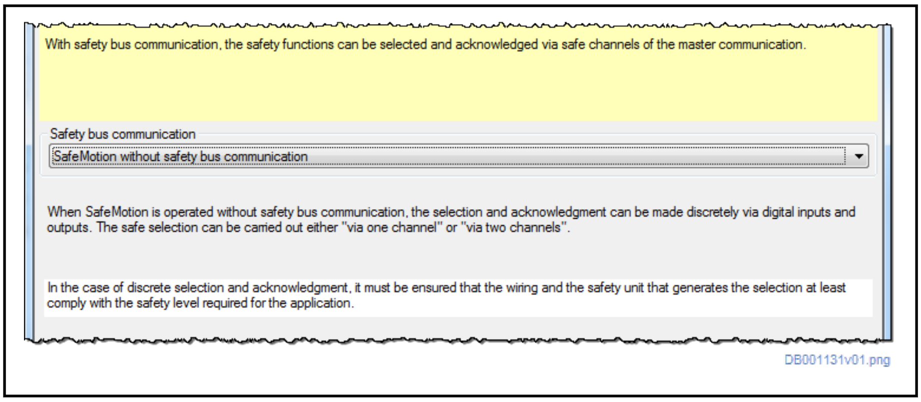

Fig. 9-17: Selecting the Safety bus system

Afterwards, the value that was set has to be verified.

> With the parameter verification, it is necessary to check / verify whether the parameterization active in the drive complies with the parameters intended or configured for this axis.
>
> The parameter verification is carried out in IndraWorks via the bottom sections of the Safe Motion dialogs ("Verification display").

CIP Safety on sercos (CSos)

If "SafeMotion with safety bus communication CIP Safety on sercos (CSos)" is selected, the "Safety Network Number (SNN)" has to be assigned to the drive in the next step. The SNN is composed of "SNN Date" and "SNN Time".

In order to allow for the drive to communicate with the safety control, both have to be in the same safe network. That is to say both have to have the same "Safety Network Number (SNN)".

Furthermore, the drive needs a "Safety Device ID" that is unequivocal in this Safety Network.

Finally, the "Target Unique Network Identifier (TUNID)" (S-0-1800.0.19) has to be assigned in this dialog. The "TUNID" can only be assigned once after the SMO default values have been loaded. The TUNID is composed of the "Safety Device ID (SDID)" and the "Safety Network Number (SNN)".

Order for assigning the "Target Unique Network Identifier (TUNID)":

> Please observe the order and the required steps when assigning the Target UNID (TUNID), because the TUNID can only be assigned once after the SMO default values have been loaded.

1. Adjust the Safety Network Number (SNN) by entering the SNN Date and SNN Time.

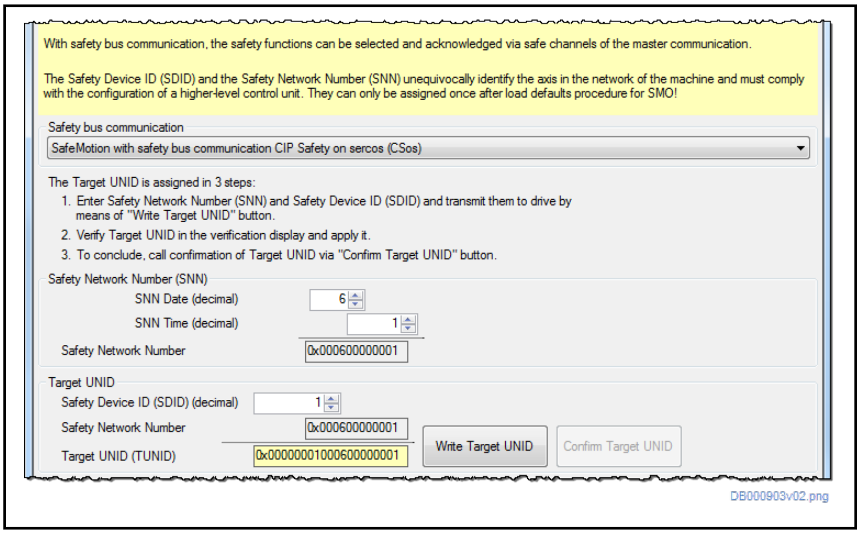

Fig. 9-18: CIP Safety on sercos (CSos): Entering the SNN Date and SNN Time

2. Enter the Safety Device ID (SDID).
3. Write the Target UNID to the drive by clicking the **Write Target UNID** button.
4. Verify the entered values via the verification display.

☞ With the parameter verification, it is necessary to check / verify whether the parameterization active in the drive complies with the parameters intended or configured for this axis.

The parameter verification is carried out in IndraWorks via the bottom sections of the Safe Motion dialogs ("Verification display").

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5. Activate the Target UNID via the **Confirm Target UNID** button.

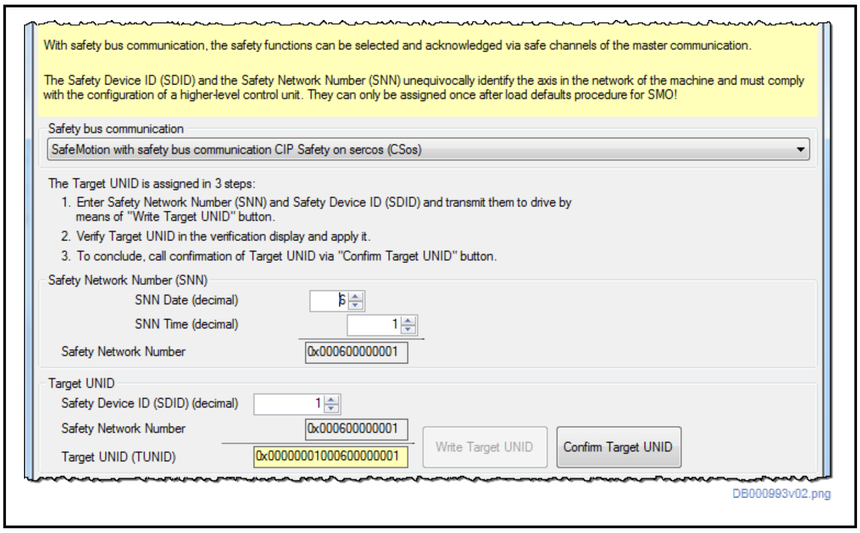

Fig. 9-19: CIP Safety on sercos (CSos): Assigning the Target UNID (TUNID)

6.

☞ The display of the drive, with the SMO axis identifier shown in the dialog, shows `Confirm SMO-Identification?`. The diagnostic LEDs H25 and H26 at the "Safe Motion" option are lit with the flashing pattern "red - green - green - red".

The diagnostic LEDs are not a safe display and cannot be used as a source of safe information on the internal state. The diagnostic LEDs only provide diagnostic data!

Confirm the Target UNID for the corresponding axis via the **Yes** button in the query dialog, or by pressing the <Enter> key at the control panel.

☞ For devices of the "IndraDrive Mi" range, the Target UNID can only be confirmed via the **Yes** button in the query dialog.

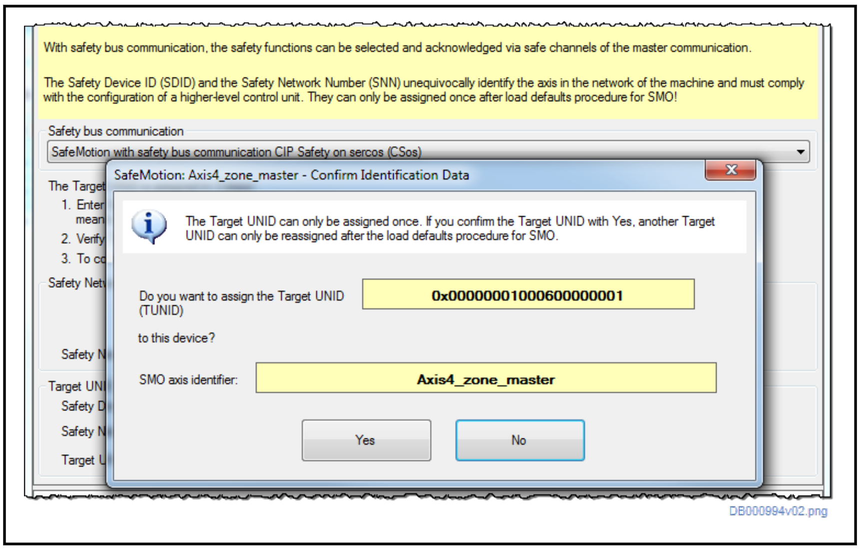

Fig. 9-20: Dialog for assigning the identification data

Pertinent parameters

- S-0-1800.0.18, SSO Proposed TUNID
- S-0-1800.0.19, SSO Target UNID
- P-0-3235.0.3, C8500 SMO: Command Apply identification data
- P-0-3235.0.4, SMO: Axis identification: Control word

Afterwards, go to the next commissioning dialog using the **Next >>** button.

FailSafe over EtherCAT (FSoE)

If "SafeMotion with safety bus communication FailSafe over EtherCAT (FSoE)" is selected, the "FSoE slave address" has to be assigned to the drive in the next step. It can only be assigned once after the SMO default values have been loaded.

☞ Please observe the order and the required steps when assigning the "FSoE slave address" as the "FSoE slave address" can only be assigned once after the SMO default values have been loaded.

1. Enter the FSoE slave address.

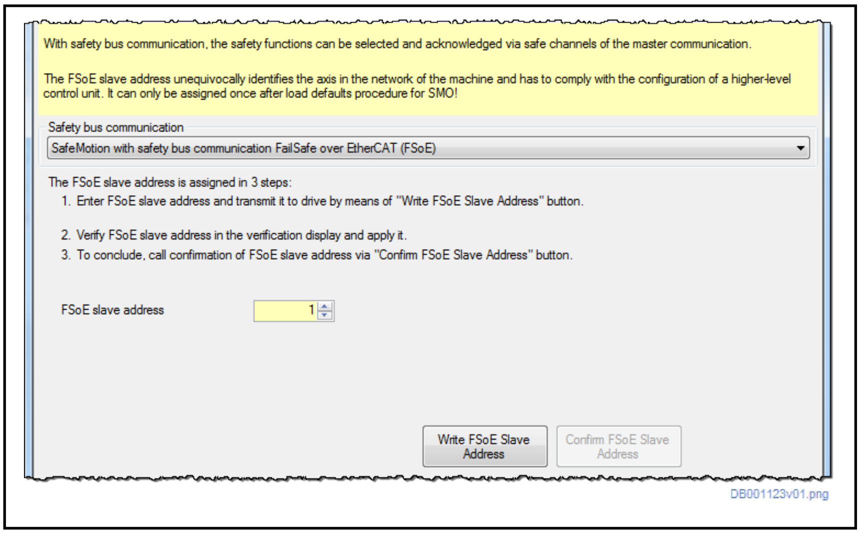

Fig. 9-21: Entering the FSoE slave address

2. Write the FSoE slave address to the drive by clicking the **FSoE slave address** button.
3. Verify the entered values via the verification display.

☞ With the parameter verification, it is necessary to check / verify whether the parameterization active in the drive complies with the parameters intended or configured for this axis.

The parameter verification is carried out in IndraWorks via the bottom sections of the Safe Motion dialogs ("Verification display").

4. Activate FSoE slave address via the **Confirm FSoE slave address** button.

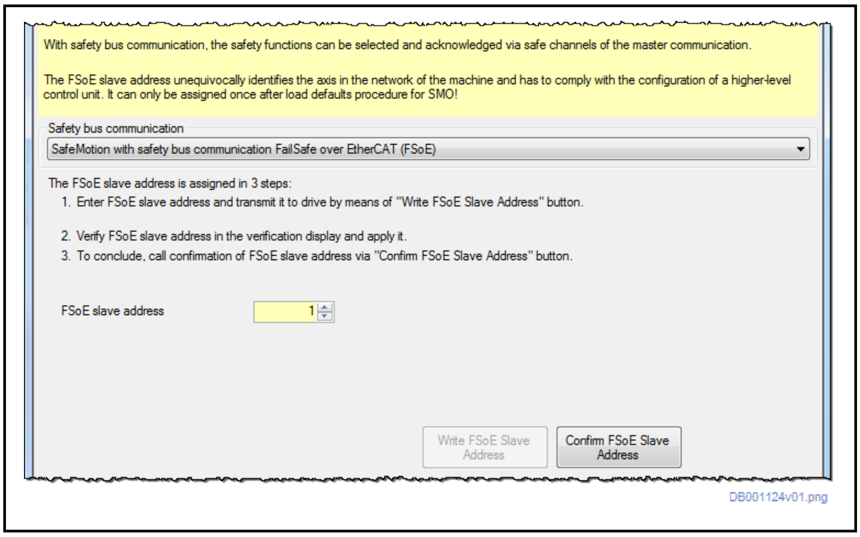

Fig. 9-22: Confirming the FSoE slave address

5.

The display of the drive, with the SMO axis identifier shown in the dialog, shows `Confirm SMO-Identification?`. The diagnostic LEDs H25 and H26 at the "Safe Motion" option are lit with the flashing pattern "red - green - green - red".

The diagnostic LEDs are not a safe display and cannot be used as a source of safe information on the internal state. The diagnostic LEDs only provide diagnostic data!

Confirm the FSoE slave address for the corresponding axis via the **Yes** button in the query dialog, or by pressing the <Enter> key at the control panel.

For devices of the "IndraDrive Mi" range, the FSoE slave address can only be confirmed via the **Yes** button in the query dialog.

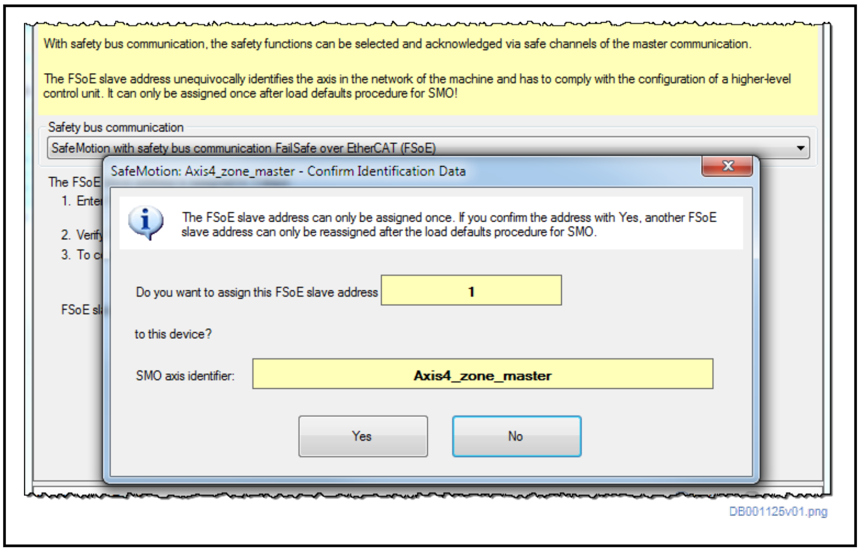

Fig. 9-23: Confirming the FSoE slave address

Pertinent parameters

- P-0-3235.0.3, C8500 SMO: Command Apply identification data
- P-0-3235.0.4, SMO: Axis identification: Control word
- P-0-3350, FSoE: Slave address
- P-0-3351, FSoE: Expected slave address

Afterwards, go to the next commissioning dialog using the **Next >>** button.

PROFIsafe

If "SafeMotion with PROFIsafe safety bus communication" is selected, the "PROFIsafe F-Device address" has to be assigned to the drive in the next step. It can only be assigned once after the SMO default values have been loaded.

Please observe the order and the required steps when assigning the "PROFIsafe F-Device address" as the "PROFIsafe F-Device address" can only be assigned once after the SMO default values have been loaded.

---

1. Enter the PROFIsafe F-Device address.

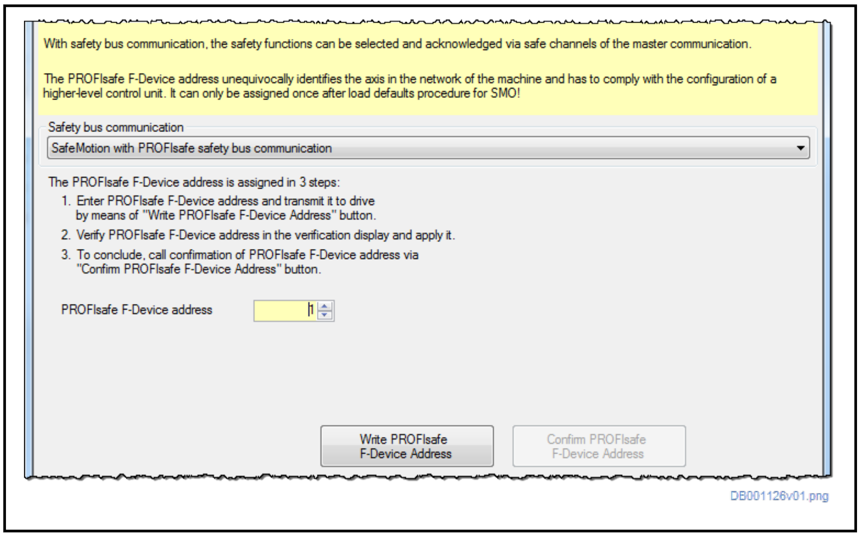

Fig. 9-24: Entering the PROFIsafe F-Device address

2. Write the PROFIsafe F-Device address to the drive by clicking the **Write PROFIsafe F-Device address** button.
3. Verify the entered values via the verification display.

☞ With the parameter verification, it is necessary to check / verify whether the parameterization active in the drive complies with the parameters intended or configured for this axis.

The parameter verification is carried out in IndraWorks via the bottom sections of the Safe Motion dialogs ("Verification display").

---

4. Activate PROFIsafe F-Device address via the **Confirm PROFIsafe F-Device address** button.

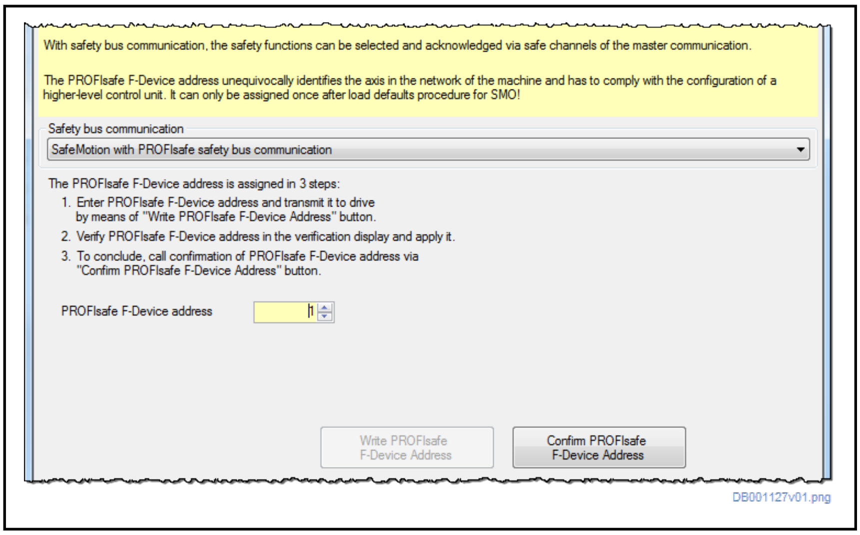

Fig. 9-25: Confirming the PROFIsafe F-Device address

5.

The display of the drive, with the SMO axis identifier shown in the dialog, shows `Confirm SMO-Identification?`. The diagnostic LEDs H25 and H26 at the "Safe Motion" option are lit with the flashing pattern "red - green - green - red".

The diagnostic LEDs are not a safe display and cannot be used as a source of safe information on the internal state. The diagnostic LEDs only provide diagnostic data!

Confirm the PROFIsafe F-Device address for the corresponding axis via the **Yes** button in the query dialog, or by pressing the <Enter> key at the control panel.

For devices of the "IndraDrive Mi" range, the PROFIsafe F-Device address can only be confirmed via the **Yes** button in the query dialog.

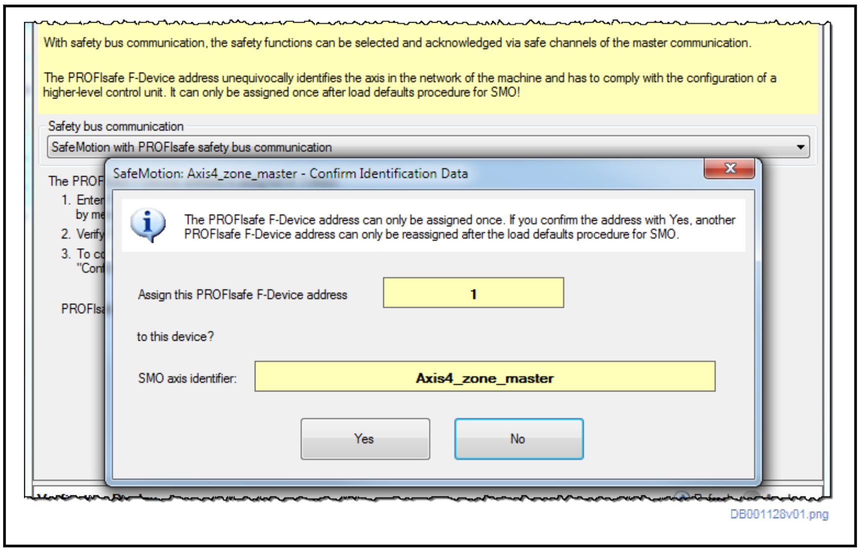

Fig. 9-26: Confirming the PROFIsafe F-Device address

Pertinent parameters

- P-0-3235.0.3, C8500 SMO: Command Apply identification data
- P-0-3235.0.4, SMO: Axis identification: Control word
- P-0-3360.0.2, PROFIsafe: Proposed F-Device address
- P-0-3360.0.1, PROFIsafe: F-Device Address

Afterwards, go to the next commissioning dialog using the **Next >>** button.

Commissioning

Predefined configuration

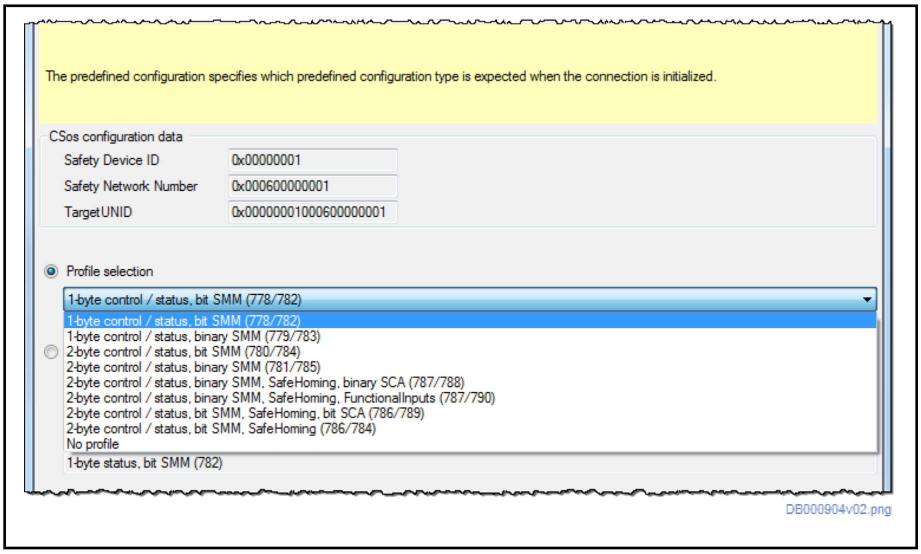

Fig. 9-27: Safety bus communication: Predefined configuration via the profile selection

The "Predefined configuration" dialog is only displayed if the Safety bus communication was activated.

In the "Predefined configuration" dialog, the predefined configurations for the consumer connection (data transmitted from the control unit to the drive) (P-0-3342.0.1) and the predefined configurations for the producer connection (data transmitted from the drive to the control unit) (P-0-3343.0.1) have to be defined for the Safety bus communication. These predefined configurations are made available to the control unit via the device data sheet. Depending on the bus communication type, the device data sheet has the following file format:

- CSos: SDDML
- FSoE: XML
- PROFIsafe: GSDML)

The predefined configurations can alternatively be configured as a profile (pre-defined combination of the predefined configuration for consumer and producer connection) or separately.

Make the profile settings in the control unit used analogously to the settings for the Safety bus communication.

It is impossible to freely configure the bit assignment in the control and status words.

Afterwards, the settings that were made have to be verified.

With the parameter verification, it is necessary to check / verify whether the parameterization active in the drive complies with the parameters intended or configured for this axis.

The parameter verification is carried out in IndraWorks via the bottom sections of the Safe Motion dialogs ("Verification display").

Go to the next commissioning dialog via the **Next >>** button.

Masking the consumer connection

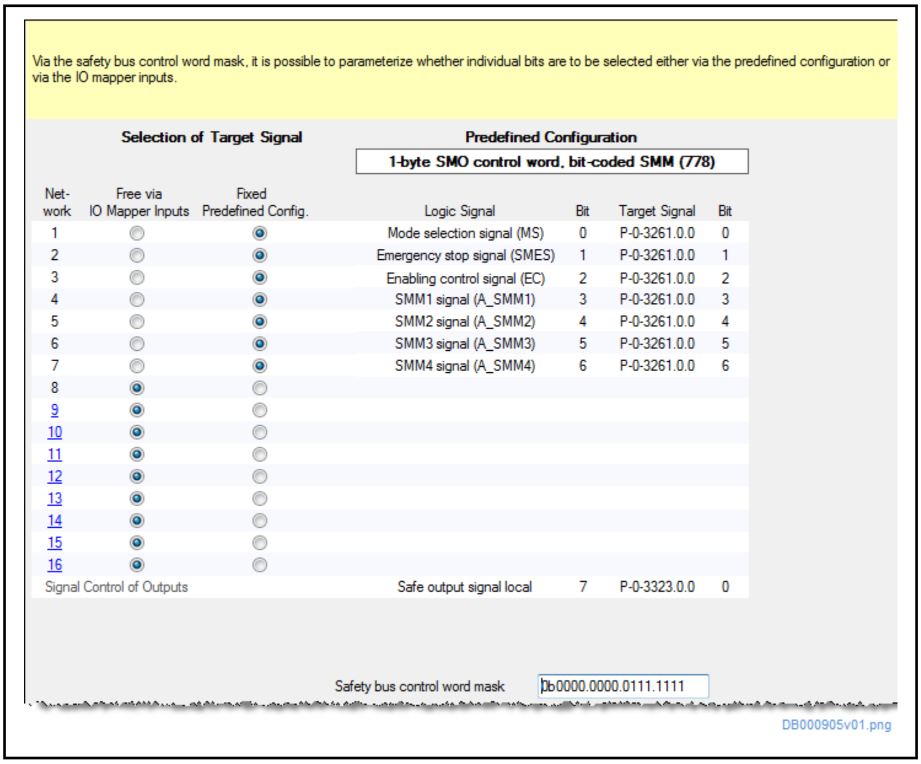

Fig. 9-28: Safety bus communication: freely selecting the target signals via the IO mapper

The "Masking the consumer connection" dialog is only displayed if the Safety bus communication was activated.

In this dialog, the consumer connection (P-0-3340.0.1) is masked, i.e. the source signals from the predefined configuration of the Safety bus are directly assigned to the networks of the "IO mapper inputs". It is necessary to configure which signals are directly and in fixed form assigned in the "IO mapper inputs" to the corresponding target signals of SMO via safe connectors (select **Fixed via predefined configuration**), and which signals are to be processed via freely configurable networks of the "IO mapper inputs" (select **Free via IO mapper inputs**).

All networks configured by selecting **Fixed via predefined configuration** are grayed out in the "IO mapper inputs" and cannot be edited any more.

Networks that are not used by the consumer connections are grayed out by default and cannot be edited (select **Fixed via predefined configuration**). If these networks are to be configured, they have to be activated (select **Free via IO mapper inputs**).

Afterwards, the settings that were made have to be verified.

With the parameter verification, it is necessary to check / verify whether the parameterization active in the drive complies with the parameters intended or configured for this axis.

The parameter verification is carried out in IndraWorks via the bottom sections of the Safe Motion dialogs ("Verification display").

Go to the next commissioning dialog via the **Next >>** button.

Safety zone and Safe door locking

In the "Safety zone and Safe door locking" dialog, configure the properties and the behavior of the axis in conjunction with a safety zone at a safety zone module.

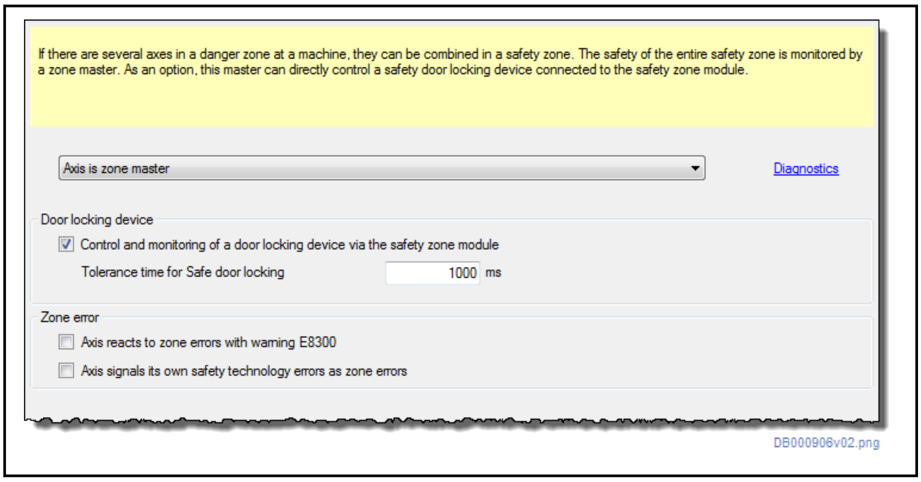

Fig. 9-29: Safety zone and Safe door locking

☞ For devices with optional safety technology module "SB" or devices of the "IndraDrive Mi" range, this dialog is not displayed.

Via the drop down list, select whether the axis is to be operated at a safety zone with safety zone module (HSZ). The following settings are possible:

- Select "Axis acknowledges safety independently (no zone node)" if the axis is not included in a safety zone via the zone bus (X42/X43).
- Select "Axis is zone node" if the axis has been connected to the zone bus (X42/X43) and not connected directly to a safety zone module (HSZ) via X43.
- Select "Axis is zone master" if the axis has been connected to the zone bus (X42/X43) and connected directly to an HSZ via X43. This axis then takes over the acknowledgment of the zone status via the outputs of the safety zone module (HSZ).

In the "Door locking device" dialog section, configure the control and monitoring of safe door locking via the safety output "SDL_Chx" (X44 1.9/2.9). The selection can only be made when the axis was configured as the zone master. When Safe door locking is used, the feedback contacts of the door latch have to be read in via the inputs of the safety zone module (HSZ) and accordingly evaluated in the "IO mapper inputs".

With MPx-20V12 and above, the time within which the feedback contacts of the door latch have to acknowledge the door locking status can be parameterized with active "Control and monitoring of a door locking device" using the "Tolerance time for Safe door locking" field. The default value of 1,000 ms should be sufficient for normal applications.

In the "Zone error" dialog section, set whether the axis is to react with the warning E8300 to zone errors signaled via the zone bus (X42/X43). For this purpose, activate the **Axis reacts to zone errors with warning E8300** check box.

Independent of the reaction to zone errors, it is possible to configure whether or not the axis signals its own safety technology errors (F3xxx, F7xxx and F83xx) as zone errors via the zone bus (X42/X43). To do this, activate the **Axis signals its own safety technology errors as zone errors** check box.

The "Door locking device" dialog section is only active for an axis with zone bus connection (X42/X43), i.e. "Axis is zone node" or "Axis is zone master" was selected in the drop down list.

Pertinent parameters

- P-0-3266.0.2, SMO: Safety zone configuration
- P-0-3266.0.4, SMO: Tolerance time for Safe door locking

Afterwards, the settings that were made have to be verified.

With the parameter verification, it is necessary to check / verify whether the parameterization active in the drive complies with the parameters intended or configured for this axis.

The parameter verification is carried out in IndraWorks via the bottom sections of the Safe Motion dialogs ("Verification display").

Go to the next commissioning dialog via the **Next >>** button.

Safety zone module

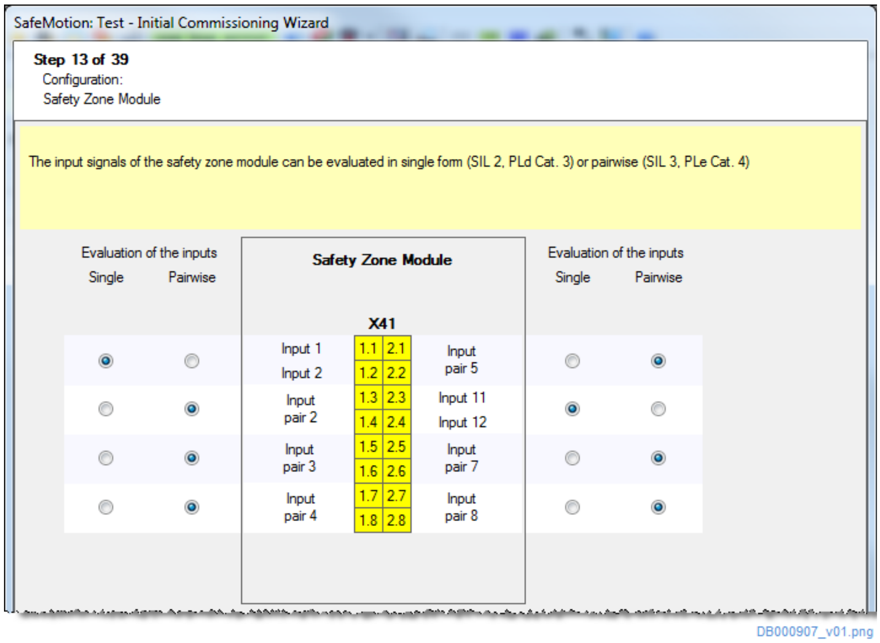

Fig. 9-30: Evaluating the inputs of the safety zone module

The "Safety zone module" dialog is only displayed if "Axis is zone node" or "Axis is zone master" was selected in the "Safety zone and Safe door locking" dialog.

For devices with optional safety technology module "SB" or devices of the "IndraDrive Mi" range, this dialog is not displayed.

In the "Safety zone module" dialog, parameterize whether the input signals (X41) of the safety zone module (HSZ) are to be evaluated "in single form" or "pairwise" in this axis. This selection can be made selectively for each input pair (see dialog). According to this setting, the input signals can then be used in the IO mapper inputs as "input x, safety zone module" with single evaluation, and "input pair x, safety zone module" with pairwise evaluation.

Pertinent parameter:

P-0-3320.0.2, SMO: Configuration Input Signals, safety zone module

☞ The input signals of the safety zone module can be evaluated in single form (SIL 2, PL d, Category 3) and pairwise (SIL 3, PL e, Category 4).

Afterwards, the settings that were made have to be verified.

☞ With the parameter verification, it is necessary to check / verify whether the parameterization active in the drive complies with the parameters intended or configured for this axis.

The parameter verification is carried out in IndraWorks via the bottom sections of the Safe Motion dialogs ("Verification display").

Go to the next commissioning dialog via the **Next >>** button.

IO mapper inputs

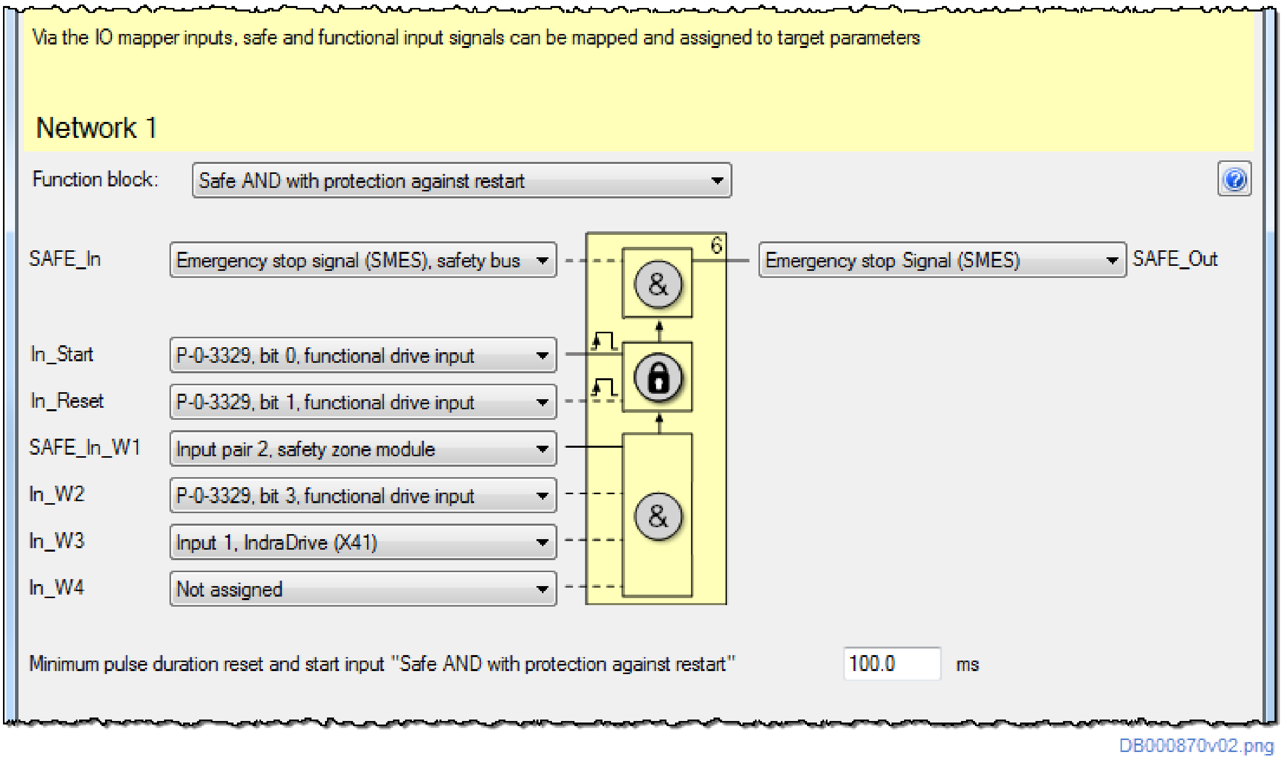

Fig. 9-31: IO mapper inputs: Example "Safe AND with protection against restart"

Via the "IO mapper inputs" dialogs, input signals for Safe Motion can be mapped to the selection signals of the safety functions. For this purpose, there are 16 IO mapper networks available in each axis.

☞ If a network has been pre-assigned by a predefined configuration of the Safety bus communication (see chapter "Masking the consumer connection" on page 323), the respective option is grayed out. The text of the option is complemented by "(predefined configuration)".

Via the drop down list, select the type of network, i.e. the function block.

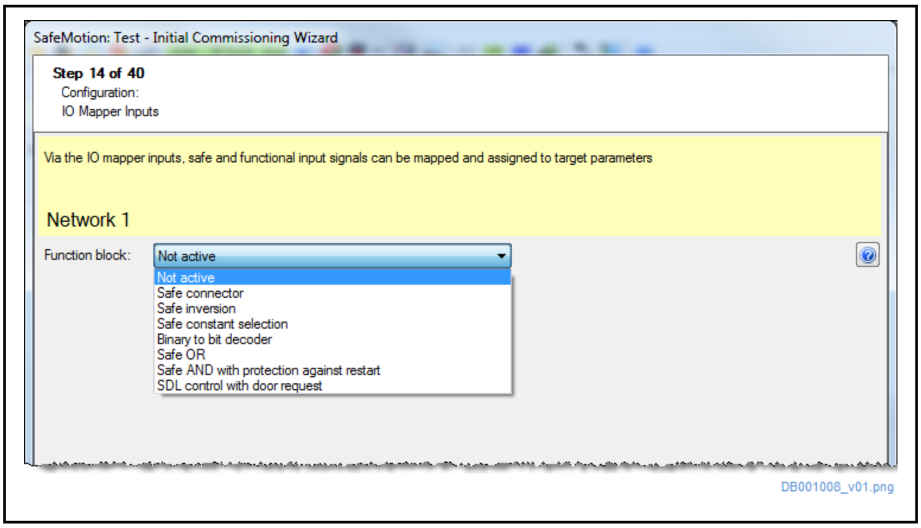

Fig. 9-32: Selecting the function block type

When a function block has been selected, a circuit diagram of the function block is displayed. Using drop down lists, the signals can be set at the inputs/ outputs of the circuit diagram. If all instances of a function block are in use, this function block is not provided any more. When the network type is changed, the allowed input/output signals change in many cases. The signals set until then are not changed, but might possibly be displayed as invalid.

The input signals / output signals are set via the drop down lists at the inputs/ outputs of the function block circuit diagram. The input types available in P-0-3331.x.1 limit the selection of possible input signals for each input of a module.

Safe inputs/outputs are marked with the "SAFE" prefix. Only safe signals can be applied to these inputs/outputs. Both safe and non-safe signals can be applied to non-safe inputs/outputs (no prefix).

For networks of the function block type 6 ("Safe AND with protection against restart"), an edit field exists for the minimum pulse duration of the reset and start input. The entered value applies to all instances of function block 6.

The top right corner of the circuit diagram of all function blocks shows a button that links to the functional description of the function block.

Pertinent parameters

- P-0-3330.x.1, SMO: IO mapper inputs, type
- P-0-3330.x.2, SMO: IO mapper inputs, IDN source
- P-0-3330.x.3, SMO: IO mapper inputs, bit source
- P-0-3330.x.4, SMO: IO mapper inputs, IDN target
- P-0-3330.x.5, SMO: IO mapper inputs, bit target
- P-0-3332.x.1, SMO: IO mapper inputs, minimum pulse duration

Afterwards, the settings that were made have to be verified.

With the parameter verification, it is necessary to check / verify whether the parameterization active in the drive complies with the parameters intended or configured for this axis.

The parameter verification is carried out in IndraWorks via the bottom sections of the Safe Motion dialogs ("Verification display").

Go to the next commissioning dialog via the **Next >>** button.

Signal control of outputs

In the "Signal control of outputs" dialog, set via the drop down list which status signal is output via the safe local outputs X41 1.1/1.3 (IndraDrive Mi: X141 8/12) (also "Local safe interface") of the optional Safe Motion module.

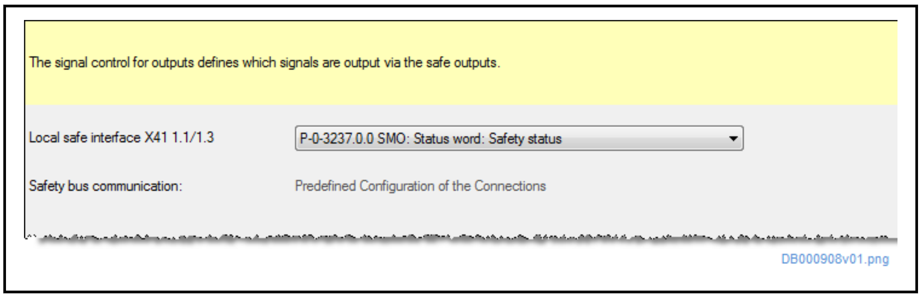

Fig. 9-33: Selecting the status signal of the safe local output

Possible combinations of **parameter number with parameter name of a status signal** (e.g. "P-0-3237.0.0 SMO: Status word") and a **logic signal name** (e.g. "Safety status") are provided for selection.

If a predefined configuration, which controls the safe outputs at the optional Safe Motion module, has been configured with Safety bus communication being active, the corresponding bit has to be actively assigned. There is no automatic configuration.

If the safe outputs at the optional Safe Motion module are used, the power supply has to be wired at X41 (IndraDrive Mi: X141).

Pertinent parameters

- P-0-3335.0.1, SMO: Signal control for discrete outputs, IDN assignment
- P-0-3335.0.2, SMO: Signal control for discrete outputs, bit number

Afterwards, the settings that were made have to be verified.

With the parameter verification, it is necessary to check / verify whether the parameterization active in the drive complies with the parameters intended or configured for this axis.

The parameter verification is carried out in IndraWorks via the bottom sections of the Safe Motion dialogs ("Verification display").

Go to the next commissioning dialog via the **Next >>** button.

Safe brake control

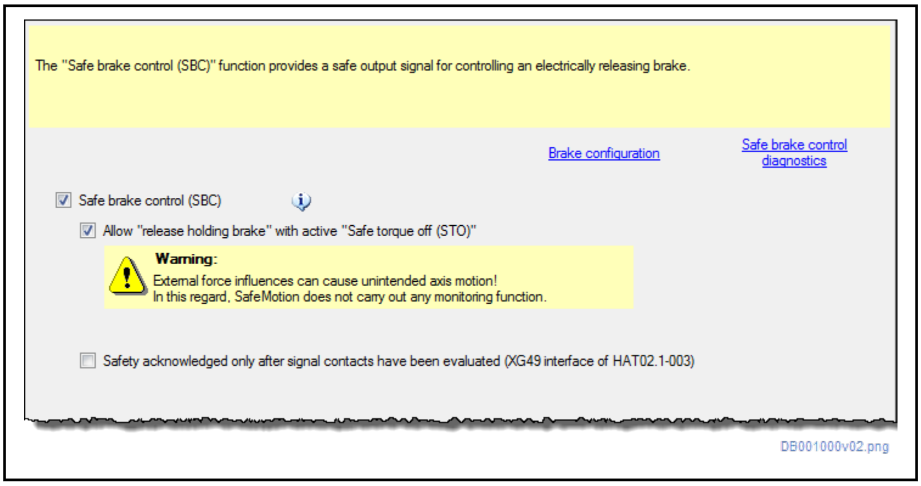

Fig. 9-34: Safe brake control

In the "Safe brake control" dialog, activate the safety technology function of the same name.

For using the Safe brake control (SBC), the following prerequisites have to be met:

- IndraDrive Cs (HCS01) with optional safety technology module "Sx"
- IndraDrive C/M/ML with optional safety technology module "Sx" and control module for inductive loads (HAT02)
- IndraDrive Mi with optional safety technology module "SD"

For all other device combinations, the SBC safety function has to be deactivated in this dialog!

If **Safe brake control** has been activated (P-0-3265.0.1), it is possible to additionally select ""Allow" release holding brake" with active "Safe torque off (STO)". This enables the manual control of the brake with the "Release holding brake" control signal in the parameter "P-0-3265.0.2, SMO: Control word of safe braking and holding function".

⚠ WARNING **Lethal injury and/or property damage caused by unintended axis motion!**

⇒ If the brake is manually controlled via the "release holding brake" control signal, the drive is no longer able to counteract external force influences. In this state, the safety technology does not carry out any monitoring function!

If external force influences are to be expected, e.g. in the case of a vertical axis, this motion has to be safely prevented by additional measures, e.g. weight compensation.

When no brake or an electrically clamping brake has been parameterized, i.e. the brake is applied at 24 V, a warning with regard to the brake is displayed. Via the "Brake configuration" link, the dialog for configuring the brake of the standard firmware can be opened.

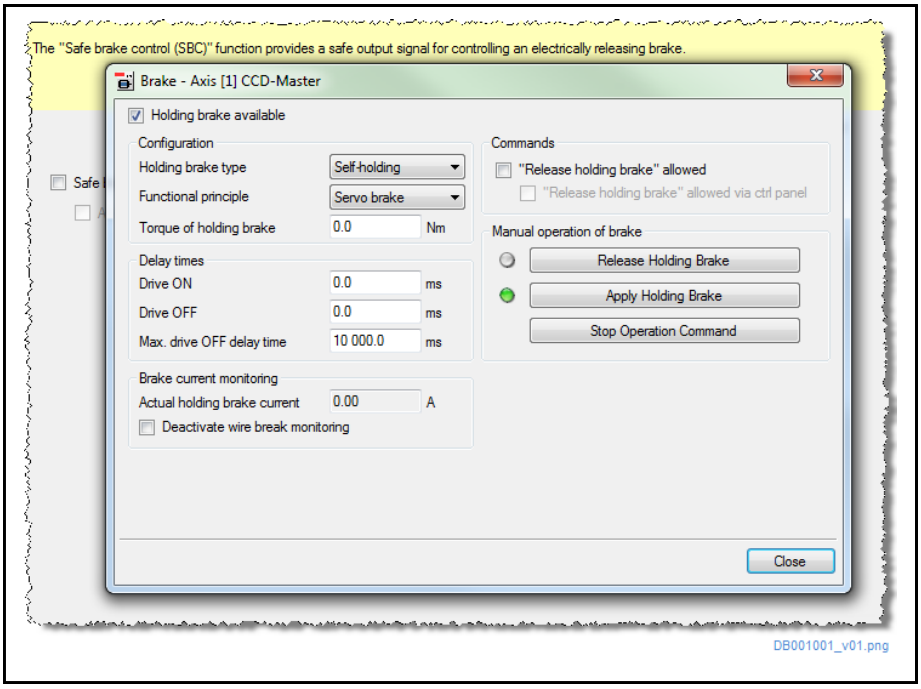

Fig. 9-35: Configuring the brake

Afterwards, the settings that were made have to be verified.

With the parameter verification, it is necessary to check / verify whether the parameterization active in the drive complies with the parameters intended or configured for this axis.

The parameter verification is carried out in IndraWorks via the bottom sections of the Safe Motion dialogs ("Verification display").

Go to the next commissioning dialog via the **Next >>** button.

Additional and auxiliary functions

In the "Additional and auxiliary functions" dialog, configure the behavior of the safety technology function "Safe parking axis".

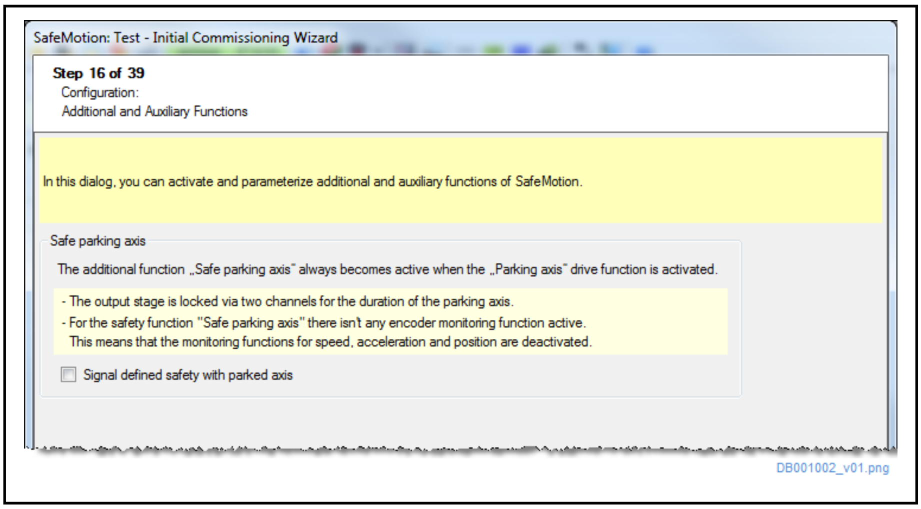

Fig. 9-36: Additional and auxiliary functions

The safety function "Safe parking axis" always becomes active, when the "Parking axis" drive function is activated. Configuring the option "Signal defined safety with parked axis" (P-0-3231.0.4) allows selecting that the axis also acknowledges safety when the safety function has been activated.

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

The control bit "defined safety with parked axis" in "P-0-3231.0.4, SMO: System configuration" signals safety which must result from the risk analysis. The risk analysis must show that the axis does not cause any danger to persons, when the axis has been parked. Using the function for axes with long coasting times (grinding wheels, spindles, rolls, ...) must be excluded.

Afterwards, the settings that were made have to be verified.

☞ With the parameter verification, it is necessary to check / verify whether the parameterization active in the drive complies with the parameters intended or configured for this axis.

The parameter verification is carried out in IndraWorks via the bottom sections of the Safe Motion dialogs ("Verification display").

Go to the next commissioning dialog via the **Next >>** button.

Step 5: Parameterizing the safety functions

Global monitoring functions

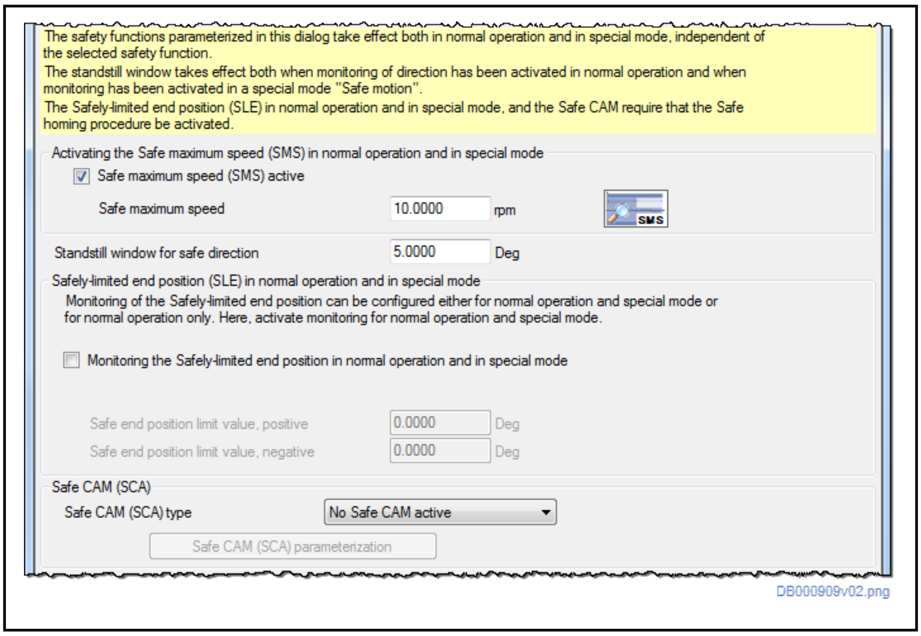

Fig. 9-37: Parameterizing global monitoring functions

Global monitoring functions are always active, both in the special modes and in normal operation.

In the dialog section "Activating the Safe maximum speed (SMS) in normal operation and in special mode", activate the "Safe maximum speed" (SMS) and parameterize the corresponding velocity threshold. (The velocity threshold can only be changed when the monitoring function has been activated.)

In the edit box "Standstill window for Safe direction", parameterize a position range that Safe Motion is to tolerate as a position deviation. Set the value so high that the encoder noise does not exceed the value and the mechanics backlash is taken into account. If safety functions with position monitoring are not used, the value does not need to be adjusted.

In the dialog section "Safely-limited end position (SLE) in normal operation and in special mode" and with MPx20V06 and above, monitoring of the safely-limited end positions can be globally activated (for normal operation and special mode) and the related position values can be parameterized. (The position limit values can only be changed when the monitoring function has been activated.)

☞ The "Safely-limited end position (SLE)" can either be parameterized globally (for normal operation and special mode) or for normal operation only. As soon as it has been parameterized for an application in the corresponding dialog, parameterization in the other dialog is deactivated (grayed out).

In the dialog section "Safe CAM (SCA)" (MPx-20V08 and above), the "Safe CAM (SCA) type" drop down list is used to select whether or which type of the safe cams is to be parameterized for this axis. Parameterization is effected in a separate dialog which is opened via the **Safe CAM (SCA) parameterization** button. (The dialog for Safe CAM can only be called if one type of the safe cams has been selected.)

Safe CAM

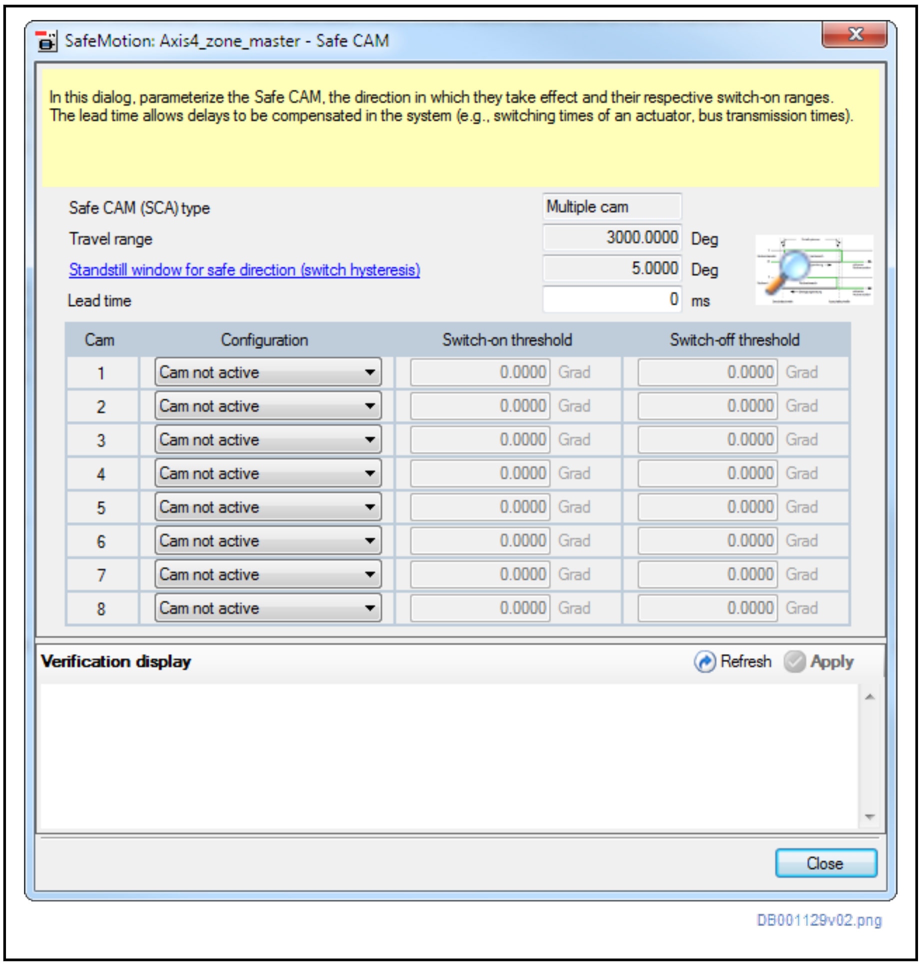

Fig. 9-38: "Safe CAM" dialog

In the "Safe CAM" dialog, the "Safe CAM (SCA) type" field shows the selected type of the safe cams which cannot be changed here. Apart from that, the travel range and the standstill window for the safe motion are displayed. Via the "Standstill window for safe direction (switching hysteresis)" link, the "Global monitoring functions" dialog can be called, and the standstill window can be adjusted in this dialog. For the Safe CAM, this acts as a switching hysteresis for the switch-on and switch-off threshold.

In the "Lead time" field, parameterize a velocity-dependent lead time for compensating time delays (internal processing times, transmission times to the safety control) when switching the cam status bits.

In the table in the bottom part of the dialog, the safe cams can be configured. In the "Configuration" column, every cam can be activated and its operating principle can be parameterized (positive, negative or both directions of motion). The relevant switch-on threshold can be parameterized in the "Switch-on threshold" column and the switch-off threshold in the "Switch-off threshold" column.

☞ To invert a cam, just exchange the value for the switch-on and switch-off threshold.

Afterwards, the settings that were made have to be verified.

☞ With the parameter verification, it is necessary to check / verify whether the parameterization active in the drive complies with the parameters intended or configured for this axis.

The parameter verification is carried out in IndraWorks via the bottom sections of the Safe Motion dialogs ("Verification display").

The dialog can be closed again using the **Close** button.

Afterwards, the settings that were made have to be verified.

☞ With the parameter verification, it is necessary to check / verify whether the parameterization active in the drive complies with the parameters intended or configured for this axis.

The parameter verification is carried out in IndraWorks via the bottom sections of the Safe Motion dialogs ("Verification display").

Pertinent parameters

- P-0-3270.0.1, SMO: Configuration of global safety functions
- P-0-3270.0.2, SMO: Safe maximum speed
- P-0-3270.0.3, SMO: Standstill window for safe direction
- P-0-3270.0.4, SMO: Safe end position limit value, positive
- P-0-3270.0.5, SMO: Safe end position limit value, negative
- P-0-3270.0.6, SMO: Safe CAM, lead time
- P-0-3271.0.x, SMO: Safe CAM 1

Go to the next commissioning dialog via the **Next >>** button.

Normal operation

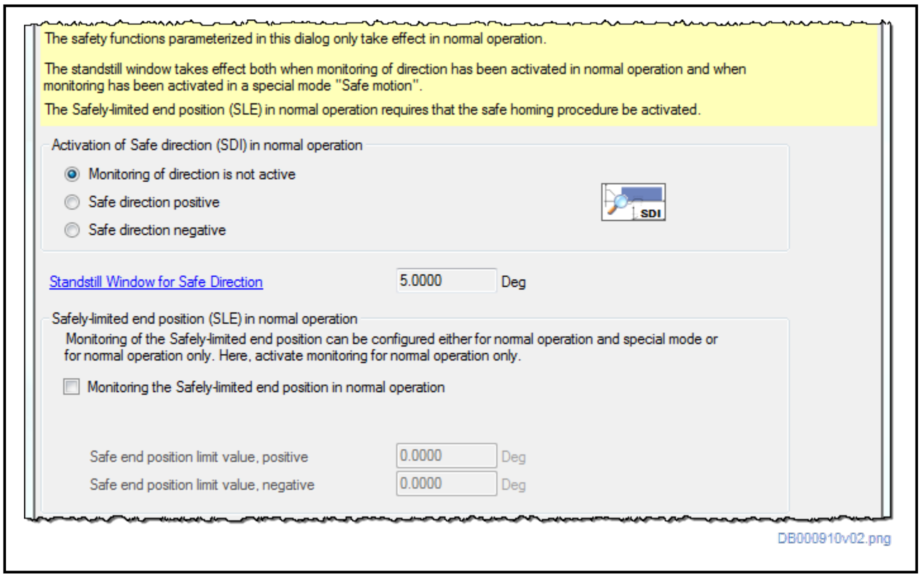

Fig. 9-39: Parameterizing safety functions for normal operation

☞ The "Normal operation" dialog is only displayed when an encoder was configured for the safety technology.

In this dialog, parameterize the safety functions which only take effect in normal operation.

In normal operation, it is possible to activate the monitoring of the safe direction (SDI) for the positive or negative direction. The standstill window active for the safety function "Safe direction" (SDI) is only displayed in this dialog. Via the "Standstill window for Safe direction" link, the "Global monitoring functions" dialog can be called, and the standstill window can be adjusted in this dialog.

In the dialog section "Safely-limited end position (SLE) in normal operation" and with MPx-20V06 and above, monitoring of the safely-limited end positions in normal operation can be activated and the related position limit values can be parameterized. (The position limit values can only be changed when the monitoring function has been activated.)

☞ The "Safely-limited end position (SLE)" can either be parameterized globally (for normal operation and special mode) or for normal operation only. As soon as it has been parameterized for an application in the corresponding dialog, parameterization in the other dialog is deactivated (grayed out).

Pertinent parameters

- P-0-3277.0.1, SMO: Configuration of normal operation (bit 0, bit 1)
- P-0-3270.0.3, SMO: Standstill window for safe direction
- P-0-3270.0.4, SMO: Safe end position limit value, positive
- P-0-3270.0.5, SMO: Safe end position limit value, negative

Afterwards, the settings that were made have to be verified.

With the parameter verification, it is necessary to check / verify whether the parameterization active in the drive complies with the parameters intended or configured for this axis.

The parameter verification is carried out in IndraWorks via the bottom sections of the Safe Motion dialogs ("Verification display").

Go to the next commissioning dialog via the **Next >>** button.

Safe standstill

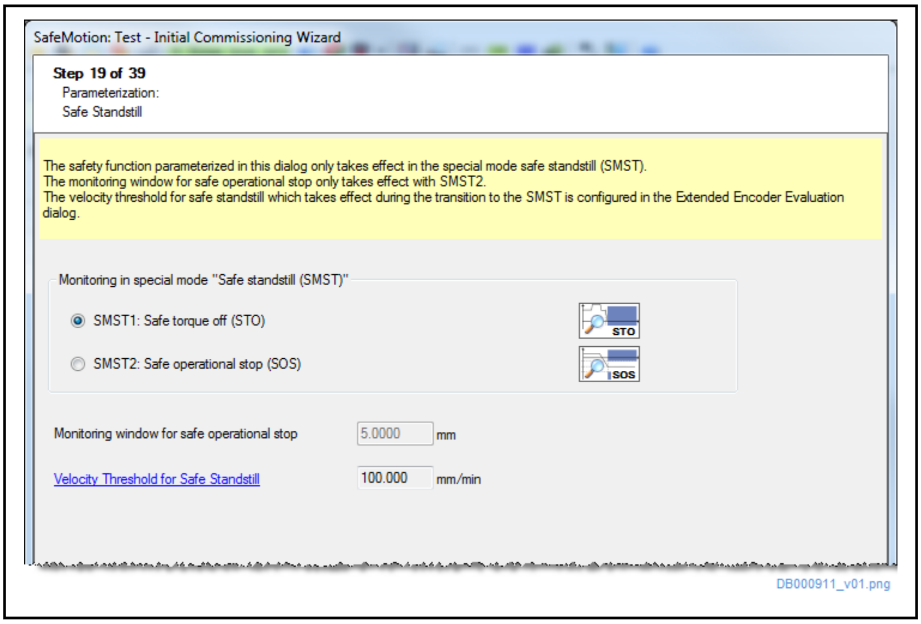

Fig. 9-40: Parameterizing safety functions for Safe standstill

In this dialog, parameterize the safety functions for the special mode "Safe standstill (SMST)". In SMST, the safety function "Safe torque off (STO)" or "Safe operating stop (SOS)" can be alternatively configured.

If SMST is configured with Safe operating stop, the "Monitoring window for Safe operating stop" has to be parameterized in addition. Set the value so high that the encoder noise does not exceed the value and the mechanics backlash is taken into account.

The velocity threshold for safe standstill active for the SMST is only displayed in this dialog. Via the "Velocity threshold for Safe standstill" link, the "Standstill monitoring" dialog can be called, and the velocity threshold can be adjusted in this dialog.

Pertinent parameters

- P-0-3285.0.1, SMO: Configuration of safe standstill
- P-0-3285.0.2, SMO: Monitoring window for safe operational stop
- P-0-3255, SMO: Velocity threshold for safe standstill

Afterwards, the settings that were made have to be verified.

With the parameter verification, it is necessary to check / verify whether the parameterization active in the drive complies with the parameters intended or configured for this axis.

The parameter verification is carried out in IndraWorks via the bottom sections of the Safe Motion dialogs ("Verification display").

Go to the next commissioning dialog via the **Next >>** button.

Safe motion 1...16

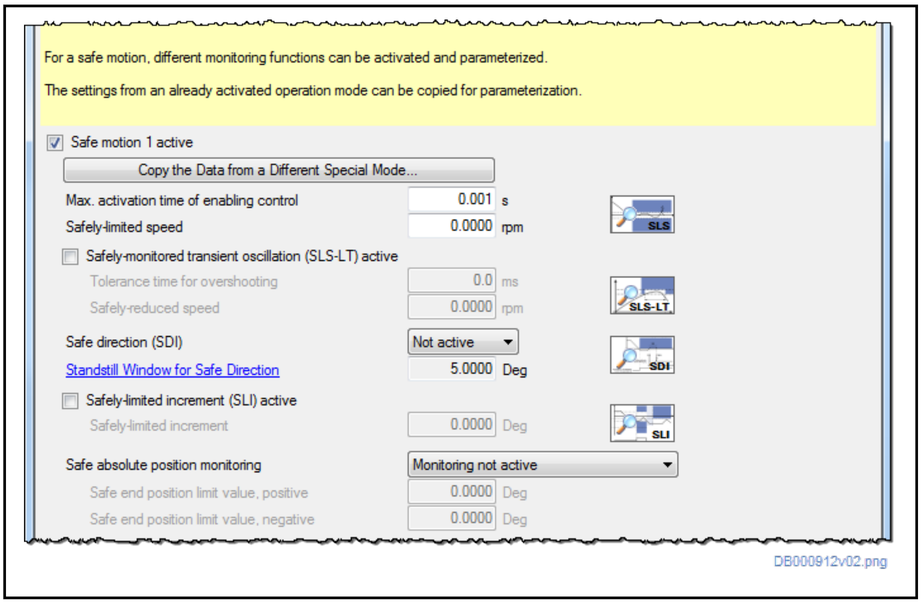

Fig. 9-41: Parameterizing Safe motion 1...16

☞ The "Safe motion 1...16" dialogs are only displayed when an encoder was configured for the safety technology.

Via the dialogs of the safe motions, configure the safety functions of the special mode safe motion (SMM). Safe Motion makes available 16 switchable operating states for the special mode safe motion (SMM1 to SMM16). The SMM can be independently configured.

Via the **Safe motion n active** check box (n stands for 1…16), the safe motion is activated and can then be configured.

Via the **Copy the data from a different special mode…** button, it is possible to apply the configuration of a different Safe motion. Via the drop down list in the dialog, the desired motion mode can be selected (only the activated motion modes are displayed). After the selection was made, a preview of the values is displayed at first. By clicking the **Copy** button, the values are applied to the configuration of the motion mode and can be edited there.

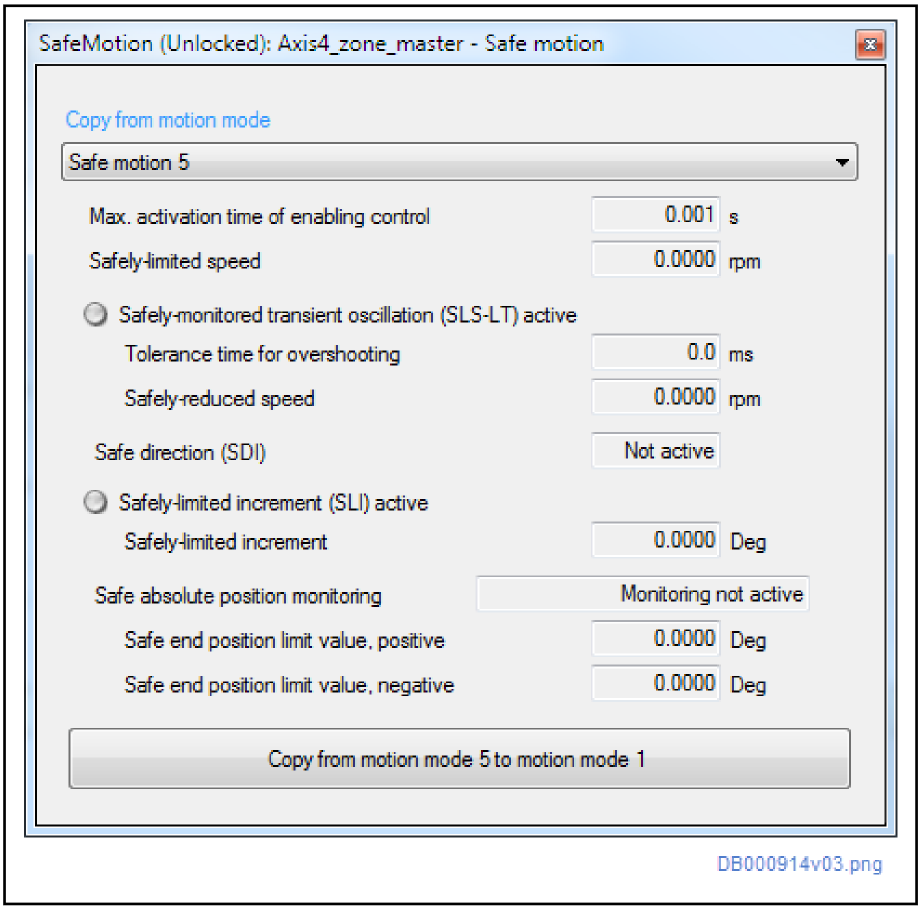

Fig. 9-42: Copying the data to a different special mode

In text field "Max. activation time of enabling control", enter the maximum allowed time for activating the enabling control. At the latest when the entered time is over, the enabling control has to be deactivated; i.e. the special mode "Safe motion" is temporary.

⚠ WARNING

Dangerous movements! Danger to life, risk of injury, serious injury or property damage by switching off the monitoring of the activation time!

It is possible to do without the monitoring of the activation time, if it is not common practice to use an enabling control in an industrial sector and if constant motion does not represent any danger. The machine manufacturer is responsible for the monitoring of the activation time and their risk analysis has to show their responsibility. With "P-0-3290.x.6, SMO: Maximum activation time of enabling control"="0", the time monitoring of the special mode "Safe motion" is deactivated (x=1…16).

In the "Safely-limited speed" field, define a speed threshold (bipolar) for the safety function "Safely-limited speed". The safety function "Safely-limited speed" is always active in the special mode "Safe motion".

If the safety function "Safely-monitored transient oscillation (SLS-LT)" is to be used, it has to be activated via the check box "Safely-monitored transient oscillation (SLS-LT) active". Afterwards, the maximum time of the occurring overshooting has to be entered in the "Tolerance time for overshooting" field. In the "Safely-reduced speed" field, parameterize the velocity threshold with regard to which monitoring is to take place after the overshooting time is over.

The monitoring of the direction for the SMM can be configured via the "Safe direction (SDI)" drop down list. The safety function "Safe direction (SDI)" can be individually configured for each SMM. The standstill window active for the SDI safety function is only displayed in this dialog. Via the "Standstill window for Safe direction" link, the "Global monitoring functions" dialog can be called, and the standstill window can be adjusted in this dialog.

If the safety function "Safely-limited increment (SLI)" is to be used, it has to be activated via the check box "Safely-limited increment (SLI) active". In the "Safely-limited increment" field, a relative position window for the SMMx (x=1...16) then has to be defined. The position window is defined with the start of the SMMx. For the duration of the SMMx, the drive can be freely moved within this position window.

If the Safe absolute position monitoring (available with MPx20V06 and above) for the SMM is to be used, it has to be activated using the "Safe absolute position monitoring" drop down list. It is possible to choose between "Safely-monitored position (SMP)" and "Safely-limited position (SLP)". Afterwards, the related position limited values have to be parameterized. (The position limit values can only be changed when the monitoring function has been activated.)

Pertinent parameters (x=1...16 for SMMx)

- P-0-3290.x.1, SMO: Configuration of safe motion
- P-0-3290.x.2, SMO: Safely-limited speed
- P-0-3290.x.3, SMO: Safely-limited increment
- P-0-3290.0.4, SMO: Safe position limit value, positive
- P-0-3290.0.5, SMO: Safe position limit value, negative
- P-0-3290.x.6, SMO: Maximum activation time of enabling control
- P-0-3290.x.7, SMO: Tolerance time for overshooting
- P-0-3290.x.8, SMO: Safely-reduced speed
- P-0-3270.x.3, SMO: Standstill window for safe direction

Afterwards, the settings that were made have to be verified.

☞ With the parameter verification, it is necessary to check / verify whether the parameterization active in the drive complies with the parameters intended or configured for this axis.

The parameter verification is carried out in IndraWorks via the bottom sections of the Safe Motion dialogs ("Verification display").

Go to the next commissioning dialog via the **Next >>** button.

Changing the operating status

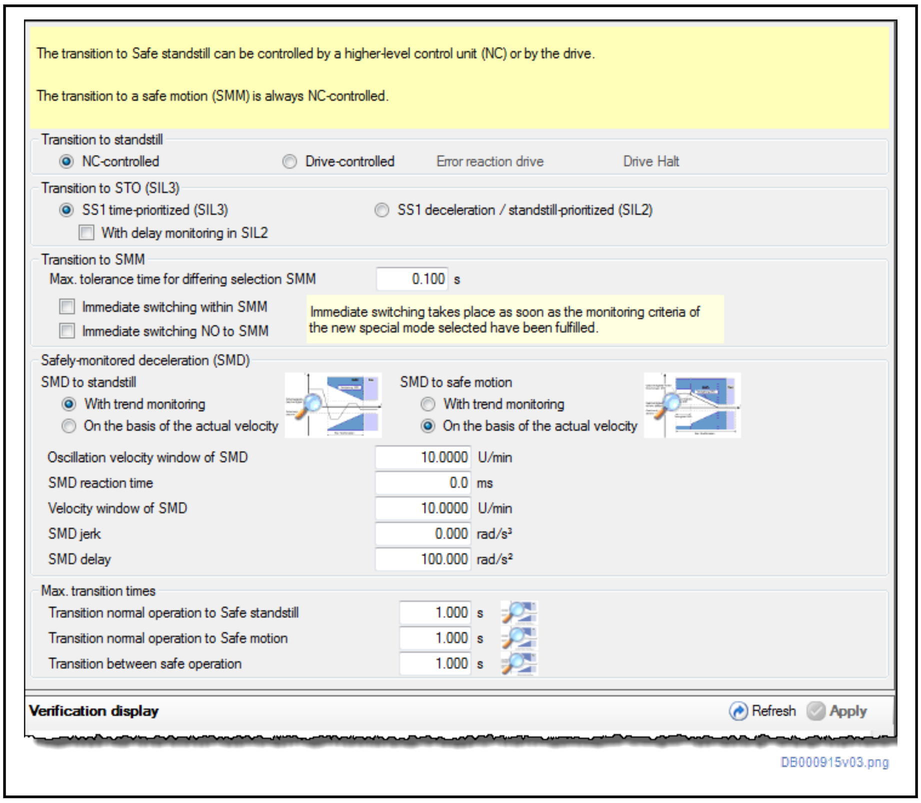

Fig. 9-43: Parameterizing the change in the operating status

Via the "Change of operating status" dialog, parameterize the transitions between the operating states of Safe Motion (normal operation, Emergency stop (SMES), special mode "Safe standstill (SMST)", special mode "Safe motion (SMM)").

In the **Transition to standstill** section, configure whether the transition to the new operating status is to be carried out in an "NC-controlled" way (i.e. the control unit actively has to perform the transition of the axis) or in a "drive-controlled" way (i.e. the drive performs the transition independent of the control unit).

Drive-controlled transition processes can only be carried out to standstill. Transitions to the special mode "Safe motion" are always NC-controlled, independent of the configuration.

With drive-controlled transition configured, the dialogs of the standard firmware, in which the axis reactions for the drive-controlled transition have been configured, can be called via the **Error reaction drive** and **Drive Halt** links.

In the **Transition to STO** section, configure the transition processes (SMES, SMST1) in which the STO safety function is active. It is possible to choose between two transition types:

- **SS1 time-prioritized:** When the transition time is over, STO **always** becomes active; this is independent of whether the axis standstill was reached or not; deceleration in SIL3.

The SMD delay monitoring can be optionally activated (**With delay monitoring in SIL2** check box); this does not increase the transition time, and considered as a whole the deceleration remains SIL3.

- **SS1 deceleration / standstill-prioritized:** The SMD delay monitoring is active. Through the escalation strategy, Safe Motion tries to accomplish axis standstill even in the case of error which can cause the deceleration time to be increased; deceleration in SIL2.

In the **Transition to SMM** section, make additional settings for the transition to the special mode "Safe motion". In the "Max. tolerance time for differing selection SMM" field, enter the maximum time during which the selection of SMMx (x=1...16) is allowed to be invalid (e.g., multiple SMM mode selectors simultaneously activated) without an error being generated. If no special mode "Safe motion" is used in the axis, the value does not need to be adjusted.

When the **Immediate switching within SMM** check box is activated, the axis, for transition processes from one SMM to another SMM, switches to the new SMM before the transition time is over, as soon as all conditions (velocity, direction of motion,..) have been fulfilled.

When the **Immediate switching NO to SMM** check box is activated, the axis, for transition processes from normal operation (NO) to an SMM, switches to the SMM before the transition time is over, as soon as all conditions (velocity, direction of motion,..) have been fulfilled. When Safe Motion has been configured without an encoder, the "Transition to SMM" section is not active (grayed out).

In the **Safely-monitored deceleration (SMD)** section, configure the SMD safety function. The SMD safety function allows monitoring transition processes to a special mode.

The SMD does **not** become active in the following cases:

- If Safe Motion has been configured without an encoder, In this case, the "Safely-monitored deceleration (SMD)" section is not active (grayed out).
- In the case of transitions to standstill, when only "SS1 time-prioritized (SIL3)" has been configured, without the option "With delay monitoring in SIL 2".

The type of SMD monitoring can be separately configured for transitions to standstill (SMES, SMST1, SMST2) and to the safe motions (SMMx, x=1...16). It is possible to choose between the following options:

- **With trend monitoring:** The drive calculates the deceleration ramp in such a way that at the end of the transition time it complies with the new velocity window. The following fields have to be configured:
  - In the "SMD delay" field, configure the value of the monitored deceleration below which the axis cannot fall in the case of a transition. The actual deceleration of the axis during the transition should be greater.

☞ Drive-controlled transitions to standstill can only be monitored "on the basis of the actual velocity". In this case, "trend monitoring" is not possible (grayed out).

- **On the basis of the actual velocity:** The drive uses the actual velocity at selection as the basis of the deceleration ramp and calculates the ramp. The following parameters have to be configured:

– In the "Oscillation velocity window of SMD" field, a tolerance velocity can be parameterized by which the velocity can increase after the selection, until the command value system has adjusted to the transition. The field is only provided when values unequal "0" have been parameterized in the "SMD reaction time" field.
– In the "SMD reaction time" field, a time can be parameterized by which the delay monitoring has to be delayed so that the command value system can react to the selection. Enter the value "0" if the delay is not required.
– In the "Velocity window of SMD" field, parameterize the velocity tolerance that at the start of the deceleration ramp is added to the current actual velocity. The value has to be greater than the velocity noise during the operation of the axis. The field can also be used to mask possible oscillation until the new target velocity has been reached.
– In the "SMD delay" field, configure the value of the monitored deceleration below which the axis cannot fall in the case of a transition. The actual deceleration of the axis during the transition should be greater.

In the **Max. transition times** section, configure the times with which Safe Motion monitors the transitions between the operating states. Within the times set here, the command value system of the drive must have been adjusted to the new operating status.

- The time in the "Transition normal operation to Safe standstill" field takes effect for all transition processes from normal operation to the special mode "Safe standstill" (SMES, SMST1, SMST2).
- The time in the "Transition normal operation to Safe motion" field takes effect for all transition processes from normal operation to the special mode "Safe motion" (SMMx, x=1...16). If no special mode "Safe motion" is used in the axis, the value does not need to be adjusted. If Safe Motion has been configured without an encoder, the "Transition normal operation to Safe motion" field is not active (grayed out).
- The time in the "Transition between safe operation" field takes effect for all transition processes that start or end in normal operation.

Pertinent parameters

- P-0-3280.0.1, SMO: Configuration of operation mode transitions
- P-0-3280.0.2, SMO: Max. transition time normal oper. to safe standstill
- P-0-3280.0.3, SMO: Max. transition time between safe operating states
- P-0-3280.0.4, SMO: Max. transition time normal oper. to safe motion
- P-0-3280.0.5, SMO: Max. tolerance time for different selection
- P-0-3280.0.6, SMO: Oscillation velocity window of SMD
- P-0-3280.0.7, SMO: SMD reaction time
- P-0-3280.0.8, SMO: Velocity window of SMD
- P-0-3280.0.9, SMO: SMD delay

Afterwards, the settings that were made have to be verified.

☞ With the parameter verification, it is necessary to check / verify whether the parameterization active in the drive complies with the parameters intended or configured for this axis.

The parameter verification is carried out in IndraWorks via the bottom sections of the Safe Motion dialogs ("Verification display").

Go to the next commissioning dialog via the **Next >>** button.

Error reaction

Via the "Error reaction" dialog, parameterize the reaction of Safe Motion to F3 errors, F7 errors and E83 warnings.

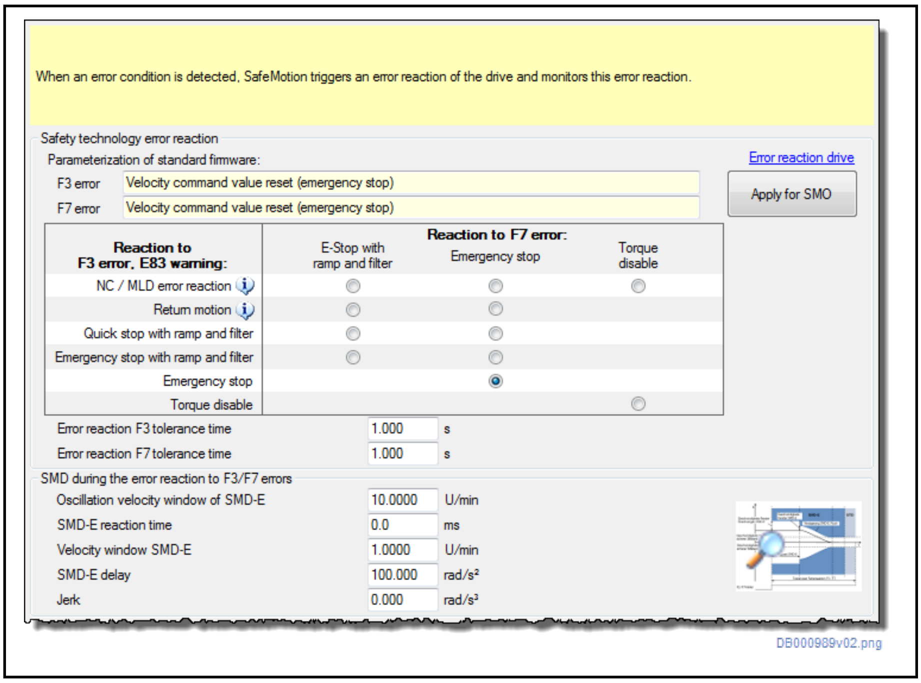

Fig. 9-44: Parameterizing the error reaction

In the **Safety technology error reaction** section, configure the Safe Motion error reaction. The upper part displays the configured error reaction of the standard firmware. Via the **Apply for SMO** button, the error reaction of the standard firmware can be applied to Save Motion. If it is impossible to apply the error reaction to Safe Motion due to invalid settings, the error reaction of the standard firmware can be adjusted accordingly via the "Error reaction drive" link.

☞ The configurations of the error reactions in the standard firmware and of Safe Motion **have to be identical**!

The table shows the error reaction combinations possible for Safe Motion. As an alternative to applying the error reaction of the standard firmware, the error reaction can be configured using the table.

In the "Error reaction F3 tolerance time" field, configure the time in which the F3 error reaction or E83 warning reaction has to be completed. The selected time has to allow the axis to be decelerated by an F3 error reaction (or an E83 warning reaction) even in the worst case (e.g., maximum velocity and maximum load).

In the "Error reaction F7 tolerance time" field, configure the time in which the F7 error reaction has to be completed. The selected time has to allow the axis to be decelerated by an F7 error reaction even in the worst case (e.g., maximum velocity and maximum load).

In the **SMD during the error reaction** section, configure the SMD safety function for the error reaction. The SMD monitoring of the error reaction always takes place "on the basis of the actual velocity". Thus, the following parameters have to be configured:

- In the "Oscillation velocity window of SMD" field, a tolerance velocity can be parameterized by which the velocity can increase after an error was triggered, until the command value system has adjusted to the error reaction. The field is only provided when values unequal "0" have been parameterized in the "SMD reaction time" field.
- In the "SMD reaction time" field, a time can be parameterized by which the delay monitoring has to be delayed so that the command value system can react to an occurring error. Enter the value "0" if the delay is not required.
- In the "Velocity window of SMD" field, parameterize the velocity tolerance that at the start of the deceleration ramp is added to the current actual velocity. The value has to be greater than the velocity noise during the operation of the axis. The field can also be used to mask possible oscillation until standstill has been reached.
- In the "SMD delay" field, configure the value of the monitored deceleration below which the axis cannot fall in the case of an error reaction. The actual deceleration of the axis during the error reaction should be greater.
- In the "Jerk" field (available with MPx-20V08 and above), configure the jerk below which the axis cannot fall in the case of an error reaction. The actual jerk value of the axis during the error reaction should be greater.

☞ The value parameterized in the "Jerk" field is considered in the delay monitoring SLE/SLP as well.

☞ If no encoder has been configured for Safe Motion or "torque disable" has been configured as the error reaction, SMD is not active (grayed out) during the error reaction.

Pertinent parameters

- P-0-3263.0.1, SMO: Configuration of stopping process
- P-0-3263.0.6, SMO: Error reaction F3 tolerance time
- P-0-3263.0.7, SMO: Error reaction F7 tolerance time
- P-0-3263.0.2, SMO: Oscillation velocity window of SMD-E
- P-0-3263.0.3, SMO: SMD-E reaction time
- P-0-3263.0.4, SMO: Velocity window of SMD-E
- P-0-3263.0.5, SMO: SMD-E delay
- P-0-3263.0.8, SMO: SMD-E jerk
- P-0-0117, Activation of control unit reaction on error
- P-0-0119, Best possible deceleration

Afterwards, the settings that were made have to be verified.

☞ With the parameter verification, it is necessary to check / verify whether the parameterization active in the drive complies with the parameters intended or configured for this axis.

The parameter verification is carried out in IndraWorks via the bottom sections of the Safe Motion dialogs ("Verification display").

Go to the next commissioning dialog via the **Next >>** button.

Support functions

Via the "Support functions" dialog, configure the limitation of the positioning velocity to a value that does not cause the velocity monitoring of Safe Motion to trigger.

To use this support function, activate it via the **Limitation of positioning velocity active** check box. Afterwards, a scaling factor for the positioning velocity limit value (P-0-3218) can be entered. The limit value for the positioning velocity results from the product of the active velocity threshold of Safe Motion (P-0-3238) and the scaling factor.

> ☞ The limit value for the positioning velocity is reduced by at least "P-0-3255, SMO: Velocity threshold for safe standstill" as compared to the active velocity threshold.
>
> The scaling factor for the positioning velocity limit value can also be changed during operation, without entering the Safe Motion password.

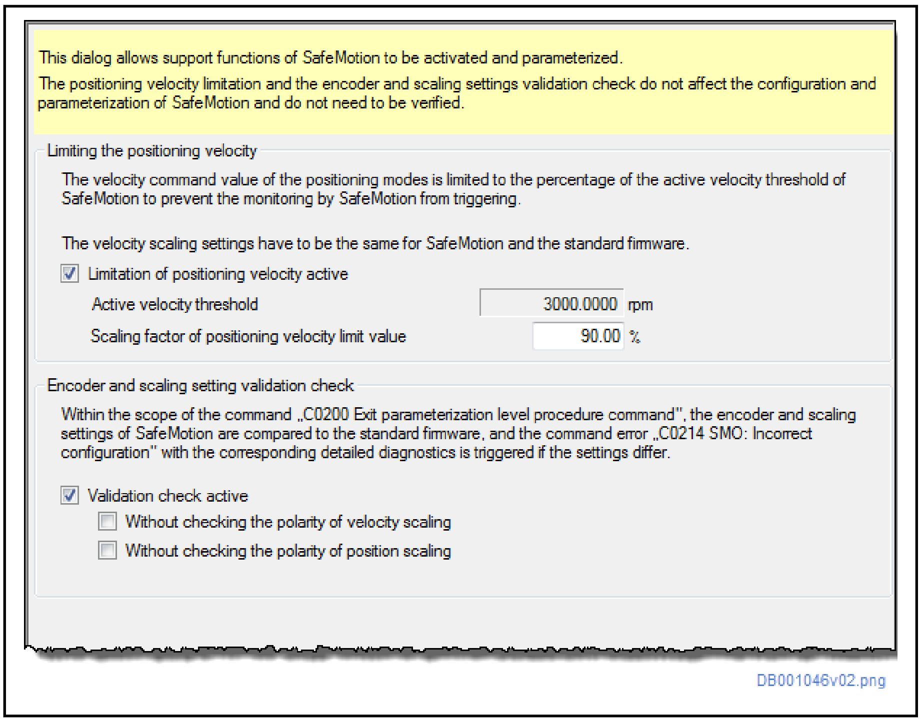

Fig. 9-45: Limiting the positioning velocity

> ☞ The limitation of the positioning velocity does not affect the configuration and parameterization of Safe Motion, and therefore does not need to be verified.

Pertinent parameters

- P-0-3218, SMO: Scaling factor for velocity limit value
- P-0-3219, SMO: Configuration of support functions
- P-0-3238, SMO: Active velocity threshold

Go to the next commissioning dialog via the **Next >>** button.

Completing the commissioning

After all Safe Motion dialogs relevant to the axis were configured, the Safe Motion report is generated and displayed:

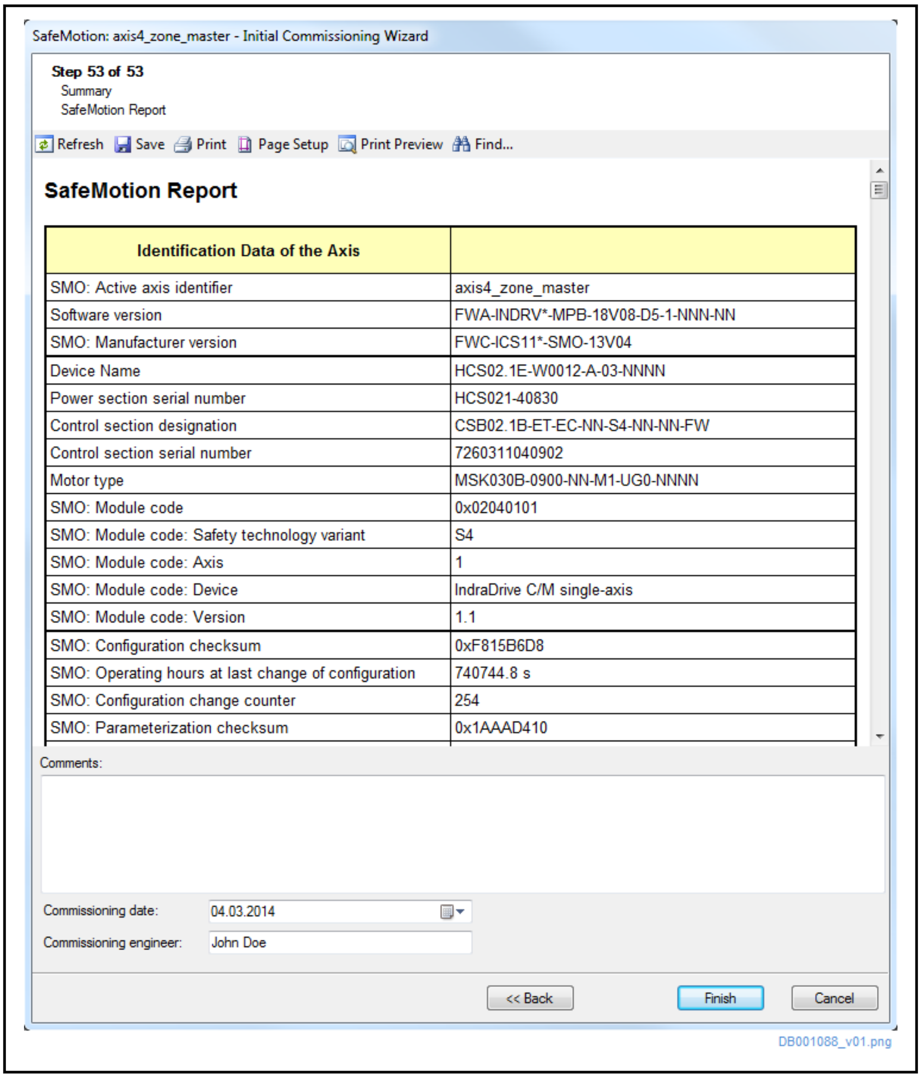

Fig. 9-46: Safe Motion report

In the "Comments" field, it is possible to add further information to the report as free text.

In the "Commissioning engineer" field, enter the person **in charge of** the Safe Motion commissioning of the axis. Afterwards, the report can be saved and printed (**Save** / **Print** buttons above the report).

The Safe Motion Report has to be signed by the **person in charge of the commissioning** and added to the machine documentation.

NOTE: If not all parameters have been verified, the Safe Motion report cannot be generated:

Commissioning

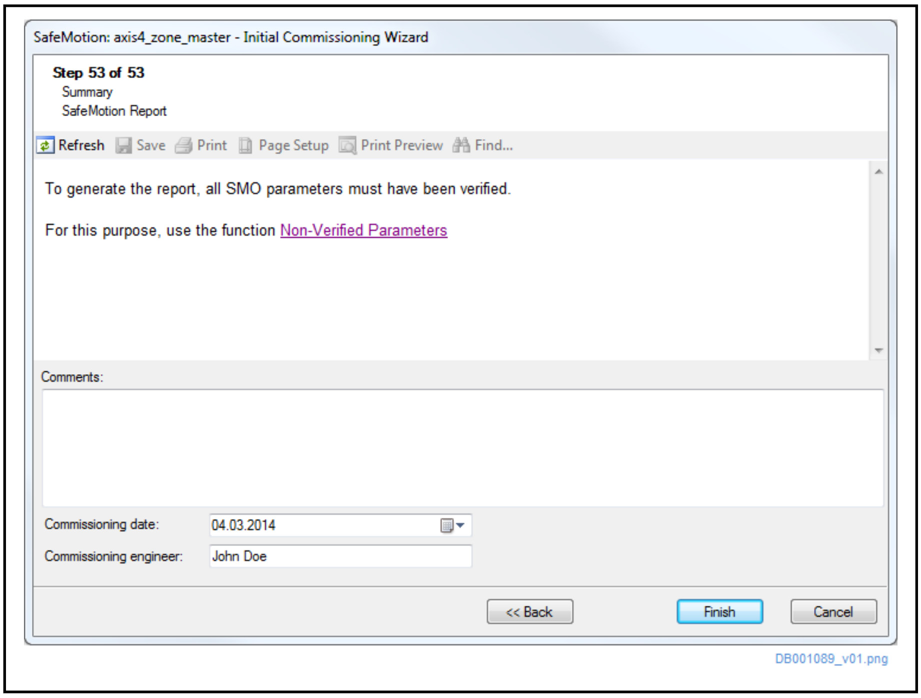

Fig. 9-47: Safe Motion report: Incomplete parameter verification

Via the "Non-verified parameters" link displayed in the dialog, call the list of unverified parameters. From there, the dialogs containing unverified parameters can be directly opened. Afterwards, the report can be generated in the "SafeMotion report" dialog via the **Refresh** button.

Each time the configuration or parameters of Safe Motion are changed, a new Safe Motion report has to be generated, signed and added to the machine documentation.

The Safe Motion report contains the counts of both Safe Motion change counters and the corresponding counts of the operating hours counters. In the event of damage, the counters allow verifying whether or not Safe Motion was subsequently modified.

Now exit the wizard via the **Finish** button.

Safe Motion now has been configured and is active.

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

- First of all, carry out the axis validation before you use the safety functions of the axis!
- Do not access the danger zone before you have carried out the axis validation!

When closing the commissioning wizard, the user is reminded that the axis has not yet been validated:

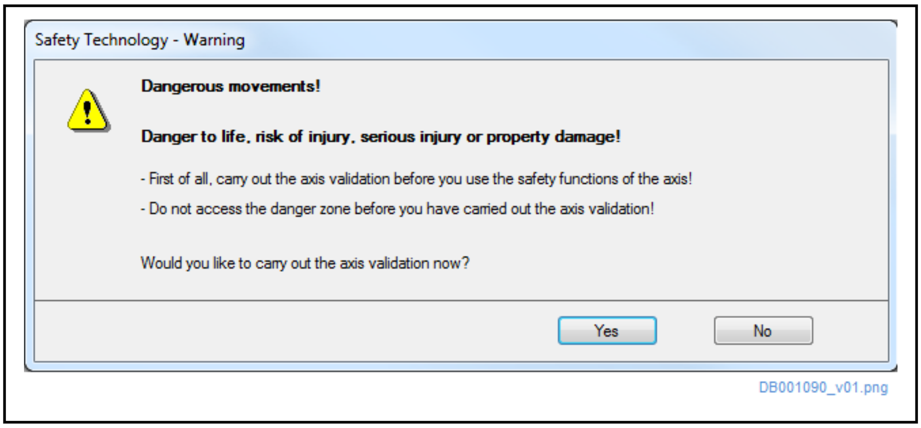

Fig. 9-48: Safety technology warning with non-validated axis

Via the **Yes** button, the axis validation can be directly started.

Step 6: Validating the axis

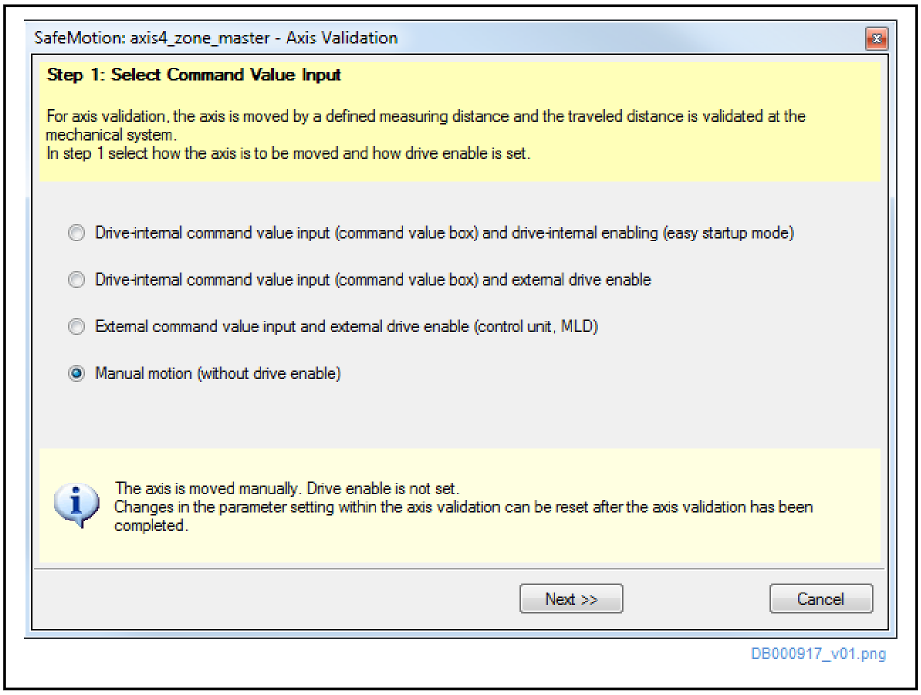

Fig. 9-49: Axis validation: Selecting the command value input

Within the scope of the axis validation, a check is run to find out whether the motion detection of "Safe Motion" (encoder and scaling settings) complies with the real motion of the mechanical axis system and the expected values. The axis validation always has to be carried out when the scaling settings or encoder settings were changed. Before it is allowed to use an axis in a safety-relevant way, the axis validation must have been successfully completed. To satisfy all applications, there are four options of axis validation:

- Drive-internal command value input and drive-internal enabling
- Drive-internal command value input and external drive enable
- External command value input and external drive enable
- Manual motion

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

- First of all, carry out the axis validation before you use the safety functions of the axis!
- Do not access the danger zone before you have carried out the axis validation!

☞ For axes without an encoder for safety technology, the axis validation does not need to be carried out. The dialogs for axis validation are not displayed (grayed out) for these axes.

☞ The axis validation always has to be carried out when scaling settings or encoder settings were set for the first time or modified in Safe Motion.

The following paragraphs describe the "manual motion" configuration, because it is possible in most of the cases and it describes the procedure very well. All other configurations have to be carried out in an analogous way and additionally are explained in the form of instructions in the dialogs for axis validation.

In step 1, select "Manual motion (without drive enable)" via the dialog for this case and then click **Next**. Axis validation without drive enable is possible if the axis or mechanical system can be moved manually without drive enable. The decisive factor is the function of the measuring system/encoder.

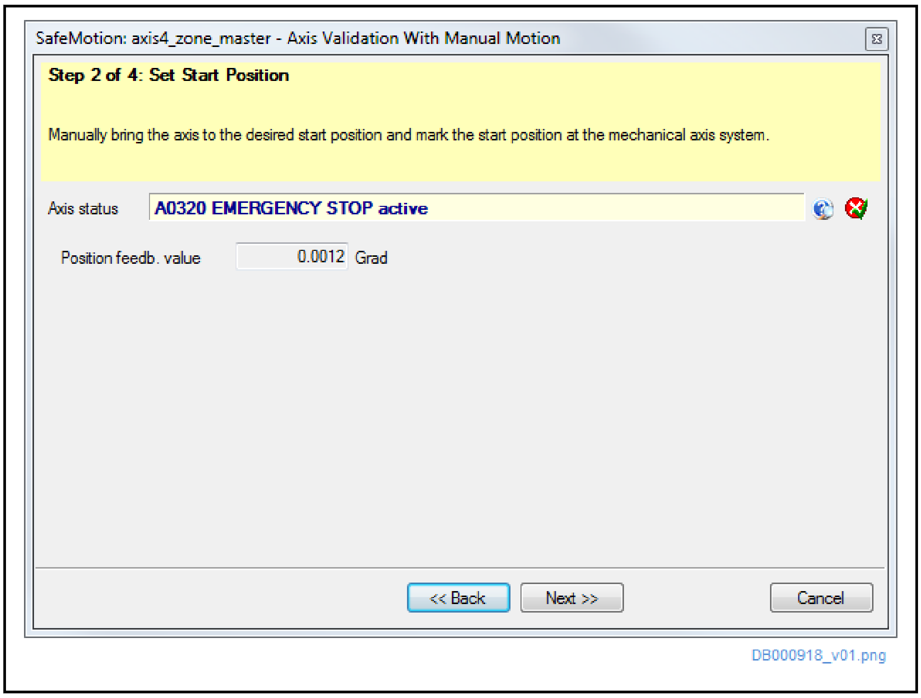

Fig. 9-50: Axis validation: Setting the start position

In step 2, the axis has to be manually moved to the desired start position. When the start position has been reached, it has to be marked at the mechanical axis system so that the travel distance can be measured later on. The position feedback value is displayed for information purposes in the dialog.

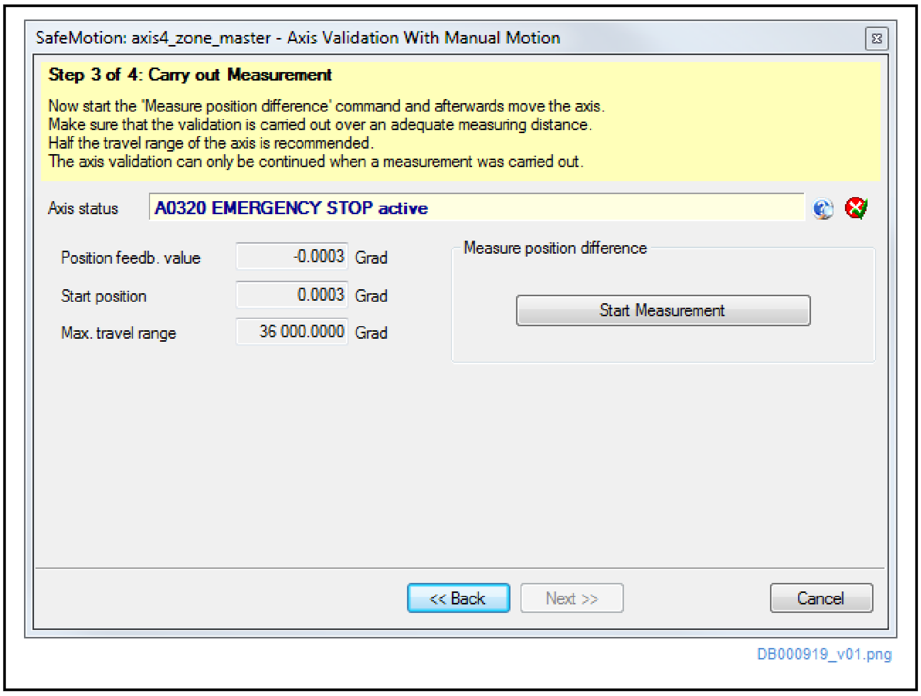

Fig. 9-51: *Axis validation: Carrying out the measurement*

After the start position has been set, the axis measurement can be started in step 3. Start the "measure position difference" command (C8600) via the **Start measurement** button.

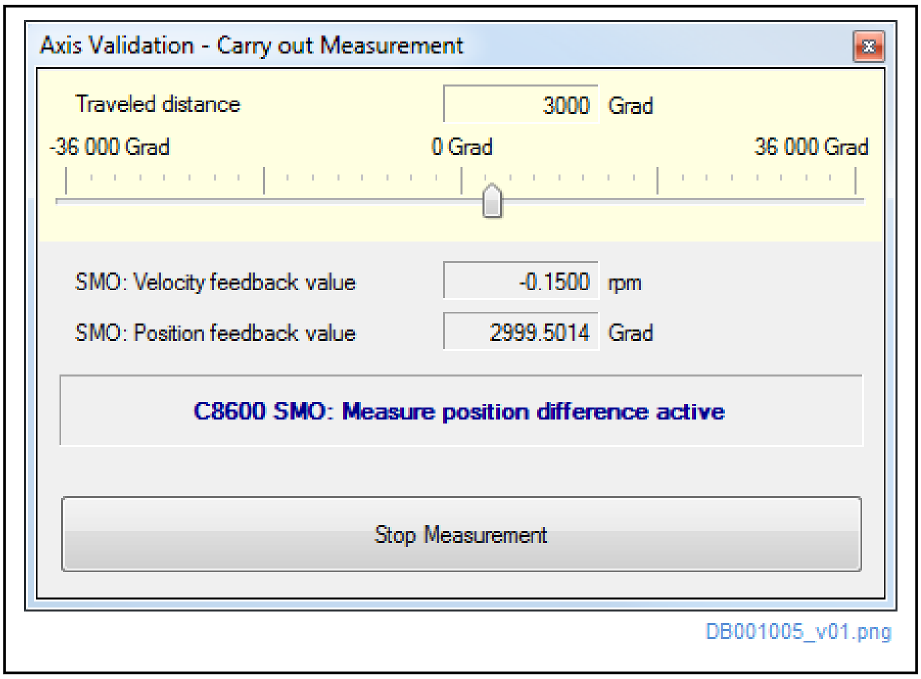

Fig. 9-52: *Axis validation: Measuring the position difference*

When the command was started, the axis has to be manually moved from the start position by a feasible distance (at least half the possible travel range should be used). When the axis motion is finished, the procedure is completed via the **Stop measurement** button. Afterwards use the **Next** button to go to the next dialog.

Commissioning

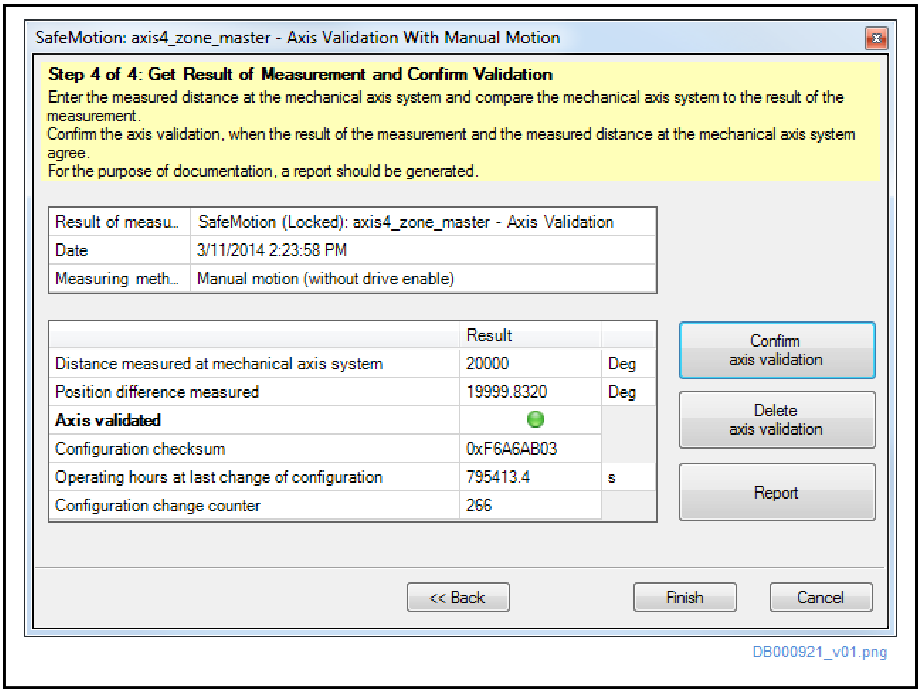

Fig. 9-53: Axis validation: Getting the result of the measurement and confirming the validation

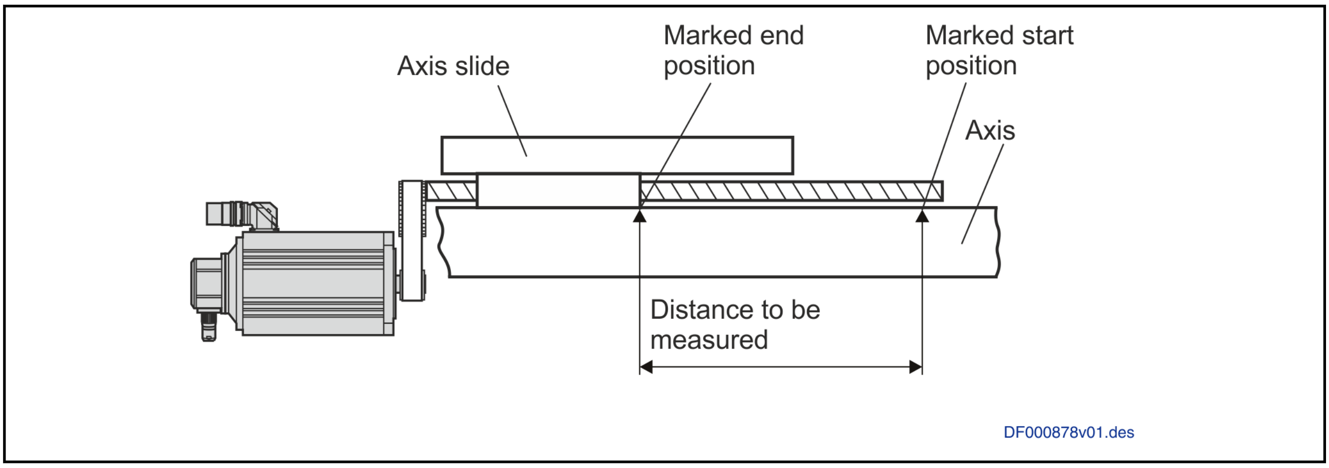

Fig. 9-54: Schematic setup

After the measurement has been completed by Safe Motion, the commissioning engineer has to measure the traveled distance at the mechanical system. With the appropriate measuring equipment, the distance from the start marker to the analog end position from step 3 is measured (see "Schematic setup"). The measured value now has to be entered in the dialog under "Distance measured at mechanical axis system". The axis configuration validation check has been successful if the traveled distance at the machine's mechanical system equals the detected position difference of "Safe Motion" with regard to the distance and polarity. By clicking the **Confirm axis validation** button, the commissioning engineer bindingly confirms the successful execution of the axis validation. The confirmation of the successful axis validation is saved in the parameter P-0-3210.0.2 and has to be confirmed in the verification window that opens.

With the parameter verification, it is necessary to check / verify whether the parameterization active in the drive complies with the parameters intended or configured for this axis.

The parameter verification is carried out in IndraWorks via the bottom sections of the Safe Motion dialogs ("Verification display").

The machine manufacturer has to define the deviation, between the travel distance determined by means of the command and the one measured at the mechanical system, that can still be accepted for an axis. It is impossible to give a general value, because it depends on many factors (e.g. mounting position and precision of the Safe Motion encoder, backlash in the mechanical system and gearbox).

Make sure that the validation is carried out over a measuring distance appropriate to the machine.

If the deviation between the travel distance determined via the command and the one measured at the mechanical system is too big for the axis, the axis validation cannot be confirmed. The scaling and encoder settings of "Safe Motion" have to be checked and modified. Afterwards, the axis validation has to be carried out again.

The axis validation has to be recorded and added to the safety-relevant documentation of the machine. The axis validation record can be generated via the **Report** button.

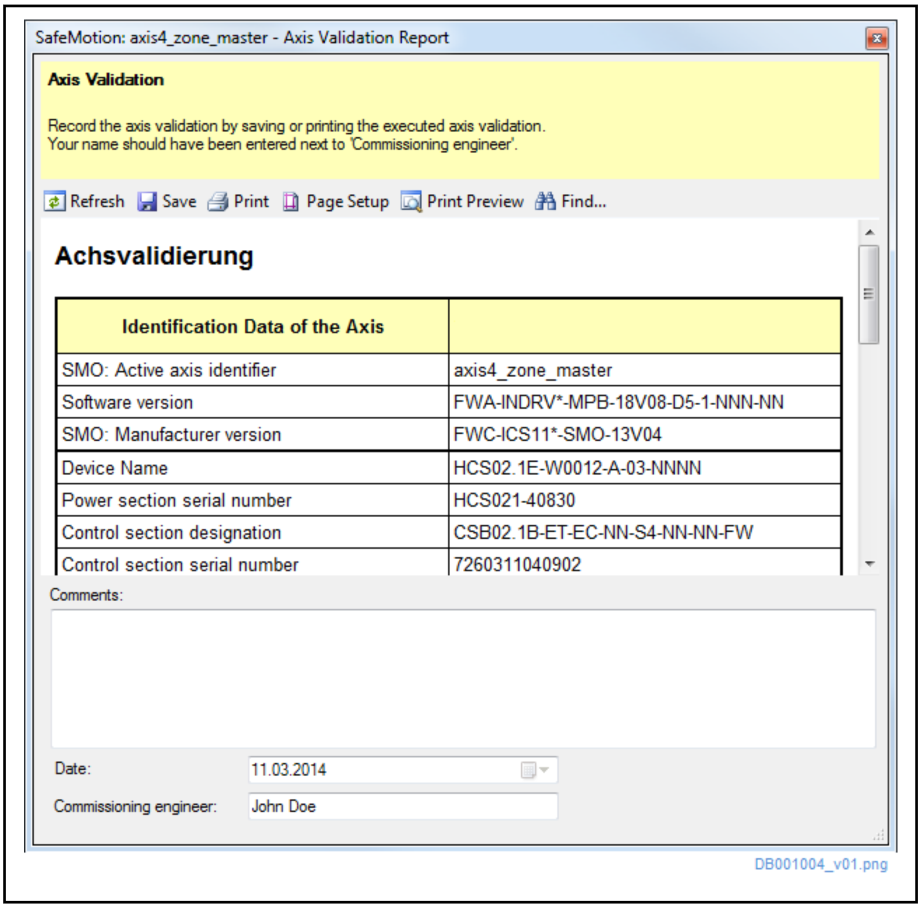

Fig. 9-55: Axis validation report

In the "Comments" field, it is possible to add further information to the report as free text. In the "Commissioning engineer" field, enter the person in charge of the "Safe Motion" commissioning of the axis. Afterwards, the report can be saved or printed (**Save** or **Print** button above the report).

The axis validation report has to be signed by the person in charge of the commissioning and added to the machine documentation.

Step 7: Acceptance test of the machine

The axis commissioning is completed with the axis validation. The machine acceptance test can now be carried out via the dialogs supporting the machine acceptance test.

See chapter "Machine acceptance test".

Safe Motion report

See chapter "Commissioning steps", "Step 5: Parameterizing the safety functions", "Completing the commissioning".

9.3 Serial commissioning

Brief description

For commissioning series machines, a simplified procedure for axes with Safe Motion can be used. To do this, the following requirements have to be fulfilled:

- The wiring of the I/Os has not changed compared to the first series machine.
- The parameterization of the "encoder and scaling setting" (SMO configuration image) is the same compared to the first series machine.

When these requirements have been fulfilled, series machines can be commissioned using the following simplified procedure **without repeated axis validation**. (This means that for serial commissioning the status of axis validation is applied from the pattern axis.)

During serial commissioning, the complete axis parameterization including the functional part of the pattern axis is always applied to the series axis. There are different options of serial commissioning:

- Option 1a: Copying an axis (1:1 copy), supported by IndraWorks
- Option 1b: Copying an axis (1:1 copy), not supported by IndraWorks
- Option 2: Copying an axis (with new identifiers)
- Option 3: Copying an axis as a template (with new identifiers and changed parameterization)
- Option 4: Automated serial commissioning (with new identifiers)

The prerequisite for all options is a parameter backup of the pattern axis that is loaded to the series axis. This parameter backup can be generated via the IndraWorks function **Saving parameter values**, it is required to save the "backup parameters".

☞ If the Safety bus communication (e.g., CSoS) is used, the master communication should be switched to phase 2 before the serial commissioning is carried out to deactivate the cyclic communication. Otherwise, error messages might occur in the drive.

Option 1a: Copying an axis (1:1 copy), supported by IndraWorks

The option 1a of serial commissioning is a 1:1 copy of an existing axis without any changes. That is to say both the SMO axis identifier, addressing of the Safety bus communication and the parameterization of the pattern axis are applied. This procedure is suited for the following cases:

- For series machine engineering of independent installations, because the SMO axis identifier and the addressing of the Safety bus communication are applied.
- In the case of loss or defect of the programming module.

The prerequisite of use is a completely commissioned and validated pattern axis, as well as the corresponding identical axis that is to be commissioned.

In the first step, a connection to the series axis has to be established via IndraWorks.

The **Safe Motion** ▸ **Commissioning** ▸ **Serial commissioning** dialog in the IndraWorks function tree provides the option of assisted serial commissioning. For option 1 select **Copying an axis (1:1 copy)**.

Carry out the following steps:

1. Select the parameter backup that is to be loaded.
2. Load SMO default values (for details see chapter "Initial commissioning,", "Step 0: Condition as supplied"). Afterwards, the selected parameter backup is automatically loaded to the axis.
3. Confirm SMO axis identifier and identification of the axis (for details see chapter "Initial commissioning", "Step 3: Entering the SMO axis identifier").
4. Confirm the address of the Safety bus communication if the Safety bus communication is active. (For details see chapter "Initial commissioning", "Step 4: Configuring the system behavior", "Safety bus communication").
5. Create a new Safe Motion report (for details see chapter "Initial commissioning", "Step 5: Parameterizing the safety functions", "completing the commissioning"), and, together with a copy of the Safe Motion report and the validation report of the pattern axis, add it to the safety-relevant documentation of the machine.
6. Carry out machine acceptance test of the entire machine (for details see chapter "Machine acceptance test").

☞ The serial commissioning of the axis ensures that the behavior of Safe Motion is identical to the one of the pattern axis. Therefore, parts of the machine acceptance test, where applicable, can be omitted or abridged. The machine manufacturer has to define the scope of the machine acceptance test for series machines, depending on the type and complexity of the machine.

Option 1b: Copying an axis (1:1 copy), not supported by IndraWorks

The option 1b of serial commissioning is a 1:1 copy of an existing axis without any changes. That is to say both the SMO axis identifier, addressing of the safe bus communication and the parameterization of the pattern axis are applied. This procedure is suited for the following cases:

- For series machine engineering of independent installations, because the SMO axis identifier and the addressing of the Safety bus communication are applied.
- In the case of loss or defect of the programming module.

The prerequisite of use is a completely commissioned and validated pattern axis, as well as the corresponding identical axis that is to be commissioned and that is in its condition as supplied (Safe Motion not active and parameters are at default values).

At first, the communication between the control unit and the series axis has to be established.

Afterwards, the following steps have to be carried out:

1. Switch axis to the parameter mode (PM or P2).
2. Select parameter backup and load it to the axis via the control unit.
3. Activate safety technology

   Start the command "P-0-3231.0.3, C8300 SMO: Command Activate parameter image" via the control unit and afterwards, after successful command acknowledgment, exit the command.
4. Identify axis and confirm identifier

☞ The axis identification should not be simultaneously carried out at multiple axes. This has to be ensured by the machine manufacturer with organizational measures.

Select the type of axis identification via "P-0-3235.0.4, SMO: Axis identification: Control word". It is possible to choose between the following settings:

- Bit 1, 0= 01: Confirm SMO axis identifier, for axes without and with Safety bus communication
- Bit 1, 0= 10: Confirm addressing of the Safety bus communication, for axes **with** Safety bus communication. The SMO axis identifier has to be confirmed before (carry out item 4 twice)

Afterwards the axis has to be identified. For this purpose, `Confirm SMO-Identification?` is automatically, by selecting the type of axis identification, shown on the display of the drive, and the diagnostic LEDs H25 and H26 at the "Safe Motion" option are lit with the flashing pattern "red - green - green - red". By pressing **Enter** at the control panel, it is necessary to confirm that the parameter backup was loaded to the correct axis.

☞ For devices of the "IndraDrive Mi" range, the confirmation can only be carried out via the control unit. After the diagnostic LEDs H25 and H26 have been checked, the command "P-0-3235.0.3, C8500 SMO: Command Apply identification data" has to be started and exited, upon successful command acknowledgment, via the control unit.

5. Compile new record with contents listed below and add it to safety-relevant documentation of the machine, together with a copy of the Safe Motion report and the validation report of the pattern axis:
   - Commissioning of series machine carried out on basis of safety technology report "SMO axis identifier (P-0-3235.0.1) of first series machine" of (date of report)
   - SMO axis identifier (P-0-3235.0.1) is at (value)
   - Configuration parameters checksum (P-0-3234.0.1) is at (value)
   - Operating hours at last change of configuration (P-0-3234.0.2) is at (value)
   - Configuration parameters change counter (P-0-3234.0.3) is at (value)
   - Safety technology parameters checksum (P-0-3234.0.4) is at (value)

- Operating hours at last change of parameterization (P-0-3234.0.5) is at (value)
- Safety technology parameters change counter (P-0-3234.0.6) is at (value)
- Serial number of control section (see type plate at device)
- Serial number of power section (see type plate at device)
- (date), (name), (signature)

NOTE: For devices without control panel ("IndraDrive Mi" range), the parameter values required for the record can only be read via the control unit. For devices with control panel, the parameter values can be queried via the `SMO Info` menu.

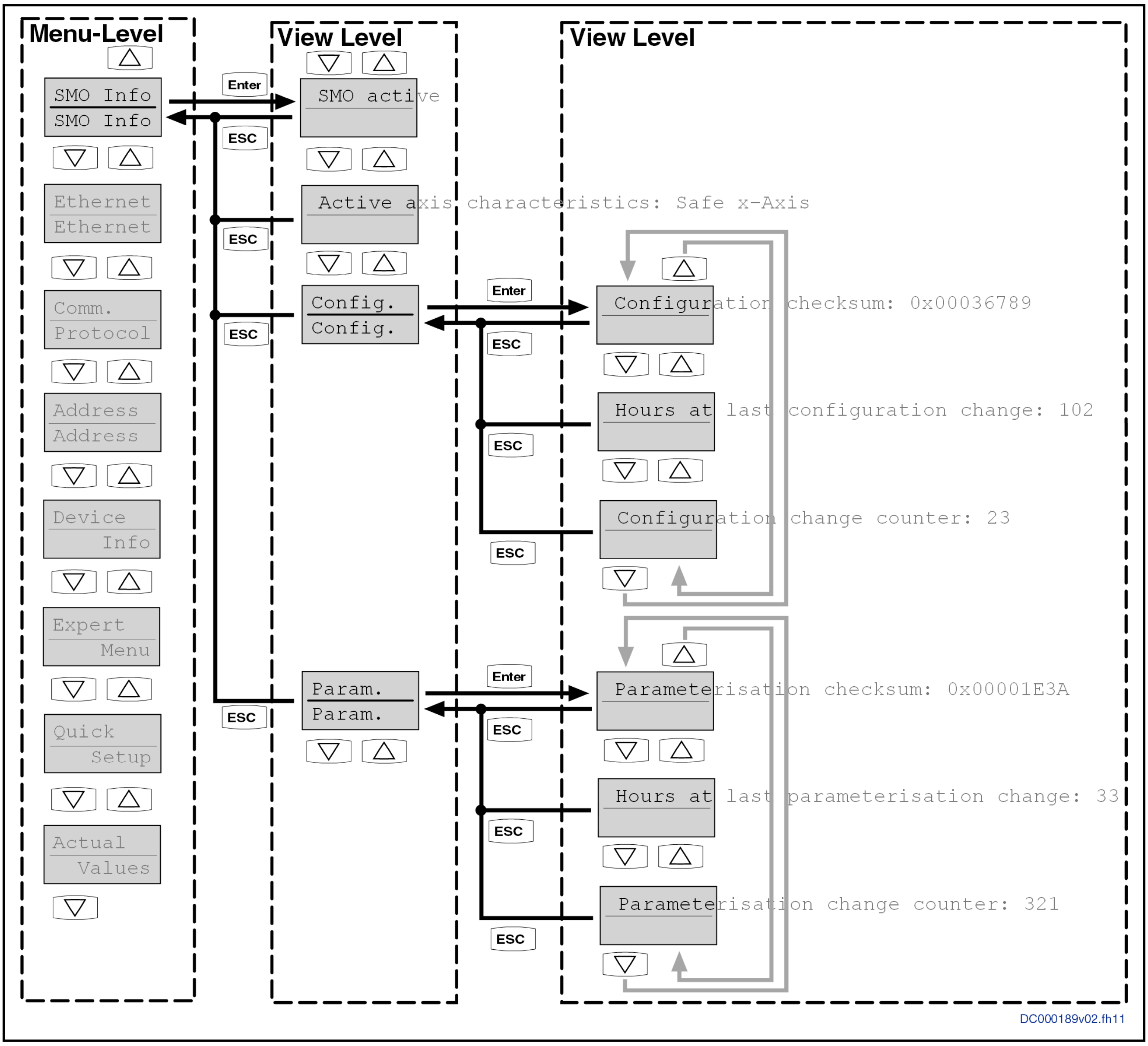

Fig. 9-56: SMO Info menu

Menu	Entry	Menu	Parameter used
SMO Info	SMO active	-	P-0-3230 SMO: Password level
	Active axis characteristic: Safe x-Axis	-	P-0-3235.0.1, SMO: Active axis identifier
	Config.	Confguration checksum: 0x00036789	P-0-3234.0.1, SMO: Configuration checksum
		Hours at last configuration change: 102	P-0-3234.0.2, SMO: Operating hours at last change of configuration
		Configuration change counter: 23	P-0-3234.0.3, SMO: Configuration change counter
	Param.	Parameterisation checksum: 0x00001E3A	P-0-3234.0.4, SMO: Parameterization checksum
		Hours at last parameterisation change: 33	P-0-3234.0.5, SMO: Operating hours at last change of parameterization
		Parameterisation change counter: 321	P-0-3234.0.6, SMO: Parameterization change counter

Tab. 9-4: Parameters used under the SMO Info menu

6. Carry out machine acceptance test of the entire machine (for details see chapter "Machine acceptance test").

☞ The serial commissioning of the axis ensures that the behavior of Safe Motion is identical to the one of the pattern axis. Therefore, parts of the machine acceptance test, where applicable, can be omitted or abridged. The machine manufacturer has to define the scope of the machine acceptance test for series machines, depending on the type and complexity of the machine.

☞ Upon serial commissioning of axes with a firmware from MPx-20V12, the configuration check sum (P-0-3234.0.1) and the parameterization check sum (P-0-3234.0.4) do not change regarding the pattern axis. Using the check sums, it can thus be verified that the parameterization has not changed regarding the pattern axis.

Option 2: Copying an axis (with new identifiers)

The option 2 of serial commissioning is a copy of an existing axis with a change in the SMO axis identifier and, if necessary, the addressing of the Safety bus communication. The parameterization of the pattern axis is applied. This procedure is suited for the following cases:

- For axes of identical machine modules within an installation.
- In the case of loss or defect of the programming module.

The prerequisite of use is a completely commissioned and validated pattern axis, as well as the corresponding identical axis that is to be commissioned.

In the first step, a connection to the series axis has to be established via IndraWorks.

The **Safe Motion ▸ Commissioning ▸ Serial commissioning** dialog in the IndraWorks function tree provides the option of assisted serial commissioning. For option 2 select **Copying an axis (with new identifiers)**.

Carry out the following steps:

1. Select the parameter backup that is to be loaded.

2. Load SMO default values (for details see chapter "Initial commissioning,", "Step 0: Condition as supplied"). Afterwards, the selected parameter backup is automatically loaded to the axis.
3. Adjust the SMO axis identifier and identification of the axis (for details see chapter "Initial commissioning", "Step 3: Entering the SMO axis identifier").
4. Adjust the addressing of the Safety bus communication if the Safety bus communication is active. (For details see chapter "Initial commissioning", "Step 4: Configuring the system behavior", "Safety bus communication").
5. Create a new Safe Motion report (for details see chapter "Initial commissioning", "Step 5: Parameterizing the safety functions", "completing the commissioning"), and, together with a copy of the Safe Motion report of the pattern axis, add it to the safety-relevant documentation of the machine.
6. Carry out machine acceptance test of the entire machine (for details see chapter "Machine acceptance test").

☞ The serial commissioning of the axis ensures that the behavior of Safe Motion is identical to the one of the pattern axis. Therefore, parts of the machine acceptance test, where applicable, can be omitted or abridged. The machine manufacturer has to define the scope of the machine acceptance test for series machines, depending on the type and complexity of the machine.

Option 3: Copying an axis as a template (with new identifiers and changed parameterization)

With option 3 of serial commissioning, an existing pattern axis is the **template** for the commissioning of an axis. The parameterization, the SMO axis identifier and, if necessary, the addressing of the Safety bus communication are adjusted in this case.

This procedure is suited for axes with an identical mechanical axis system, but with a modified safety parameterization (e.g., axis-specific monitoring thresholds).

The prerequisite for using option 3 is a completely commissioned and validated pattern axis, as well as an axis with an identical mechanical axis system that is to be commissioned.

In the first step, a connection to the series axis has to be established via IndraWorks.

The **Safe Motion** ▸ **Commissioning** ▸ **Serial commissioning** dialog in the IndraWorks function tree provides the option of assisted serial commissioning. For option 3 select **Copying an axis as a template (with new identifiers and changed parameterization)**.

Carry out the following steps:

1. Select the parameter backup that is to be loaded.
2. Load SMO default values (for details see chapter "Initial commissioning,", "Step 0: Condition as supplied"). Afterwards, the selected parameter backup is automatically loaded to the axis.
3. Adjust the SMO axis identifier and identification of the axis (for details see chapter "Initial commissioning", "Step 3: Entering the SMO axis identifier").
4. Adjust the addressing of the Safety bus communication if the Safety bus communication is active. (For details see chapter "Initial commissioning", "Step 4: Configuring the system behavior", "Safety bus communication").

5. Adjust safety parameterization to the new axis (for details see chapter "Initial commissioning", "Step 5: Parameterizing the safety functions").
6. Create a new Safe Motion report (for details see chapter "Initial commissioning", "Step 5: Parameterizing the safety functions", "completing the commissioning"), and, together with a copy of the Safe Motion report and the validation report of the pattern axis, add it to the safety-relevant documentation of the machine.
7. Carry out machine acceptance test of the entire machine (for details see chapter "Machine acceptance test").

Option 4: Automated serial commissioning (with new identifiers)

With option 4 - of automated serial commissioning -, an existing pattern axis is the **template** for the commissioning of an axis. The SMO axis identifier and, if necessary, the addressing of the Safety bus communication are adjusted in this case. The parameterization of the pattern axis is applied.

The automated serial commissioning can be carried out without IndraWorks, e.g. with a functional control.

Direct access to the drive controller is not necessary.

There are special acceptance criteria for the series axis, which are described in more detail further down in these instructions. This procedure is suited for the following cases:

- For axes of identical machine modules within an installation.
- In the case of loss or defect of the programming module.

The prerequisite for using option 4 is a completely commissioned and validated pattern axis, as well as an axis with an identical mechanical axis system that is to be commissioned. For the automated commissioning, IndraWorks is not required. This commissioning option is exclusively effected via parameter access to parameters that are not password-protected and do not have to be verified.

- P-0-3230.0.1, SMO: Password
- P-0-3231.0.1, C8100 SMO: Command Activate configuration mode
- P-0-3231.0.2, C8200 SMO: Command Exit configuration mode
- P-0-3231.0.3, C8300 SMO: Command Activate parameter image
- P-0-3235.0.3, C8500 SMO: Command Apply identification data
- P-0-3235.0.4, SMO: Axis identification: Control word
- P-0-3235.0.6, SMO: Proposed axis identifier, auto commissioning
- P-0-3235.0.7, SSO Proposed TUNID, auto commissioning
- P-0-3353, Proposed FSoE slave address, auto commissioning
- P-0-3360.0.6, PROFIsafe: Proposed F-Device address, auto commissioning
- P-0-4090, Configuration for loading default values
- S-0-0262, C07_x Load defaults procedure command

The parameters of the automated commissioning are accessed via a higher-level control unit.

It has to be ensured with organizational measures that the drive address and/or IP address at the drive controller has been set correctly. This is the prerequisite for automated commissioning. The following steps are to be carried out for the automated serial commissioning:

1. Load SMO default values (for details see chapter "Initial commissioning,", "Step 0: Condition as supplied").

"Load SMO default values" can be executed using a higher-level control unit. To do so, proceed as follows:

1. Enter the active axis identifier (P-0-3235.0.1) in "P-0-3230.0.1 SMO: Password".

   ⇒ Safe Motion is in password level "3" (P-0-3230).
2. In "P-0-4090, Configuration for loading default values", enter the value "5"
3. Start the command "C0720 SMO: Load defaults procedure command" via parameter "S-0-0262, C07_x Load defaults procedure command".

   ⇒ Safe Motion is reset to default values.

2. Load the parameter backup of the pattern axis to the series axis.
3. Activate the parameter image using the command "C8300 SMO: Command Activate parameter image" (P-0-3231.0.3).
4. Execute the command "C8100 SMO: Command Activate configuration mode" (P-0-3231.0.1).
5. Enter the identification data in the parameters of the automatic commissioning.
   - Enter the new axis identifier in parameter "P-0-3235.0.6, SMO: Proposed axis identifier, auto commissioning".

   Optionally, when using a safety bus system, enter the corresponding address:
   - CsoS: "P-0-3235.0.7, SSO Proposed TUNID, auto commissioning" or
   - FSoE: "P-0-3353, Proposed FSoE slave address, auto commissioning" or
   - PROFIsafe: "P-0-3360.0.6, PROFIsafe: Proposed F-Device address, auto commissioning"
6. "P-0-3235.0.4, SMO: Axis identification: Control word", set bit 2 to "1".
7. Apply with command "C8500 SMO: Command Apply identification data" (P-0-3235.0.3) and apply the values written in item 6 to the axis.
8. Execute the command "C8200 SMO: Command Exit configuration mode" (P-0-3231.0.2).
9. Verify the identification data of the automated commissioning as described below.

   Due to the omitted assignment of the SMO axis identifier and the address for the Safety bus communication via IndraWorks, if applicable, the identification data have to be verified in a separate step. The verification is to ensure the following:
   - The correct parameters have been loaded to the axis.
   - The identification data have been correctly assigned to the axis.

   In a Safe Motion report for the automated commissioning, the following information is to be checked and compared to the specifications:
   - P-0-3234.0.4, SMO: Parameterization checksum
   - P-0-3234.0.1, SMO: Configuration checksum
   - P-0-3235.0.2, SMO: Proposed axis identifier
   - P-0-3235.0.1, SMO: Active axis identifier

- S-0-1800.0.19, SSO Target UNID
- P-0-3350, FSoE: Slave address
- P-0-3360.0.1, PROFIsafe: F-Device Address

Using the parameter "P-0-3235.0.2, SMO: Proposed axis identifier" and the two checksums (P-0-3234.0.1, P-0-3234.0.4), it is possible to prove after the automated serial commissioning that the correct SMO image has been loaded to the axis.

☞ Parameter "P-0-3235.0.2, SMO: Proposed axis identifier" still contains the value of the pattern axis.

By comparing the active identification data (P-0-3235.0.1, SMO: Active axis identifier) and the active address of the Safety bus communication (S-0-1800.0.19, P-0-3350 or P-0-3360.0.1), if applicable, to the specified values, correct execution of the command "C8500 SMO: Command Apply identification data" can be verified. Apart from that, the correct assignment of the SMO axis identifier to the address of the Safety bus communication is ensured.

The assignment of the identification data to the physical axis has to be verified using the safety control. To this end, an action is triggered at the axis to be verified via the safety control and/or an action at the axis to be verified triggered by the functional control is monitored by the safety control and compared to an expectation. Depending on the application environment, different procedures can be used here:

- Axis-specific selection by the safety control and verification at the display and/or diagnostics at an HMI

  - or -

- "Enabling normal operation" at only one axis by the safety control and execution of an NC-controlled motion. Check whether "F2025 Drive not ready for control" is generated at the corresponding axis.

  - or -

- Triggering "F3100 F3 test error during machine acceptance test" via the functional control at one axis and check via Safe status at the safety control.

10. Compile new record with contents listed below and add it to safety-relevant documentation of the machine, together with a copy of the Safe Motion report of the pattern axis:
    - Commissioning of series machine carried out on basis of safety technology report "SMO axis identifier (P-0-3235.0.1) of first series machine" of (date of report)
    - SMO axis identifier (P-0-3235.0.1) is at (value)
    - Configuration parameters checksum (P-0-3234.0.1) is at (value)
    - Operating hours at last change of configuration (P-0-3234.0.2) is at (value)
    - Configuration parameters change counter (P-0-3234.0.3) is at (value)
    - Safety technology parameters checksum (P-0-3234.0.4) is at (value)
    - Operating hours at last change of parameterization (P-0-3234.0.5) is at (value)

- Safety technology parameters change counter (P-0-3234.0.6) is at (value)
- Serial number of control section (see type plate at device)
- Serial number of power section (see type plate at device)
- (date), (name), (signature)

NOTE: For devices without control panel ("IndraDrive Mi" range), the parameter values required for the record can only be read via the control unit. For devices with control panel, the parameter values can be queried via the `SMO Info` menu.

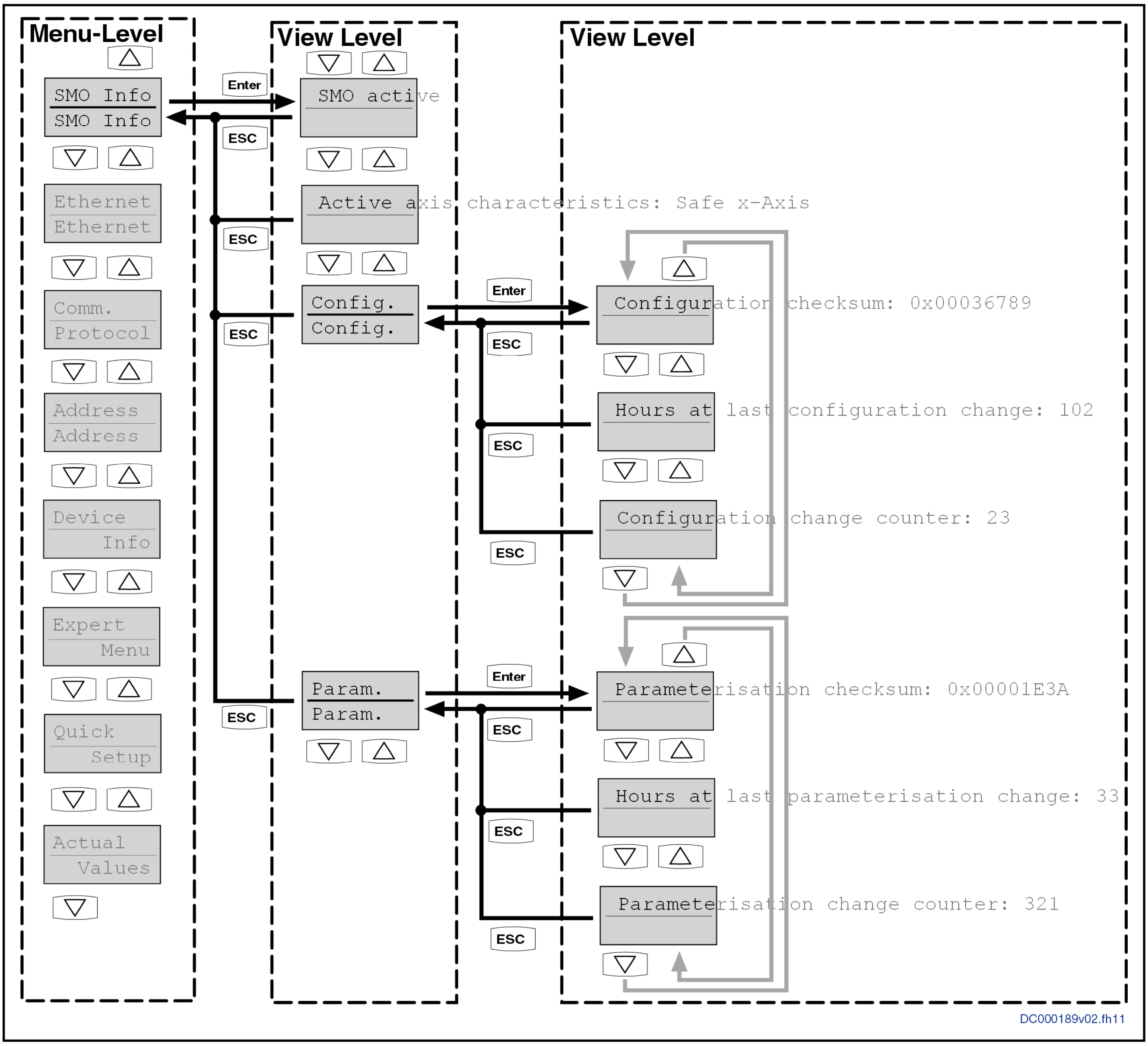

Fig. 9-57: Menu "SMO Info"

Menu	Entry	Menu	Parameter used
SMO Info	SMO active	-	P-0-3230 SMO: Password level
	Active axis characteristic: Safe x-Axis	-	P-0-3235.0.1, SMO: Active axis identifier
	Config.	Confguration checksum: 0x00036789	P-0-3234.0.1, SMO: Configuration checksum
		Hours at last configuration change: 102	P-0-3234.0.2, SMO: Operating hours at last change of configuration
		Configuration change counter: 23	P-0-3234.0.3, SMO: Configuration change counter
	Param.	Parameterisation checksum: 0x00001E3A	P-0-3234.0.4, SMO: Parameterization checksum
		Hours at last parameterisation change: 33	P-0-3234.0.5, SMO: Operating hours at last change of parameterization
		Parameterisation change counter: 321	P-0-3234.0.6, SMO: Parameterization change counter

Tab. 9-5: Parameters used under the "SMO Info" menu

11. Carry out machine acceptance test of the entire machine (for details see chapter "Machine acceptance test").

☞ The serial commissioning of the axis ensures that the behavior of Safe Motion is identical to the one of the pattern axis. Therefore, parts of the machine acceptance test, where applicable, can be omitted or abridged. The machine manufacturer has to define the scope of the machine acceptance test for series machines, depending on the type and complexity of the machine.

☞ Upon serial commissioning of axes with a firmware from MPx-20V12, the configuration check sum (P-0-3234.0.1) and the parameterization check sum (P-0-3234.0.4) do not change regarding the pattern axis. Using the check sums, it can thus be verified that the parameterization has not changed regarding the pattern axis.

9.4 Axis acceptance test

See chapter "Commissioning steps", Step 6: Validating the axis.

9.5 Machine Acceptance Test

9.5.1 Overview

A machine acceptance test from the drive's point of view is always required when the safety technology of an axis was parameterized for the first time (initial commissioning) or modified[4)].

4) *"modified": Safety technology parameters were changed or an extended serial commissioning was carried out (copy of an axis as a template with a new axis identifier and modified parameterization)*

☞ The acceptance tests for the machine described here typically are not complete for a machine acceptance test, because they are exclusively limited to the axis-related safety functions. The machine might have more safety parts and safety functions which are not taken into consideration in the acceptance tests described here. Therefore, the acceptance tests described below are only recommendations that can be used to check the axis-related safety functions within the scope of the machine acceptance test.

☞ In every case, the changes and tests carried out must be recorded.

☞ For commissioning the safety technology, you should always use the current release of the corresponding firmware version. If you do not use the current release, take the corresponding manufacturer information on detected and solved problems into account and verify their relevance for the machine application. For the manufacturer information, see the "Rexroth eBusiness Portal" under http://www.boschrexroth.com/portal.

The support functions are divided into different topics. In IndraWorks, the corresponding acceptance test dialog is available for each topic:

- Selection
- Global Monitoring Functions
- Monitoring Functions in Normal Operation
- Special mode "Safe standstill"
- Special mode "Safe motions"
- Error reaction
- Safety Zone and Safe Door Locking
- Signal control of outputs

In IndraWorks, the dialogs can be called in the function tree via the branch **SafeMotion ▸ Commissioning ▸ Machine Acceptance Test**.

9.5.2 Selection

In IndraWorks, the "Selection" dialog can be opened via the branch ... ▸ **Machine Acceptance Test ▸ Selection**.

☞ The dialog is not provided in the following cases:

- The "Safe bus communication" has been configured (P-0-3345, SMO: Safety bus configuration, bit 0="1") and networks of the IO mapper inputs were not masked (P-0-3340.0.1, SMO: Mask of control word, safety bus).

  - or -

- The default settings of the IO mapper inputs are active.

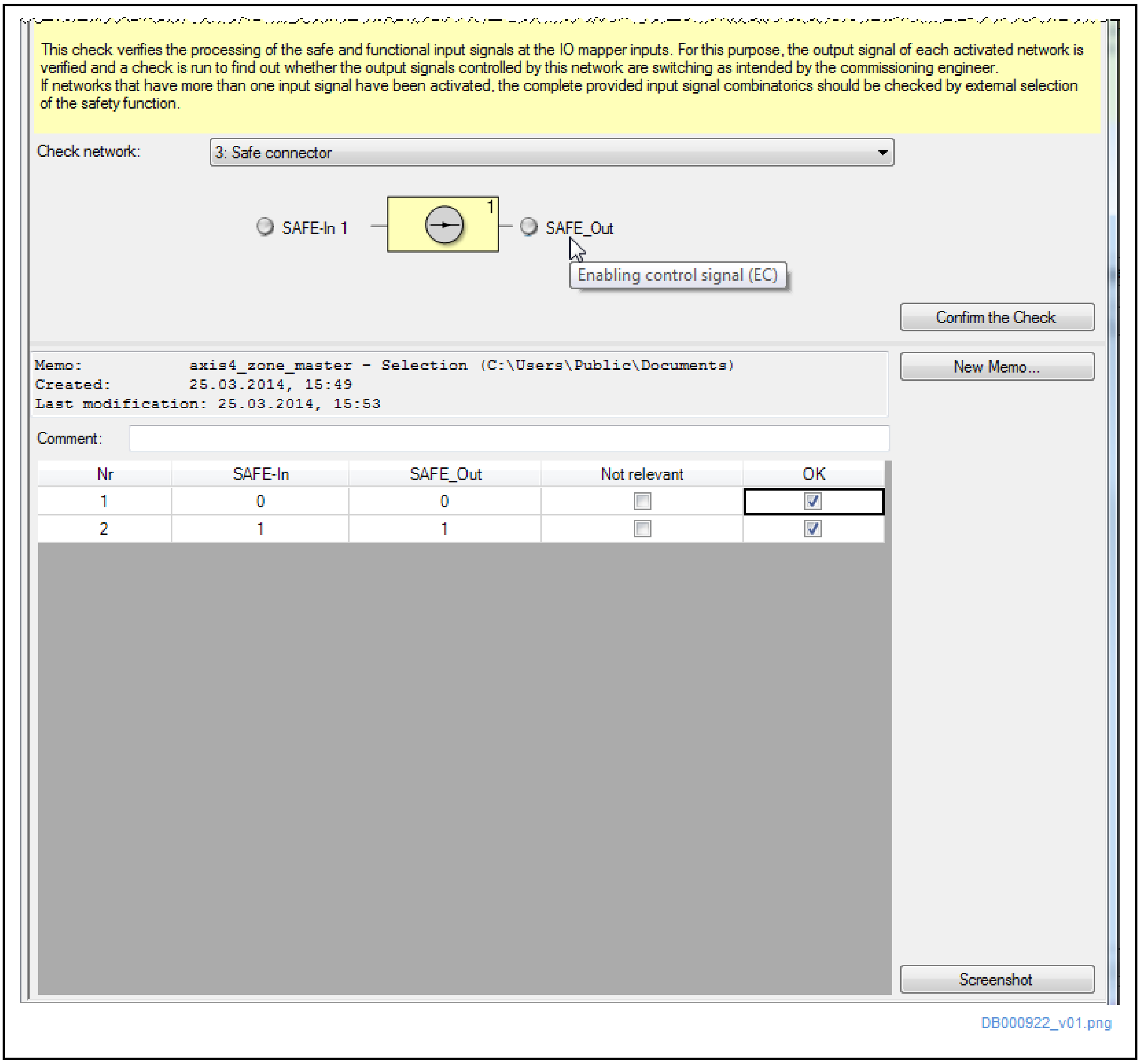

Fig. 9-58: Machine Acceptance Test: Selection

In this dialog, the processing of the safe and functional input signals at the "IO mapper inputs" can be checked. For this purpose, it is necessary to check whether the output signals of the network are switching as intended. If networks that have more than one input signal have been activated, the complete provided input signal combinations should be checked to make sure that there is no inadmissible input-output combination for the machine.

Via the drop down list "Check network", select the network to be checked. After the selection was made, the circuit diagram of the function block is displayed. The assigned signals are provided with check boxes displaying the current states of the corresponding bit signals. The logic signal names of inputs and outputs are displayed as tooltips. Via the **Confirm the check** button, the currently displayed input-output combination will be marked as "OK" on the memo. If no memo exists at this point, the memo is created.

The name of the memo is made from the axis identifier. When the memo is created, the user can choose the directory in which the memos are to be saved. The default directory for memos is the "My Documents" directory of the logged-on user. This directory is also used for further memos. The active axis identifier is entered in the header of the memo. In addition, the time at which the memo was created and the time of the last modification are stored. The "Comment" edit field allows entering a free text.

In the "Not relevant" column, the commissioning engineer can mark combinations irrelevant due to the system configuration and thereby document why these combinations were not checked. Changes made to the "OK" column and the "Not relevant" column of the memo or to the comment are immediately written to the memo file.

With the "Screenshot" button, a screenshot of the section highlighted below is copied to the clipboard for the purpose of documentation:

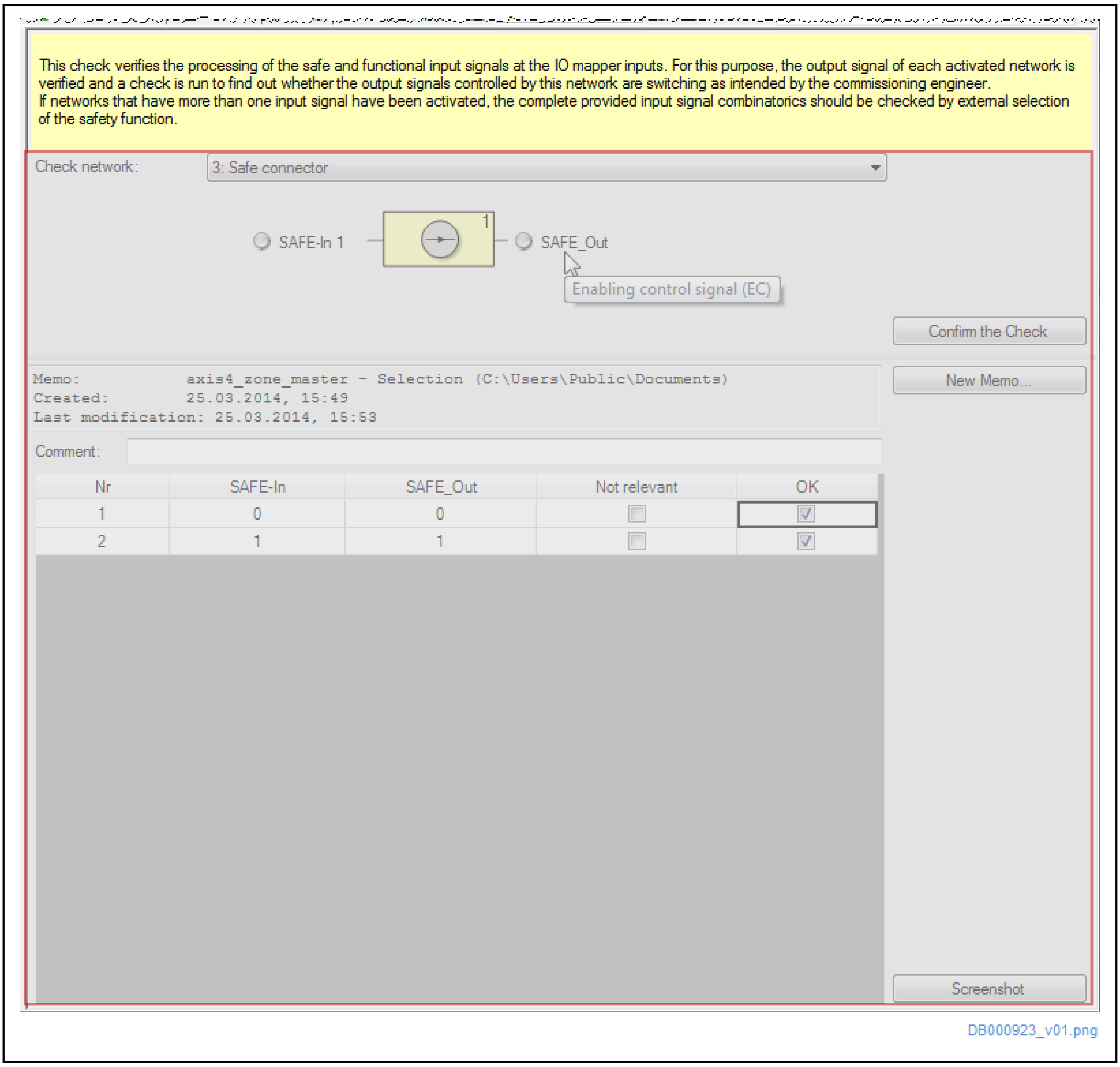

Fig. 9-59: Machine Acceptance Test: Selection

The corresponding parameters are:

- P-0-3330.x.1, SMO: IO mapper inputs, type

- P-0-3330.x.2, SMO: IO mapper inputs, IDN source
- P-0-3330.x.3, SMO: IO mapper inputs, bit source
- P-0-3330.x.4, SMO: IO mapper inputs, IDN target
- P-0-3330.x.5, SMO: IO mapper inputs, bit target

9.5.3 Global monitoring functions

In IndraWorks, the "Global Monitoring Functions" dialog can be opened via the branch ... ▸ **Machine Acceptance Test** ▸ **Global Monitoring Functions.**

☞ The dialog is not provided if no encoder has been configured in Safe Motion ("P-0-3242.1.1, SMO: Phys. encoder type" equal "0").

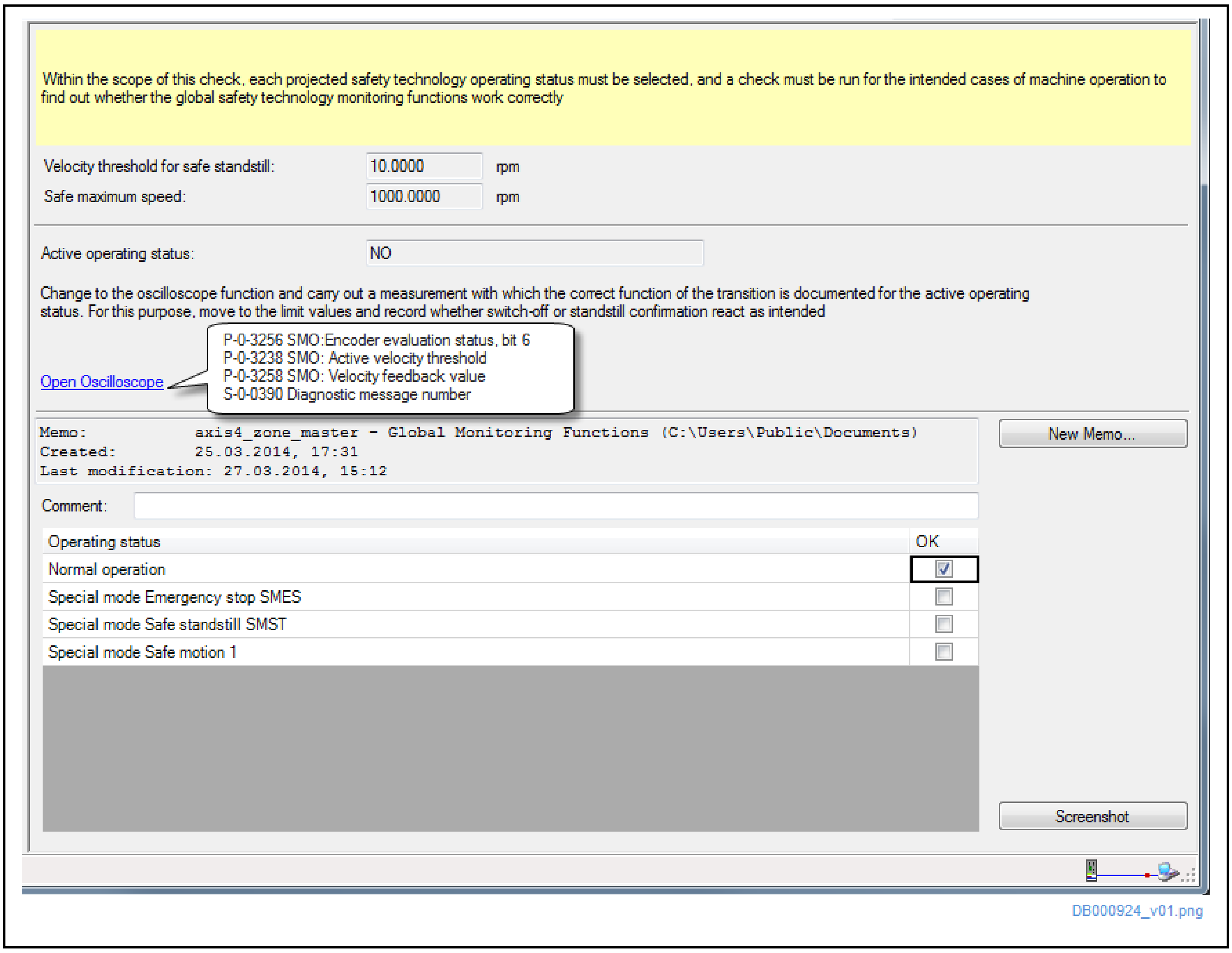

Fig. 9-60: Machine Acceptance Test: Global Monitoring Functions

In this dialog, the function of the global monitoring function can be checked. For this purpose, the configured monitoring functions with the corresponding thresholds are displayed in the top section of the dialog. The following checks must be run:

- Checking the safe maximum speed
- Checking the velocity threshold for Safe standstill

Checking the safe maximum speed

The "safe maximum speed" is active in all operating states. To check the safety function, the axis must be switched to the operating status "normal operation", because only in this operating status is it possible to accelerate the axis up to the safe maximum speed. In all other operating states, moving the axis is completely prevented (SMES and SMSTx operating states) or other velocity monitoring functions are active in parallel and already trigger at lower velocities (SMMx operating states).

⚠ WARNING **Personal injury or property damage caused by insufficient overrun distance of the axis!**

Before starting to check the safe maximum speed, make sure that the braking ability and the overrun distance are sufficient. If this is not the case, the test must not be carried out. If necessary, the velocity threshold for this axis must be adjusted.

First of all, the oscilloscope function must be called via the link in the dialog. When the oscilloscope is started, the measuring signals already are automatically configured. Afterwards, the trigger must be configured. It is recommended that you use the following settings:

- Trigger method: Signal trigger
- Pre Trigger: 50%
- Trigger signal: S-0-0390.0.0 Diagnostic message number
- Trigger edge: == Equal
- Trigger value: F7020 (Safe maximum speed exceeded)
- Trigger mask: F7020 (Safe maximum speed exceeded)

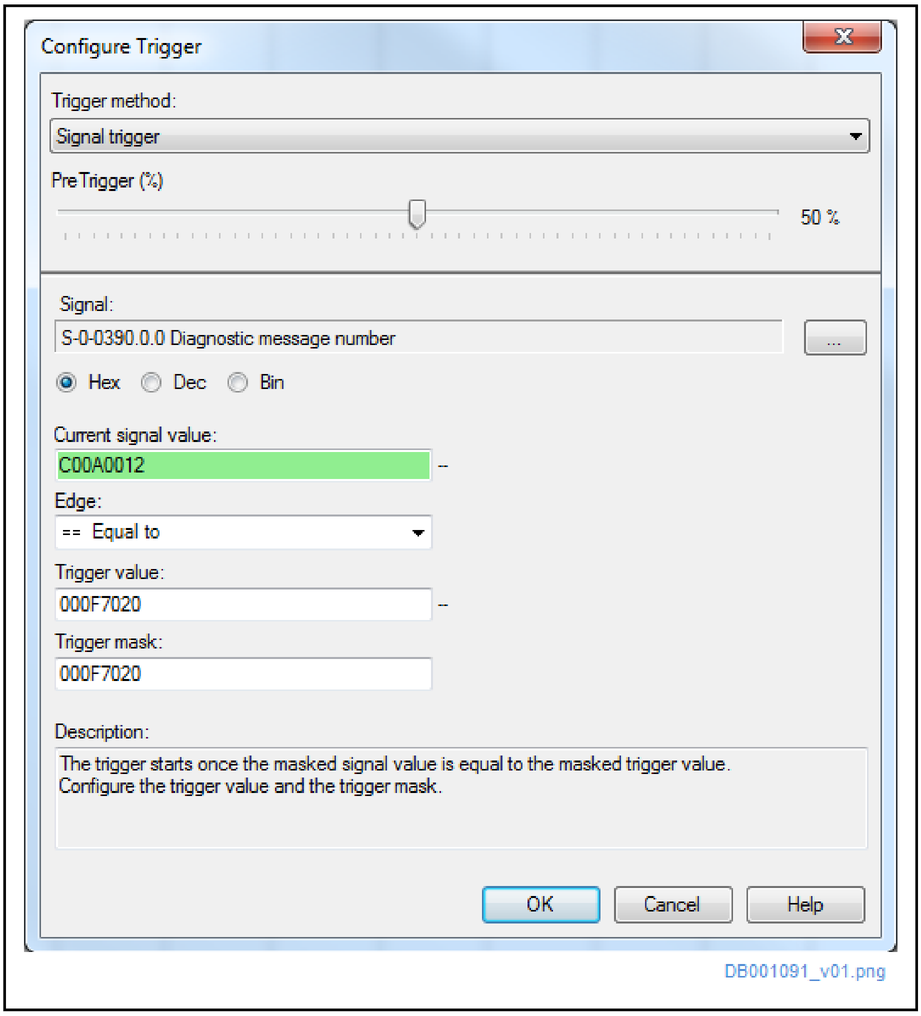

Fig. 9-61: Trigger configuration to check the safe maximum speed

After the configuration, the oscilloscope must be activated via the **Start** button. Afterwards, the axis must be moved in such a way that the threshold of the "Safe maximum speed" is exceeded. With the corresponding oscilloscope measurement, the check can be accordingly documented.

In normal operation, the threshold of the "Safe maximum speed" is displayed in the recorded parameter "P-0-3238, SMO: Active velocity threshold".

Checking the velocity threshold for Safe standstill

The "velocity threshold for Safe standstill" is active in all operating states. It can be checked in each operating status in which the axis can be moved.

First of all, the oscilloscope function must be called via the link in the dialog. When the oscilloscope is started, the measuring signals already are automatically configured. Afterwards, the trigger must be configured. It is recommended that you use the following settings:

- Trigger method: Signal trigger
- Pre Trigger: 50%
- Trigger signal: P-0-3256.0.0, SMO: Encoder evaluation status
- Trigger edge: ↑ Rising edge
- Trigger value: 0000
- Trigger mask: 0040 hex

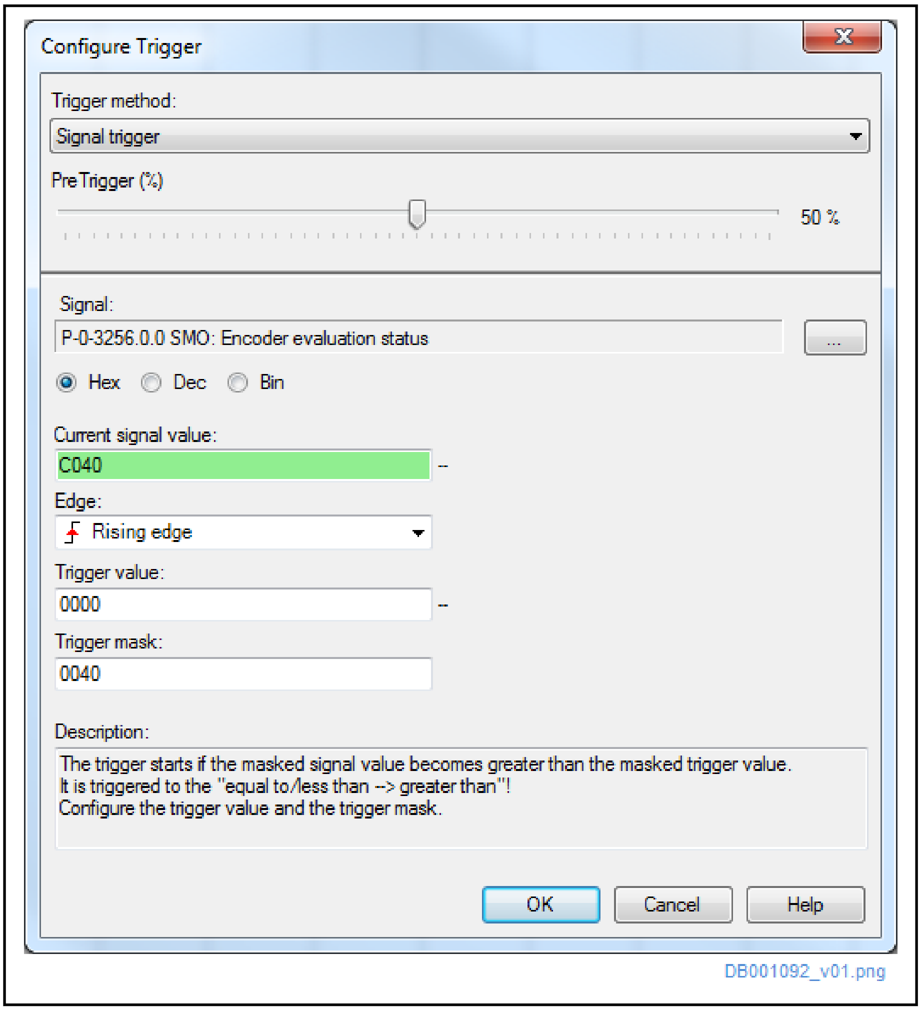

Fig. 9-62: Trigger configuration to check the "velocity threshold for Safe standstill"

After the configuration, the oscilloscope must be activated via the **Start** button. Afterwards, the axis must be stopped from a velocity greater than the "velocity threshold for Safe standstill". With the corresponding oscilloscope measurement, the check can be accordingly documented.

At the point in time the measurement is triggered, Safe Motion has safely detected the axis standstill and acknowledges this in the parameter "P-0-3256.0.0, SMO: Encoder evaluation status" , bit 6. Via the recorded parameter "P-0-3258.0.0, SMO: Velocity feedback value", the exact velocity can be determined below which Safe Motion safely detects the axis standstill.

The corresponding parameters are:

- S-0-0390, Diagnostic message number
- P-0-3256, SMO: Encoder evaluation status
- P-0-3238, SMO: Active velocity threshold
- P-0-3255, SMO: Velocity threshold for safe standstill
- P-0-3270, SMO: Safe maximum speed

In the bottom section of the dialog, it is possible to document, via the memo, the operating states in which the global monitoring functions were checked. With the "Screenshot" button, a screenshot of the memo can be copied to the clipboard for the purpose of documentation.

9.5.4 Monitoring Functions in Normal Operation

In IndraWorks, the "Monitoring Functions in Normal Operation" dialog can be opened via the branch ... ▸ **Machine Acceptance Test** ▸ **Monitoring Functions in Normal Operation**.

The dialog is not provided in the following cases:

- No encoder has been configured in Safe Motion ("P-0-3242.1.1, SMO: Phys. encoder type" equal "0")

  - or -

- No "Safe direction" has been configured for normal operation (P-0-3277.0.1, SMO: Configuration of normal operation).

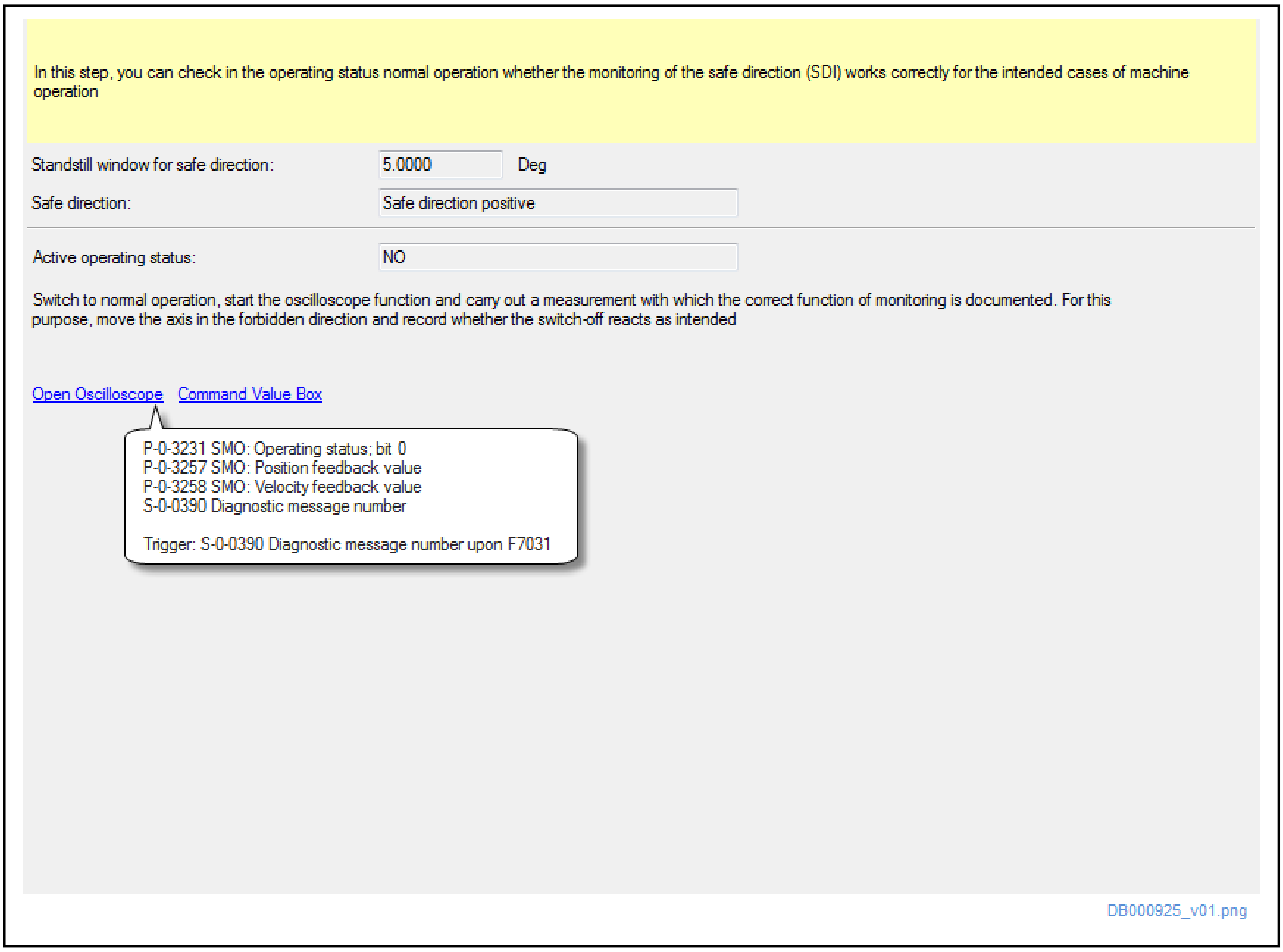

Fig. 9-63: Machine Acceptance Test: Monitoring Functions in Normal Operation

In this dialog, the function of the safety functions that are only active in normal operation can be checked. For this purpose, the configured monitoring functions with the corresponding thresholds are displayed in the top section of the dialog. The following check must be run:

- Checking the Safe Direction

Checking the Safe Direction

To check the safety function, the axis must be switched to the operating status "normal operation" and the oscilloscope function must be called via the link in the dialog. When the oscilloscope is started, the measuring signals already are automatically configured. The oscilloscope can be activated via the **Start** button. Afterwards, move the axis in the forbidden direction (e.g. via the command value box integrated in the drive) until the **Standstill window for Safe direction** (P-0-3270.0.3) is exceeded and the error "F7031 Incorrect direction of motion" is generated. With the corresponding oscilloscope measurement, the check can be accordingly documented.

The corresponding parameters are:

- S-0-0390, Diagnostic message number
- P-0-3231, SMO: Operating status
- P-0-3257, SMO: Position feedback value
- P-0-3258, SMO: Velocity feedback value
- P-0-3270, SMO: Standstill window for safe direction
- P-0-3277.0.1, SMO: Configuration of normal operation

9.5.5 Special mode "Emergency stop" and special mode "Safe standstill"

In IndraWorks, the "Special Mode Safe Standstill" dialog can be opened via the branch ... ▸ **Machine Acceptance Test** ▸ **Special Mode Safe Standstill**.

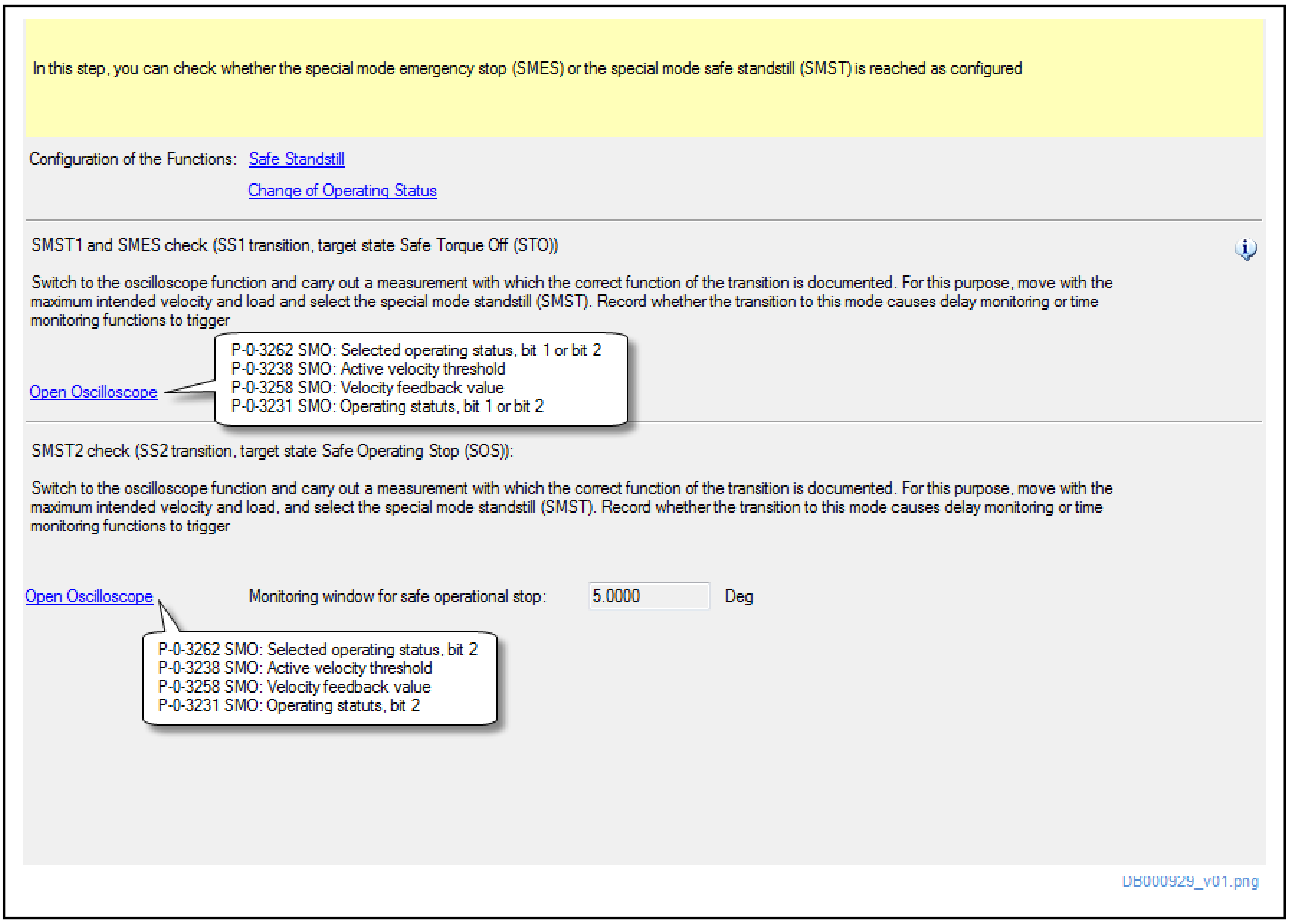

Fig. 9-64: Machine Acceptance Test: Special mode "EMERGENCY STOP" and special mode "Safe standstill"

In this dialog, it is possible to check whether the axis can go without error to the special mode "emergency stop" (SMES) or the special mode "Safe standstill" (SMST), and whether the monitoring functions work correctly in the special mode "Safe standstill" (SMST). The following checks must be run:

- Checking the SMST1 and SMES Transitions
- Checking the SMST2 Transition
- Checking the monitoring windows for Safe operating stop

Checking the SMST1 and SMES Transitions

☞ The operating states SMST and SMES cannot be deactivated in the Bosch Rexroth Safe Motion profile; it is possible, however, to "mask" them by means of safe constant selection in the "IO mapper inputs". In this case, it is impossible to check the transition to the respective operating status.

⚠ WARNING **Personal injury or property damage caused by insufficient overrun distance of the axis!**

Before starting to check the transition, make sure that the braking ability and the overrun distance are sufficient. If this is not the case, the test must not be carried out. If necessary, the deceleration for this axis must be adjusted.

To check the transition, the axis must be switched to the operating status "normal operation" and the oscilloscope function must be called via the link in the dialog. When the oscilloscope is started, the measuring signals already are automatically configured and the oscilloscope can be activated via the **Start** button. Afterwards, the axis must be moved with maximum velocity and load and go to SMST1 or SMES by means of selection. Make sure that the transition does not cause delay monitoring functions or time monitoring functions to trigger. With the corresponding oscilloscope measurement, the check can be accordingly documented.

The following error messages signal incorrect transition:

- F7051 Safely-monitored deceleration exceeded
- F8351 Safely-monitored deceleration exceeded
- F7050 Maximum transition time exceeded
- F8350 Maximum transition time exceeded

☞ During the transition, the threshold of the deceleration monitoring is displayed in the recorded parameter "P-0-3238, SMO: Active velocity threshold".

The corresponding parameters are:

- S-0-0390, Diagnostic message number
- P-0-3231, SMO: Operating status
- P-0-3238, SMO: Active velocity threshold
- P-0-3262, SMO: Selected operating status
- P-0-3258, SMO: Velocity feedback value

Checking the SMST2 Transition

☞ The SMST operating status cannot be deactivated in the Bosch Rexroth Safe Motion profile; it is possible, however, to "mask" it by means of safe constant selection in the "IO mapper inputs". In this case, it is impossible to check the transition to the operating status.

☞ If SMST2 with the safety function "Safe operating stop" has not been configured for the special mode "Safe standstill" (SMST), this check is not required (the section is grayed out).

⚠ WARNING **Personal injury or property damage caused by insufficient overrun distance of the axis!**

Before starting to check the transition, make sure that the braking ability and the overrun distance are sufficient. If this is not the case, the test must not be carried out. If necessary, the deceleration for this axis must be adjusted.

To check the transition, the axis must be switched to the operating status "normal operation" and the oscilloscope function must be called via the link in the dialog. When the oscilloscope is started, the measuring signals already are automatically configured and the oscilloscope can be activated via the **Start** button. Afterwards, the axis must be moved with maximum velocity and load and go to SMST2 by means of selection. Make sure that the transition does not cause delay monitoring functions or time monitoring functions to trigger. With the corresponding oscilloscope measurement, the check can be accordingly documented.

The following error messages signal incorrect transition:

- F7051 Safely-monitored deceleration exceeded
- F8351 Safely-monitored deceleration exceeded
- F7050 Maximum transition time exceeded
- F8350 Maximum transition time exceeded

☞ During the transition, the threshold of the deceleration monitoring is displayed in the recorded parameter "P-0-3238, SMO: Active velocity threshold".

The corresponding parameters are:

- S-0-0390, Diagnostic message number
- P-0-3231, SMO: Operating status
- P-0-3238 SMO: Active velocity threshold
- P-0-3262, SMO: Selected operating status
- P-0-3258, SMO: Velocity feedback value

Checking the monitoring windows for Safe operating stop

☞ The SMST operating status cannot be deactivated in the Bosch Rexroth Safe Motion profile; it is possible, however, to "mask" it by means of safe constant selection in the "IO mapper inputs". In this case, it is impossible to check the transition to the operating status.

☞ If SMST2 with the safety function "Safe operating stop" has not been configured for the special mode "Safe standstill" (SMST), this check is not required (section is grayed out).

The "monitoring window for Safe operating stop" is only active in the special mode "Safe standstill 2". First of all, it is necessary to switch to the special mode "Safe standstill 2" and the oscilloscope function must be called via the link in the dialog. Afterwards, the trigger and the measuring signals must be configured. It is recommended that you use the following settings:

- Trigger method: Signal trigger
- Pre Trigger: 75%
- Trigger signal: S-0-0390.0.0, Diagnostic message number

- Trigger edge: == Equal
- Trigger value: F7030 (Position window for safe operating stop exceeded)
- Trigger mask: F7030 (Position window for safe operating stop exceeded)

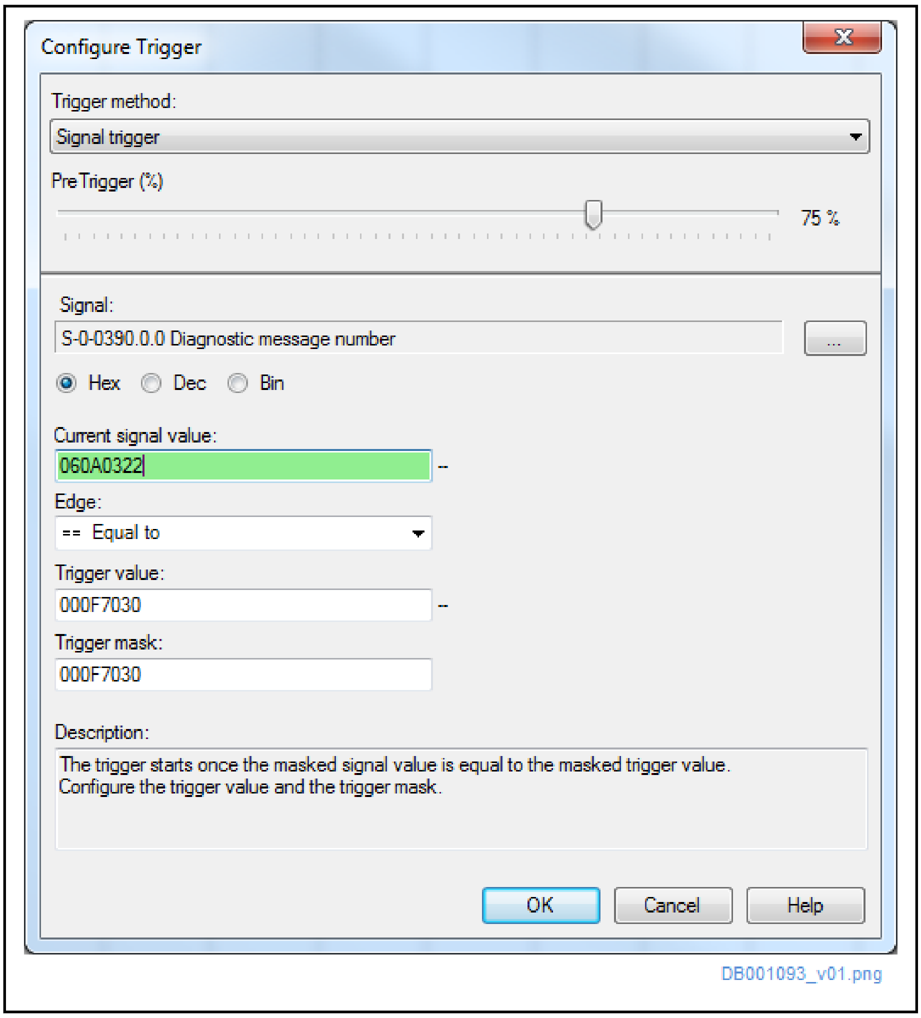

Fig. 9-65: Trigger configuration to check the monitoring window for the Safe operating stop

Measuring signals:

- S-0-0390.0.0, Diagnostic message number
- P-0-3231.0.0, SMO: Operating status , bit 2
- P-0-3257.0.0, SMO: Position feedback value
- P-0-3258.0.0, SMO: Velocity feedback value

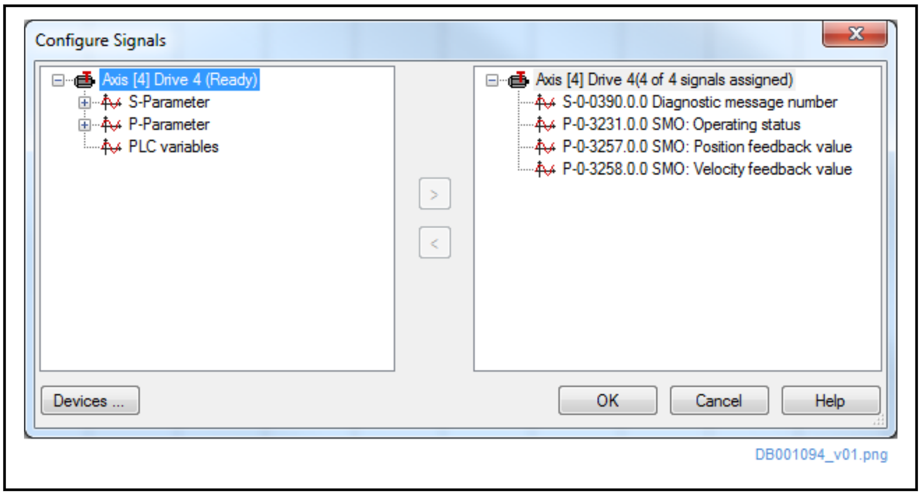

Fig. 9-66: Configuring the Signals

After the configuration, the oscilloscope must be activated via the **Start** button. Afterwards, the axis must be moved by a value greater than "P-0-3285.0.2, SMO: Monitoring window for safe operational stop" until the error "F7030 Position window for safe operating stop exceeded" is generated. With the corresponding oscilloscope measurement, the check can be accordingly documented.

The procedure for moving the axis depends on the configured transition to safe standstill (P-0-3280.0.1):

- **NC-controlled:**

  The axis can be moved via the command value input of the control unit or via the command value box integrated in the drive. The velocity must be smaller than the value parameterized in "P-0-3255, SMO: Velocity threshold for safe standstill" as with higher velocities, the command value monitoring function of the drive generates the error "F6200 Velocity command value > standstill window in SOS".

- **drive-controlled:**

  The axis **cannot** be moved via a command value input. Instead, drive enable must be removed, the possibly available brake must be released and the axis must be manually moved. If it is impossible to move the axis manually, the test cannot be carried out and must be accordingly documented.

The corresponding parameters are:

- S-0-0390, Diagnostic message number
- P-0-3231, SMO: Operating status
- P-0-3238 SMO: Active velocity threshold
- P-0-3262, SMO: Selected operating status
- P-0-3255, SMO: Velocity threshold for safe standstill
- P-0-3258, SMO: Velocity feedback value
- P-0-3280.0.1, SMO: Configuration of operation mode transitions
- P-0-3285.0.2, SMO: Monitoring window for safe operational stop

9.5.6 Special mode "Safe motion"

In IndraWorks, the "Special Mode Safe Motion" dialog can be opened via the branch ... ▸ **Machine Acceptance Test** ▸ **Special Mode Safe Motion.**

☞ The dialog is not provided if no special mode "safe motion" (SMM1…16) has been configured.

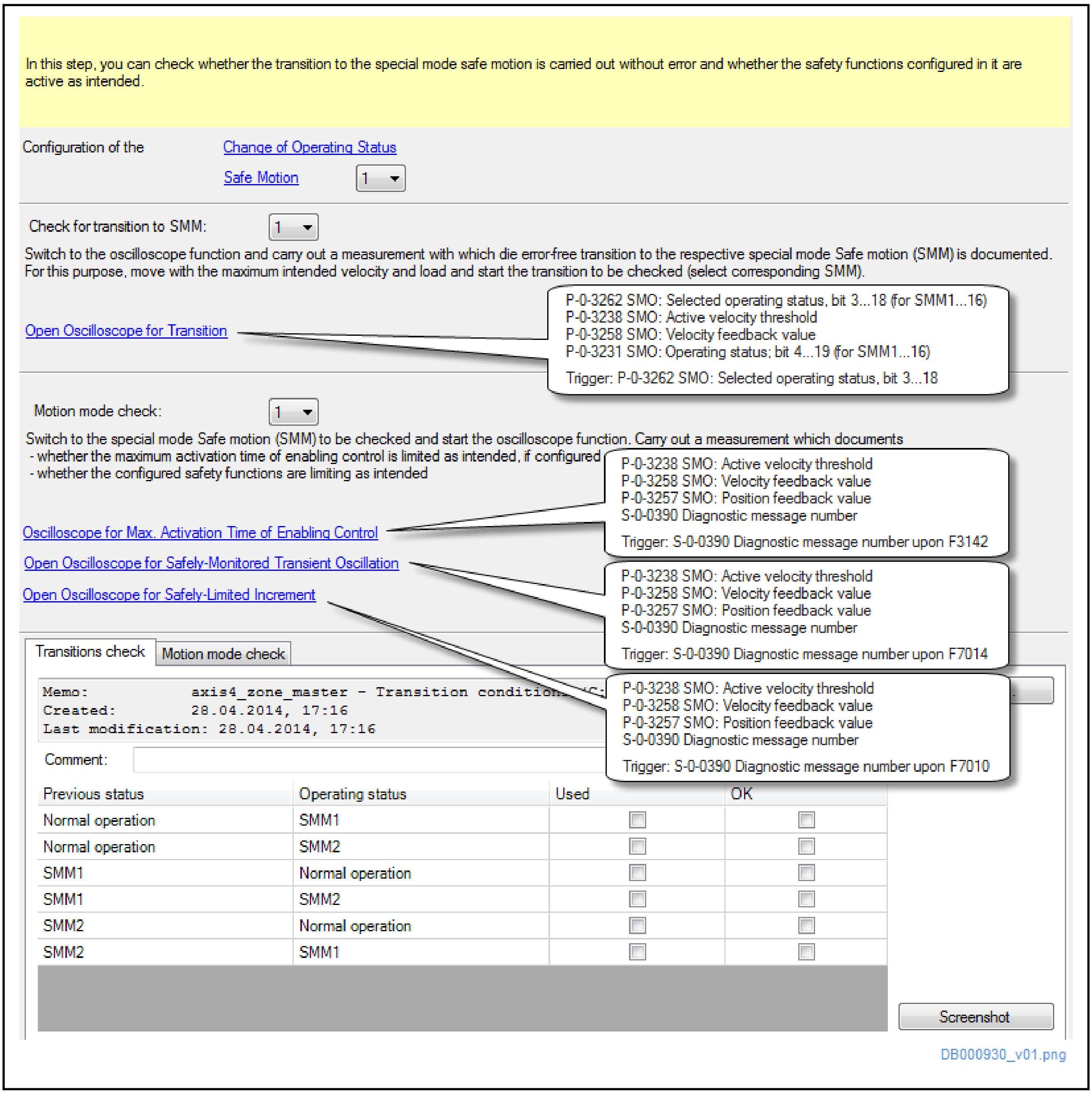

Fig. 9-67: Machine Acceptance Test: Special mode "Safe motion"

In this dialog, it is possible to check whether the axis can go without error to the special mode "safe motion". In the special mode "safe motion", it is possible to check whether the safety functions configured in this mode are limiting as intended.

The top section of the dialog refers to the configuration dialogs in which the operating states and operating state transitions can be parameterized.

The following checks must be run:

- Transition to the special mode "safe motion"
- Monitoring the activation time of enabling control
- "Safely-limited speed"
- "Safely-monitored transient oscillation"
- "Safe direction"
- "Safely-limited increment"

Checking the Transition to the Special Mode "Safe Motion"

⚠ WARNING **Personal injury or property damage caused by insufficient overrun distance of the axis!**

Before starting to check the transition, make sure that the braking ability and the overrun distance are sufficient. If this is not the case, the test must not be carried out. If necessary, the deceleration for this axis must be adjusted.

At the beginning of the check, you must select the special mode "Safe motion" (SMM) for which the transition is to be checked in the drop down list "Check transition to SMM:". Afterwards, the oscilloscope function must be called via the link in the dialog. When the oscilloscope is started, the measuring signals for the selected SMM already are automatically configured and the oscilloscope can be activated via the **Start** button. It is now necessary to go to an operating status (normal operation or another special mode "safe motion") from which the chosen SMM can be selected. In this status, the axis must be moved with maximum velocity and load and go to the chosen SMM by means of selection. Make sure that the transition does not cause delay monitoring functions or time monitoring functions to trigger. With the corresponding oscilloscope measurement, the check can be accordingly documented.

The following error messages signal incorrect transition:

- F7051 Safely-monitored deceleration exceeded
- F8351 Safely-monitored deceleration exceeded
- F7050 Maximum transition time exceeded
- F8350 Maximum transition time exceeded

☞ During the transition, the threshold of the deceleration monitoring is displayed in the recorded parameter "P-0-3238, SMO: Active velocity threshold".

This check should be repeated for all other operating states from which the chosen SMM can be selected.

☞ It is not necessary to check the transition from the special mode "emergency stop" (SMES) and the special mode "Safe standstill" (SMST1 or SMST2) to the special mode "Safe motion", because in these cases direct switching (without transition) is always carried out.

If several special modes "safe motion" have been configured, the check should be repeated for each configured SMM.

In the bottom section of the dialog ("Transitions check" tab page), the test progress can be documented by means of the memo. The "Transitions check" tab page contains one row for each possible change in the operating status. In the "Used" column, the commissioning engineer marks all changes in the operating states relevant to the axis and only checks these changes. The successful checks can be documented in the "OK" column in the corresponding transitions.

Via the **Screenshot** button, a screenshot of the tab page can be copied to the clipboard for the purpose of documentation.

The corresponding parameters are:

- P-0-3231, SMO: Operating status
- P-0-3238 SMO: Active velocity threshold
- P-0-3262 SMO: Selected operating status
- P-0-3258, SMO: Velocity feedback value

Checking the Monitoring of Activation Time of Enabling Control

To verify the safety function, you have to select the special mode "Safe motion" (SMM) which is to be checked in the drop down list "Motion mode check:" Afterwards, the oscilloscope function can be called via the link in the dialog. When the oscilloscope is started, the measuring signals already are automatically configured and the oscilloscope can be activated via the **Start** button. Afterwards, the chosen SMM should be selected from normal operation until the "maximum activation time of enabling control" [P-0-3290.x.6 (x=SMM1…16)] is exceeded and the error "F3142 Activation time of enabling control exceeded" is generated. With the corresponding oscilloscope measurement, the check can be accordingly documented.

If several special modes "safe motion" have been configured, the check should be repeated for each configured SMM.

In the bottom section of the dialog ("Motion mode check" tab page), the test progress can be documented by means of the memo. The "Motion mode check:" tab page contains one row for each configured special mode "Safe motion". The successful check of all monitoring functions for an SMM can be accordingly documented in the "OK" column.

Via the **Screenshot** button, a screenshot of the tab page can be copied to the clipboard for the purpose of documentation.

The corresponding parameters are:

- S-0-0390, Diagnostic message number
- P-0-3231, SMO: Operating status
- P-0-3238, SMO: Active velocity threshold
- P-0-3257, SMO: Position feedback value
- P-0-3258, SMO: Velocity feedback value

Checking the "Safely-limited speed"

To verify the safety function, you have to select the special mode "Safe motion" (SMM) which is to be checked in the drop down list "Motion mode check:"

☞ If the safety function "Safely-monitored transient oscillation" has been configured for the selected special mode "Safe motion", the "Safely-limited speed" does not need to be checked, because the "Safely-limited speed" is automatically checked, too, when the safety function "Safely-monitored transient oscillation" is checked.

First of all, the oscilloscope function must be called via a link in the dialog. Afterwards, the trigger and the measuring signals must be configured. It is recommended that you use the following settings:

- Trigger method: Signal trigger
- Pre Trigger: 75%
- Trigger signal: S-0-0390.0.0, Diagnostic message number
- Trigger edge: == Equal
- Trigger value: F7013 (Velocity threshold exceeded)
- Trigger mask: F7013 (Velocity threshold exceeded)

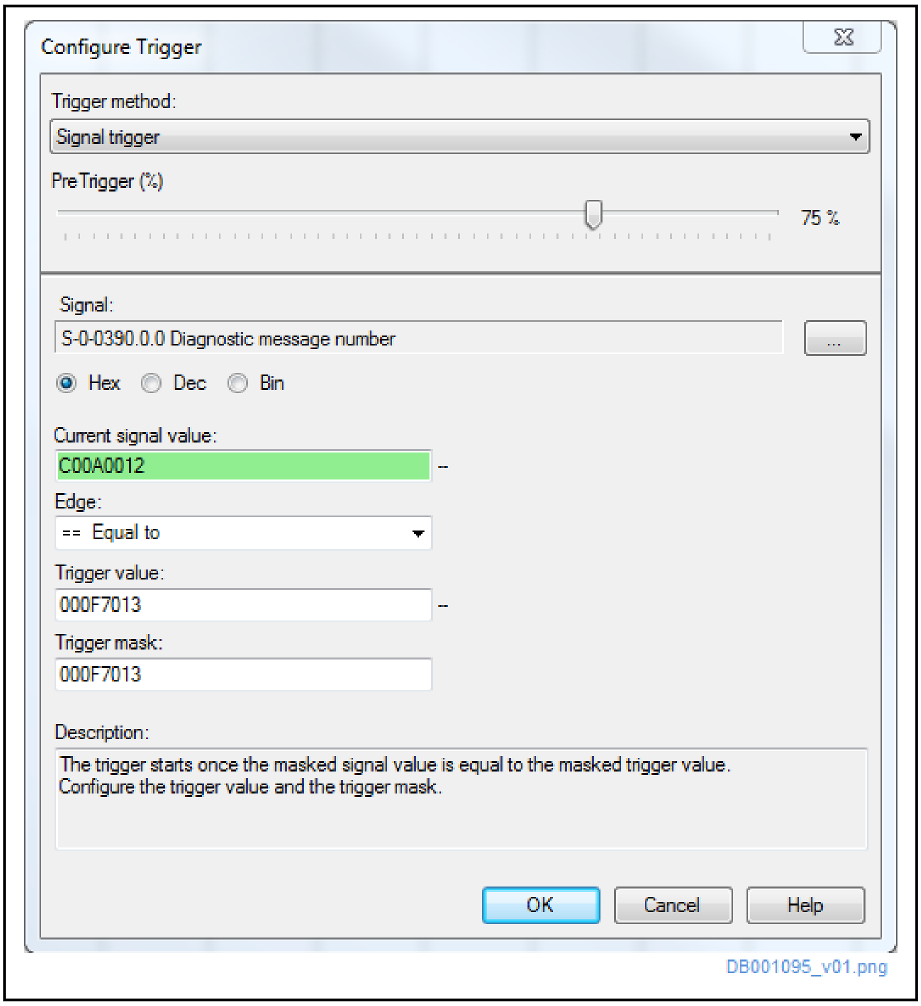

Fig. 9-68: Trigger Configuration to Check the Safely-Limited Speed

Measuring signals:

- S-0-0390.0.0, Diagnostic message number
- P-0-3231.0.0, SMO: Operating status, bit 3 to bit 18
- P-0-3238.0.0, SMO: Active velocity threshold
- P-0-3258.0.0, SMO: Velocity feedback value

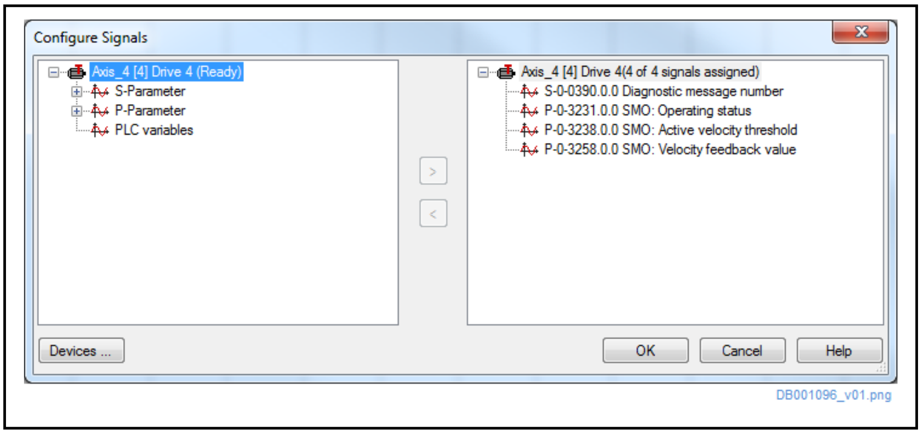

Fig. 9-69: Configuring the Signals

After the configuration, the oscilloscope must be activated via the **Start** button. Afterwards, the selected SMM must be activated and the axis must be moved in such a way that the parameterized "Safely-limited speed" [P-0-3290.x.2 (x=SMM1…16)] is exceeded and the error "F7013 Velocity threshold exceeded" is generated. With the corresponding oscilloscope measurement, the check can be accordingly documented.

☞ In normal operation, the threshold of the "Safely-limited speed" is displayed in the recorded parameter "P-0-3238, SMO: Active velocity threshold".

Checking the "Safely-Monitored Transient Oscillation"

☞ If the safety function "safely-monitored transient oscillation" has not been configured for the selected special mode "safe motion", this check does not need to be run (the link is grayed out).

To verify the safety function, you have to select the special mode "Safe motion" (SMM) which is to be checked in the drop down list "Motion mode check:"

Afterwards, the oscilloscope function can be called via the link in the dialog. When the oscilloscope is started, the measuring signals already are automatically configured and the oscilloscope can be activated via the **Start** button. Afterwards, activate the selected SMM and move the axis in such a way that either the parameterized "Safely-limited speed" [P-0-3290.x.2 (x=SMM1…16)] is exceeded or the "Safely-reduced speed" [P-0-3290.x.8 (x=SMM1…16)] is exceeded for a longer time than the "tolerance time for overshooting" [P-0-3290.x.7 (x=SMM1…16)], and the error "F7014 Timeout in safely-monitored transient oscillation" or "F7013 Velocity threshold exceeded" is generated. With the corresponding oscilloscope measurement, the check can be accordingly documented.

☞ If the safely-monitored transient oscillation is to be checked by triggering "F7013 Velocity threshold exceeded", the trigger value and trigger mask in the oscilloscope must be changed from F7014 to F7013.

☞ During the check, the threshold of the safely-monitored transient oscillation is displayed in the recorded parameter "P-0-3238, SMO: Active velocity threshold".

If several special modes "safe motion" have been configured, the check should be repeated for each configured SMM.

In the bottom section of the dialog, the test progress can be documented on the "Motion mode check" tab page of the memo. The "Motion mode check" tab page contains one row for each configured special mode "safe motion". The successful check of the monitoring function can be accordingly documented for each SMM in the "OK" column.

Via the **Screenshot** button, a screenshot of the tab page can be copied to the clipboard for the purpose of documentation.

The corresponding parameters are:

- S-0-0390, Diagnostic message number
- P-0-3231, SMO: Operating status
- P-0-3238, SMO: Active velocity threshold
- P-0-3257, SMO: Position feedback value
- P-0-3258, SMO: Velocity feedback value

Checking the "Safe Direction"

To verify the safety function, you have to select the special mode "Safe motion" (SMM) which is to be checked in the drop down list "Motion mode check:"

> ☞ If the safety function "safe direction" has not been configured for the selected special mode "safe motion", this check does not need to be run.

First of all, the oscilloscope function must be called via a link in the dialog. Afterwards, the trigger and the measuring signals must be configured. It is recommended that you use the following settings:

- Trigger method: Signal trigger
- Pre Trigger: 75%
- Trigger signal: S-0-0390.0.0, Diagnostic message number
- Trigger edge: == Equal
- Trigger value: F7031 (Incorrect direction of motion)
- Trigger mask: F7031 (Incorrect direction of motion)

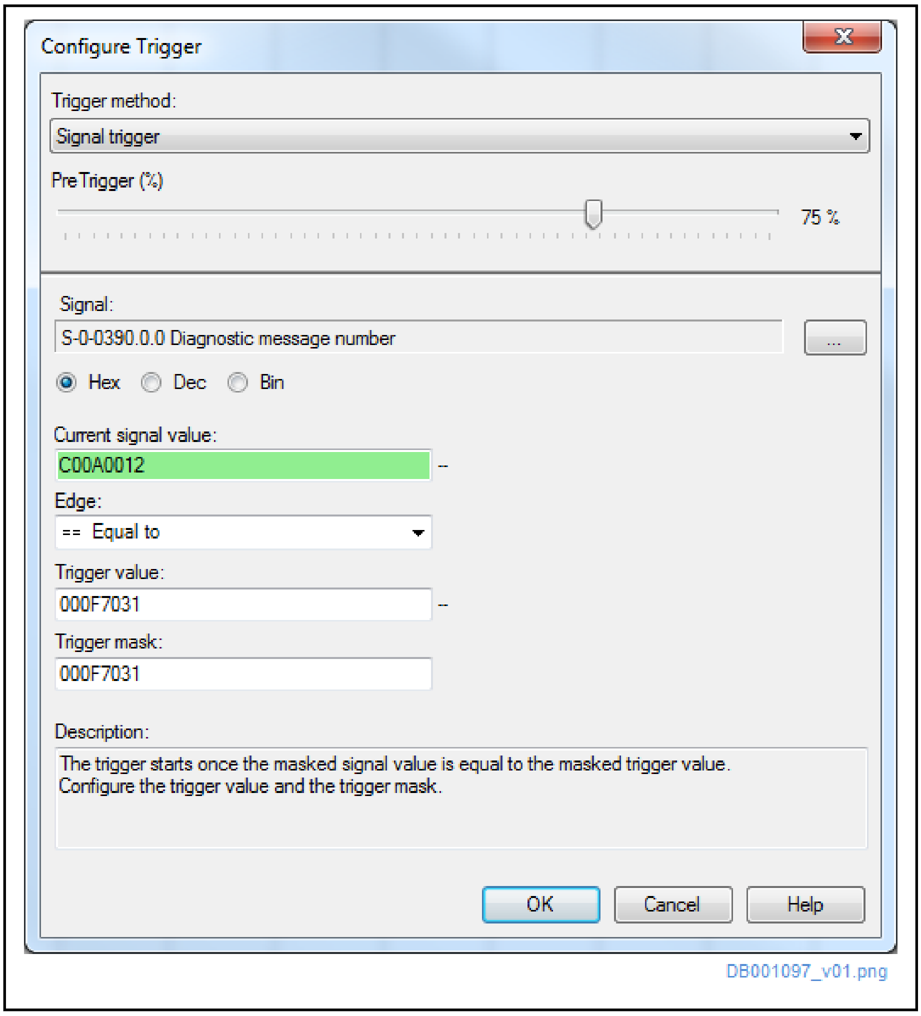

Fig. 9-70: Trigger Configuration to Check the Safe Direction

Measuring signals:

- S-0-0390.0.0, Diagnostic message number
- P-0-3231.0.0, SMO: Operating status , bit 3 to bit 18
- P-0-3257.0.0, SMO: Position feedback value
- P-0-3258.0.0, SMO: Velocity feedback value

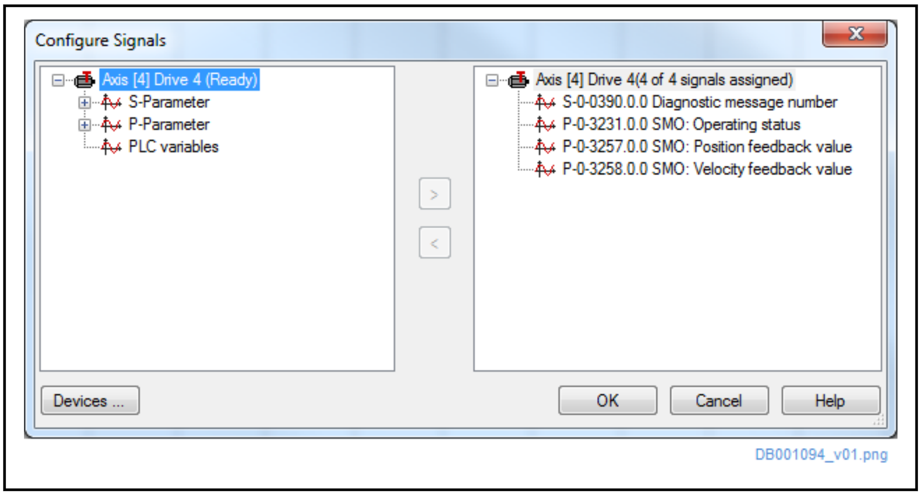

Fig. 9-71: Configuring the Signals

After the configuration, the oscilloscope must be activated via the **Start** button. Afterwards, activate the selected SMM and move the axis in the forbidden direction (e.g. via the command value box integrated in the drive) until the "Standstill window for Safe direction" (P-0-3270.0.3) is exceeded and the error "F7031 Incorrect direction of motion" is generated. With the corresponding oscilloscope measurement, the check can be accordingly documented.

If several special modes "safe motion" have been configured, the check should be repeated for each configured SMM.

In the bottom section of the dialog, the test progress can be documented on the "Motion mode check" tab page of the memo. The "Motion mode check" tab page contains one row for each configured special mode "safe motion". The successful check of all monitoring functions for an SMM can be accordingly documented in the "OK" column.

Via the **Screenshot** button, a screenshot of the tab page can be copied to the clipboard for the purpose of documentation.

The corresponding parameters are:

- S-0-0390, Diagnostic message number
- P-0-3231, SMO: Operating status
- P-0-3257, SMO: Position feedback value
- P-0-3258, SMO: Velocity feedback value
- P-0-3270.0.3, SMO: Standstill window for safe direction

Checking the "Safely-Limited Increment"

To verify the safety function, you have to select the special mode "Safe motion" (SMM) which is to be checked in the drop down list "Motion mode check:"

> ☞ If the safety function "safely-limited increment" has not been configured for the selected special mode "safe motion", this check does not need to be run (the link is grayed out).

Afterwards, the oscilloscope function can be called via the link in the dialog. When the oscilloscope is started, the measuring signals already are automatically configured and the oscilloscope can be activated via the **Start** button. Afterwards, the selected SMM must be activated and the axis must be moved in such a way that the parameterized "Safely-limited increment" [P-0-3290.x.3 (x=SMM1…16)] is exceeded and the error "F7010 Safely-limited increment exceeded" is generated. With the corresponding oscilloscope measurement, the check can be accordingly documented.

If several special modes "safe motion" have been configured, the check should be repeated for each configured SMM.

In the bottom section of the dialog ("Motion mode check" tab page), the test progress can be documented by means of the memo. The "Motion mode check" tab page contains one row for each configured special mode "safe motion". The successful check of all monitoring functions for an SMM can be accordingly documented in the "OK" column.

Via the Screenshot button, a screenshot of the tab page can be copied to the clipboard for the purpose of documentation.

The corresponding parameters are:

- S-0-0390, Diagnostic message number
- P-0-3231, SMO: Operating status
- P-0-3238, SMO: Active velocity threshold
- P-0-3257, SMO: Position feedback value
- P-0-3258, SMO: Velocity feedback value

9.5.7 Error reaction

In IndraWorks, the "Error reaction" dialog can be opened via the branch ... ▸ Machine acceptance ▸ Error reaction.

In this dialog, it is possible to check whether the axis can be decelerated as configured when a safety technology error occurs, and that Safe Motion does not go to "escalation".

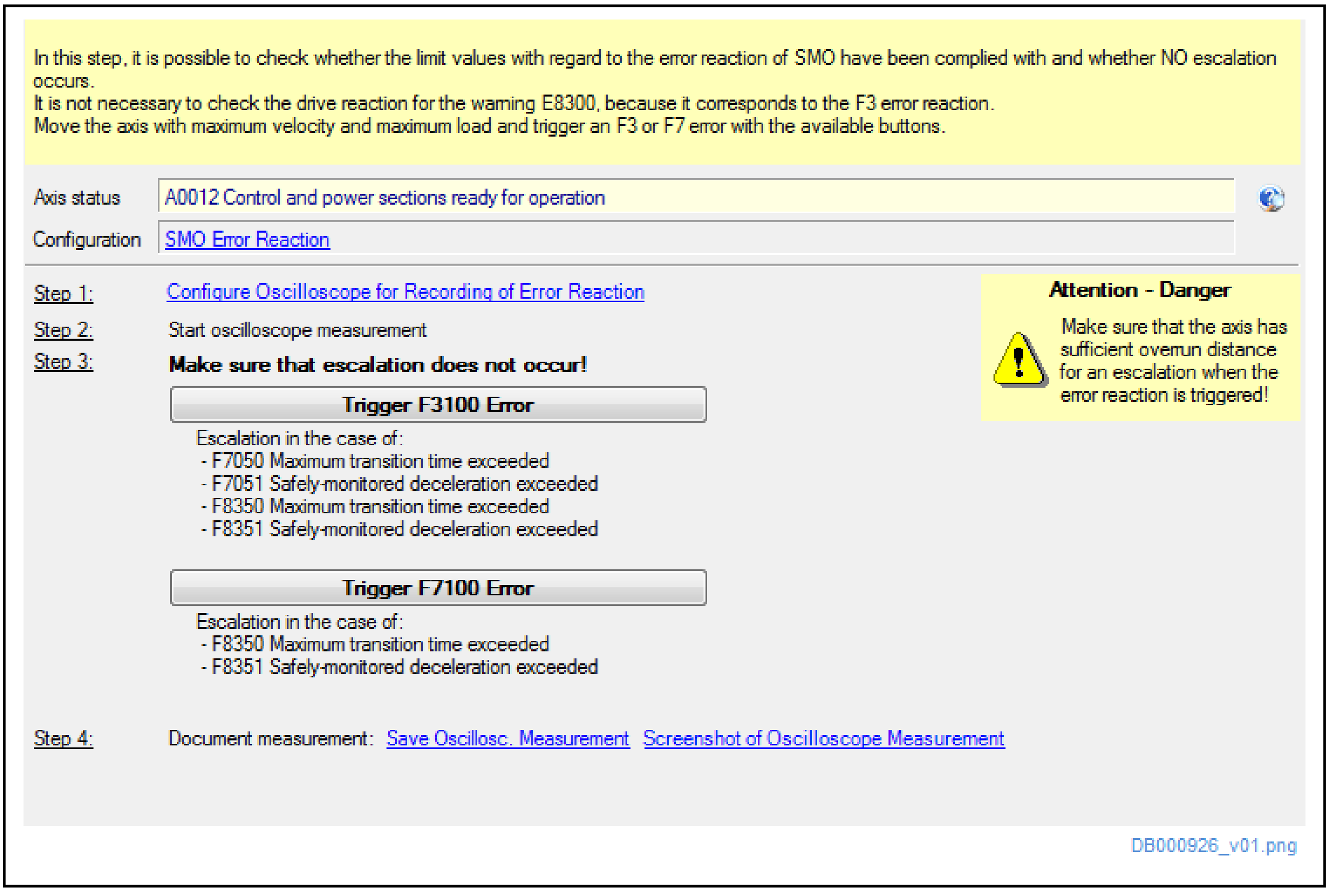

Fig. 9-72: Machine Acceptance Test: Error reaction

The top section of the dialog displays the current axis status allowing to monitor the error reaction, and refers to the dialog for configuring the error reaction. The error reaction can be checked as follows:

1. Via the link "Configure Oscilloscope for Recording of Error Reaction" call the oscilloscope function. Afterwards, the trigger and the measuring signals must be configured. It is recommended that you use the following settings:
   - Trigger method: Signal trigger
   - Pre Trigger: 10%
   - Trigger signal: P-0-3231.0.0, SMO: Operating status
   - Trigger edge: == Equal
   - Trigger value: Bit 0…31="0"
   - Trigger mask: Bit 25="1", all other bits="0"

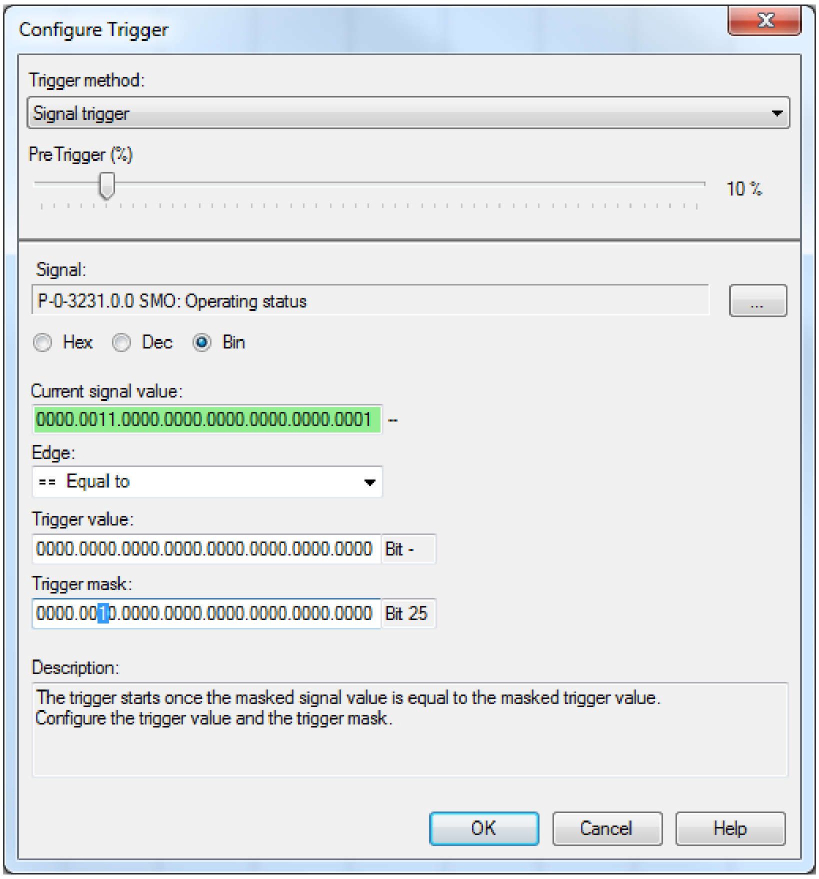

Fig. 9-73: Trigger Configuration to Check the Error Reaction

Measuring signals:

- S-0-0390, Diagnostic message number
- P-0-3231, SMO: Operating status, bit 25
- P-0-3238, SMO: Active velocity threshold
- P-0-3258, SMO: Velocity feedback value

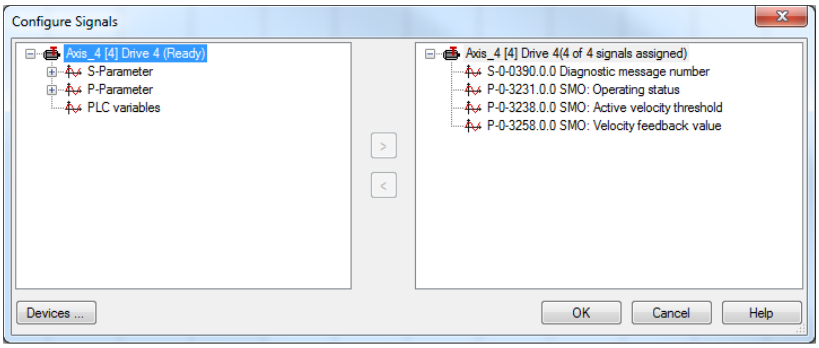

Fig. 9-74: Configuring the Signals

2. After the configuration, the oscilloscope must be activated via the **Start** button.

3. **⚠ DANGER** **Dangerous movements! Danger to life, risk of injury, serious injury or property damage!**

   Make sure that when the error reaction is triggered, the axis has sufficient overrun distance for a possible error escalation.

   Afterwards, the axis must be moved with the maximum velocity and load that the mechanical properties of the axis tolerate. Via the **Trigger F3100 Error** button, an F3 error reaction must be triggered. After the error reaction has been completed, make sure that none of the following safety technology errors has been entered in the axis status:

   - F7051 Safely-monitored deceleration exceeded
   - F8351 Safely-monitored deceleration exceeded
   - F7050 Maximum transition time exceeded
   - F8350 Maximum transition time exceeded

4. Document the escalation-free error reaction by saving the oscilloscope measurement via the "Save Oscillosc. Measurement" link or by copying a screenshot to the clipboard via the "Screenshot of Oscilloscope Measurement" link.
5. Repeat the steps 1 to 4 for the error reaction of the "F7xxx" error class. In doing so, use the **Trigger F7100 Error** button in step 3. After the error reaction has been completed, make sure that none of the following safety technology errors has been entered in the axis status:

   - F8351 Safely-monitored deceleration exceeded
   - F8350 Maximum transition time exceeded

9.5.8 Safety Zone and Safe Door Locking

In IndraWorks, the "Safety Zone and Safe Door Locking" dialog can be opened via the branch **... ▸ Machine Acceptance Test ▸ Safety Zone and Safe Door Locking.**

☞ The dialog is not provided if the following requirements apply:

- The axis is neither a zone node nor a zone master

  - and -

- No zone errors are generated or no reaction to zone errors takes place (see P-0-3266.0.2)

In this dialog, it is possible to check whether the axis, as configured, generates a zone error or reacts to zone errors.

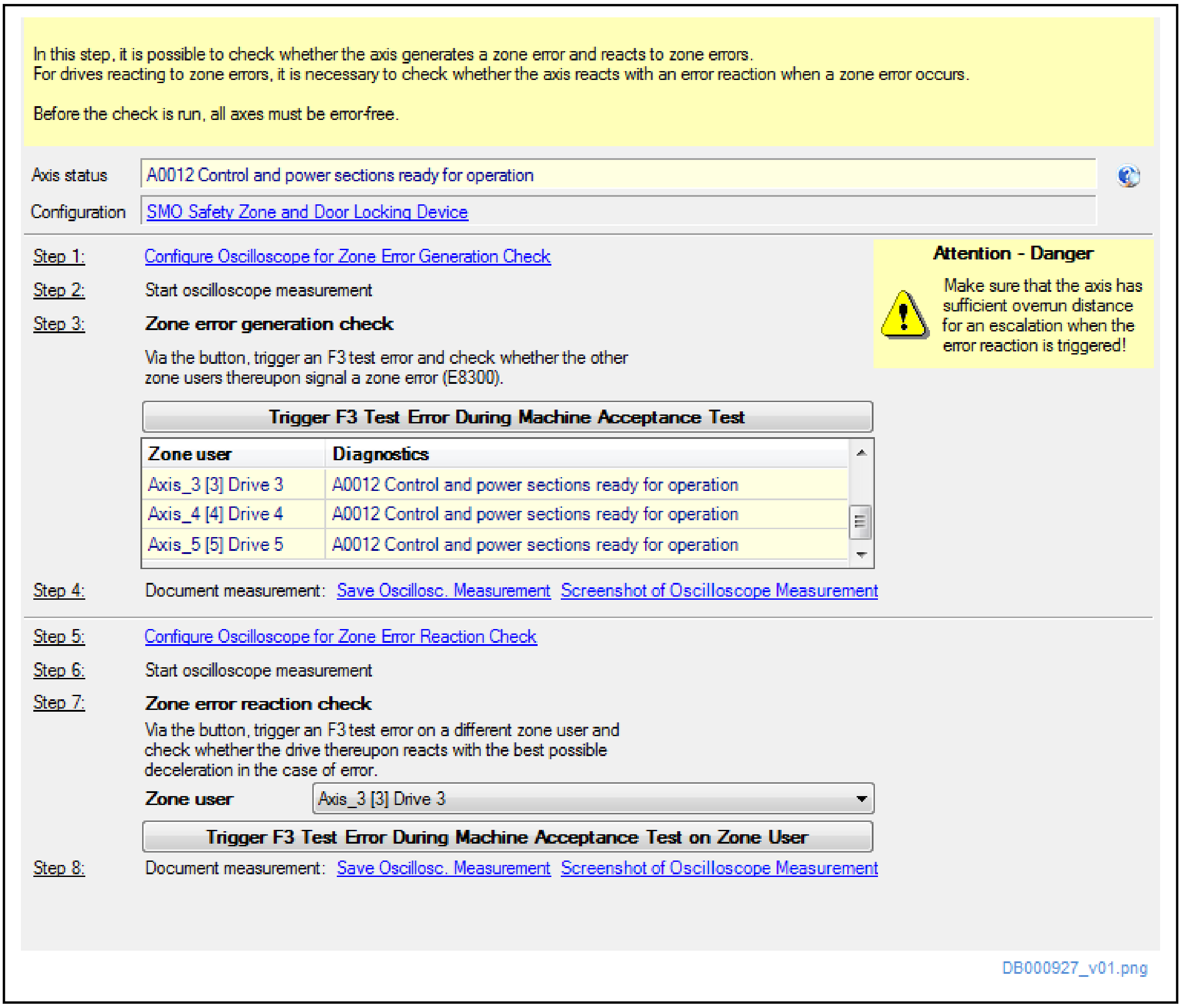

Fig. 9-75: Machine Acceptance Test: Safety Zone and Safe Door Locking

The top section of the dialog displays the current axis status and refers to the dialog for configuring the axis behavior in the safety zone. The generation of zone errors and the reaction to zone errors can be checked as follows:

Checking the Generation of Zone Errors

☞ If the axis has **not** been configured in such a way that it signals its own safety technology errors as zone errors, this check does not need to be run (steps 1 to 4 are grayed out in the dialog).

1. Via the link "Configure Oscilloscope for Zone Error Generation Check" call the oscilloscope function. When the oscilloscope is called, the measuring signals are automatically configured. Afterwards, the trigger must be configured. It is recommended that you use the following settings:
   - Trigger method: Signal trigger
   - Pre Trigger: 10%
   - Trigger signal: P-0-3231.0.0, SMO: Operating status
   - Trigger edge: == Equal

- Trigger value: Bit 0…31="0"
- Trigger mask: Bit 25="1", all other bits="0"

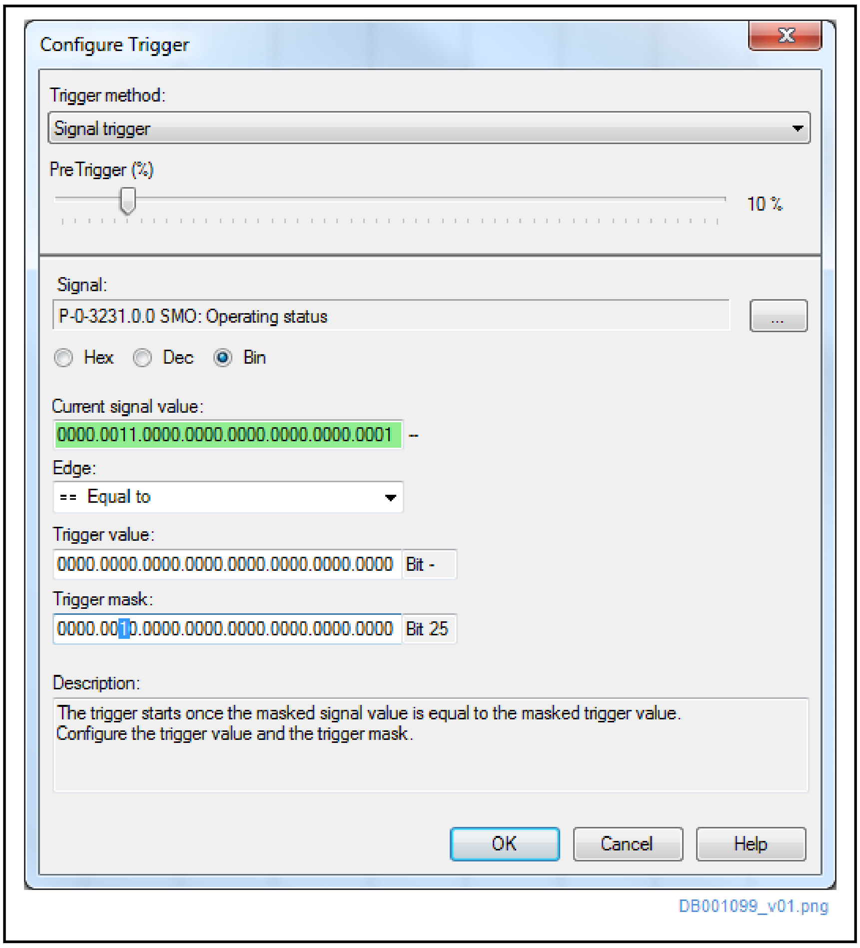

Fig. 9-76: Trigger Configuration to Check the Generation of Zone Errors

2. After the configuration, the oscilloscope must be activated via the **Start** button.
3.

Before triggering the F3 test error, you should make sure that there isn't any warning or error present at the nodes of the safety zone. Possibly existing warnings or errors must be removed before the zone error reaction can be checked.

Afterwards, an F3 error reaction must be triggered via the **Trigger F3 Test Error During Machine Acceptance Test** button. In this context, it is necessary to check whether the other zone users which are to react to zone errors, signal the warning "E8300 SMO: Error within the safety zone" after the F3 test error has been triggered.

4. Document the generation of zone errors by saving the oscilloscope measurement via the "Save Oscillosc. Measurement" link or by copying it to the clipboard via the "Screenshot of Oscilloscope Measurement" link.

The corresponding parameters are:

- S-0-0390, Diagnostic message number

- P-0-3231, SMO: Operating status
- P-0-3266.0.1, SMO: Safety zone control word
- P-0-3266.0.2, SMO: Safety zone configuration

Checking the Reaction to Zone Errors

☞ If the axis has not been configured in such a way that it reacts to zone errors, this check does not need to be run (steps 5 to 8 are grayed out).

1. Via the link "Configure Oscilloscope for Zone Error Reaction Check" call the oscilloscope function. When the oscilloscope is called, the measuring signals are automatically configured. Afterwards, the trigger must be configured. It is recommended that you use the following settings:
   - Trigger method: Signal trigger
   - Pre Trigger: 10%
   - Trigger signal: P-0-3231.0.0, SMO: Operating status
   - Trigger edge: == Equal
   - Trigger value: Bits 24 and 25="1", all other bits="0"
   - Trigger mask: Bits 0…19, 24 and 25="1", all other bits="0"

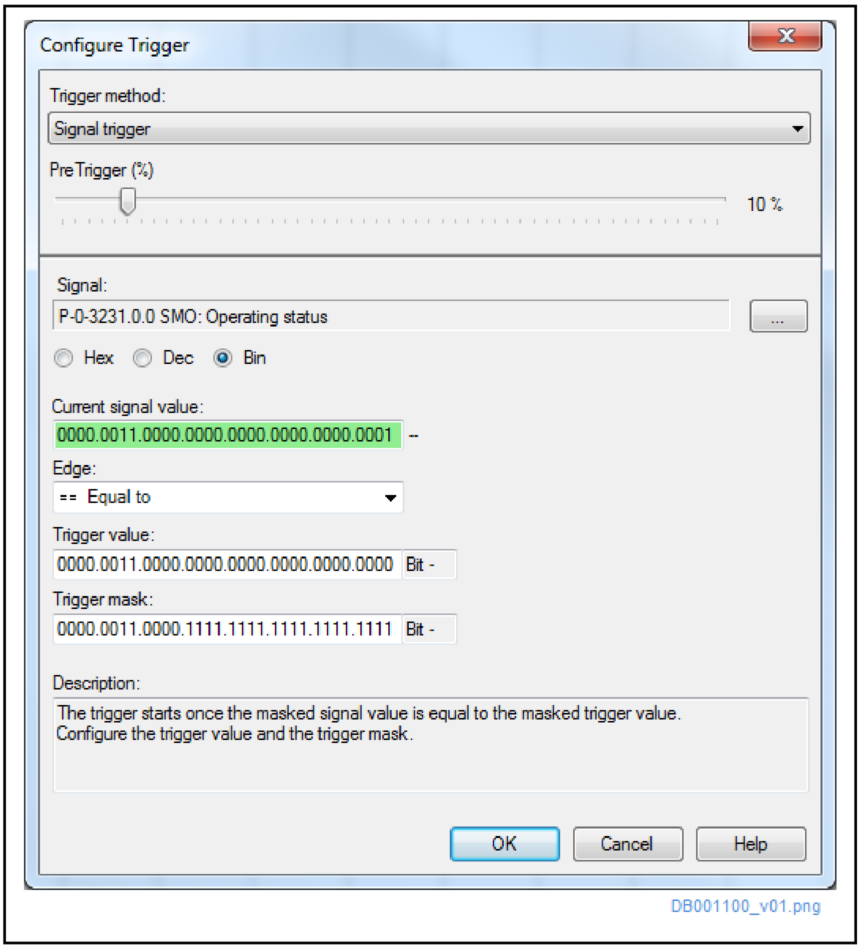

Fig. 9-77: Configuring the Trigger

2. After the configuration, the oscilloscope must be activated via the **Start** button.

3. Via the "Zone user" (= zone node) drop down list, select the zone node for which the F3 test error is to be generated to check the zone error reaction of the axis to be checked.

☞ Make sure to select an axis for which the generation of zone errors has been configured.

---

4. Trigger F3 test error

☞ Before triggering the F3 test error, you should verify whether the following requirements have been met:
- There mustn't be any warning or error present at the nodes of the safety zone. Possibly existing warnings or errors must be removed before the zone error reaction can be checked.
- The zone node to be checked must be in the operating mode (OM).

☞ If it is impossible to establish a valid communication connection (e.g. CCD or sercos) to other zone nodes via IndraWorks, the dialog will not provide the option to trigger an F3 test error. In this case, IndraWorks must be manually connected to the respective axis to generate the F3 test error, and then the error must be triggered via the branch ... ▸ **Machine acceptance** ▸ **Error reaction.**

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

Make sure that when the error reaction is triggered, the axis has sufficient overrun distance for a possible error escalation.

Via the **Trigger F3 Test Error During Machine Acceptance Test on Zone User** button, trigger an F3 error reaction on the selected zone user (= zone node). Verify whether the warning "E8300 SMO: Error within the safety zone" is generated at the axis to be checked.

5. Document the axis reaction to zone errors by saving the oscilloscope measurement via the "Save Oscillosc. Measurement" link or by copying it to the clipboard via the "Screenshot of Oscilloscope Measurement" link.

The corresponding parameters are:
- S-0-0390, Diagnostic message number
- P-0-3231, SMO: Operating status
- P-0-3266.0.1, SMO: Safety zone control word
- P-0-3266.0.2, SMO: Safety zone configuration

9.5.9 Signal control of outputs

In IndraWorks, the "Signal Control of Outputs" dialog can be opened via the branch ... ▸ **Machine Acceptance Test** ▸ **Signal Control of Outputs**.

☞ The dialog is not provided if no source signal has been assigned to the safe output in "P-0-3335.0.2, SMO: Signal control for discrete outputs, bit number".

In this dialog, it is possible to check whether the signal applied to the safe local output is correctly processed.

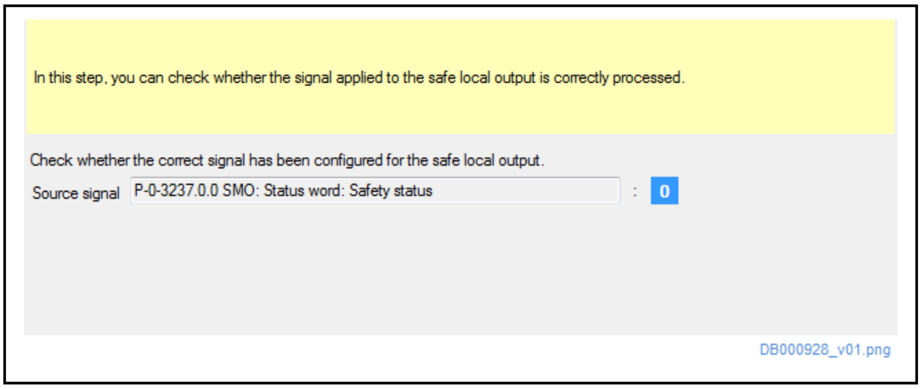

Fig. 9-78: Machine Acceptance Test: Signal control of outputs

Pertinent parameters:

- P-0-3335.0.1, SMO: Signal control for discrete outputs, IDN assignment
- P-0-3335.0.2, SMO: Signal control for discrete outputs, bit number

10 Maintenance

10.1 Replacing drive components

10.1.1 General information

☞ When replacing drive components, observe the safety instructions the in chapter "Safety instructions for electric drives and controls"!

10.1.2 Replacing the motor

⚠ WARNING **Lethal electric shock by live parts with more than 50 V!**

The supply unit may only be replaced by qualified personnel which have been trained to perform the work on or with electrical devices.

☞ The motor has to be replaced by a motor of identical type. Only by doing this is it ensured that all parameter settings can remain unchanged. Moreover, it is not required in this case to repeat the acceptance test within the scope of the "Integrated safety technology" function.

1. If necessary, write down last absolute value
2. Open main switch
3. Make sure main switch cannot be switched on again
4. Disconnect plug-in connectors

☞ When replacing the motor, cover the open mating sites of power lines with protective caps if sprinkling with cooling liquid/lubricant or pollution may occur (admissible pollution degree according to EN50178: 2).

5. Replace motor

☞ To mechanically replace the AC servo motor, observe the instructions of the machine manufacturer.

6. Connect plug-in connectors
7. WARNING! Risk of accident caused by unintended axis motion! Servo axes with indirect distance measuring system via the motor encoder will lose their position data reference when the motor is replaced!

   This position data reference to the machine coordinate system must therefore be reestablished after replacement.
8. Record the replacement in the safety-related documentation of the machine (serial number, type, …). To do this, use the IndraDrive Service Tool (IDST), for example.

10.1.3 Replacing the optional encoder

⚠ WARNING **Lethal electric shock by live parts with more than 50 V!**

The supply unit may only be replaced by qualified personnel which have been trained to perform the work on or with electrical devices.

☞ The encoder may only be replaced by an encoder of identical type. Only by doing this is it ensured that all parameter settings can remain unchanged. Moreover, it is not required in this case to repeat the acceptance test within the scope of the integrated safety technology.

1. If necessary, write down last absolute value
2. Open main switch
3. Make sure main switch cannot be switched on again
4. Disconnect plug-in connectors
5. Replace encoder

☞ To mechanically replace the optional encoder, observe the mounting instructions of the encoder manufacturer.

If the optional encoder is used as safety technology encoder, it has to be ensured that the replacement encoder complies with the requirements of safety technology! (see chapter "Required motors and measuring systems").

6. Connect plug-in connectors

☞ If the optional encoder is used as safety technology encoder, make sure it is plugged into X4 (X4.n).

7. WARNING! Risk of accident caused by unintended axis motion! Axes with absolute measuring system will loose the position data reference when the encoder is replaced!

   This position data reference to the machine coordinate system must therefore be reestablished after replacement.
8. Record the replacement in the safety-related documentation of the machine (serial number, type, …). To do this, use the IndraDrive Service Tool (IDST), for example.

10.1.4 Replacing the supply unit

☞ Replacing the supply unit might require a lifting device due to its size and weight.

⚠ WARNING **Lethal electric shock from live parts with more than 50 V!**

The replacement may only be carried out by qualified personnel who have been trained to perform the work at or with electric devices.

⚠ WARNING **Lethal electric shock by live parts with more than 50 V!**

Before working on live parts: De-energize installation and secure power switch against unintentional or unauthorized re-energization.

Wait at least **30 minutes** after switching off the supply voltages to allow **discharging.**

Check whether voltage has fallen below 50 V before touching live parts!

☞ Prior to the replacement, check by means of the type plates whether these devices are of the same types. Only replace devices of the same types.

Proceed as follows for the replacement:

1. De-energize installation and secure it against being switched on again by unauthorized staff or in an accidental way.
2. Using an appropriate measuring device, check whether installation has been de-energized. If necessary, wait for devices to discharge.
3. Make sure that motors have come to a safe standstill.
4. Secure vertical axes against motion.
5. Remove all electrical connections at defective device.
6. Release mounting screws and remove device from control cabinet (use lifting device, if necessary).
7. Mount replacement device in control cabinet (use lifting device, if necessary).
8. Connect replacement device according to connection diagram of machine manufacturer.
9. If you secured vertical axes mechanically before replacing the device, remove these securing devices at this point.
10. By reading error memories of connected drive controllers make sure that device defect has not been caused by drive controllers.

The replacement has been completed. The installation can be put into operation again.

☞ Within the scope of the "Integrated safety technology" function, it is not required to repeat the acceptance test.

10.1.5 Replacing the controller

Overview

A controller of the IndraDrive range consists of the components power section, control section and programming module / control panel (incl. firmware). The control section may be configured with additional components (e.g. optional safety technology module). The control section and power section are firmly connected to each other; only Rexroth service engineers or especially trained users are allowed to replace individual components. The paragraphs below describe how to replace the complete drive controller.

The controller has to be replaced by a device of identical type. This is the only way to ensure that the originally configured functions can be used in unchanged form.

When using devices with integrated safety technology, make sure by organizational measures that only an authorized person replaces the device, e.g., by a lockable control cabinet. Also make sure that the device replacement is not carried out for several axes at a time to avoid accidentally interchanging the axes.

A device intended for replacement that has already been in operation (thus is not in the factory-new condition as supplied), has to be brought to the condition as supplied again ["load defaults procedure (factory settings)", command C0750] before it is used.

The figure below illustrates the basically required individual steps.

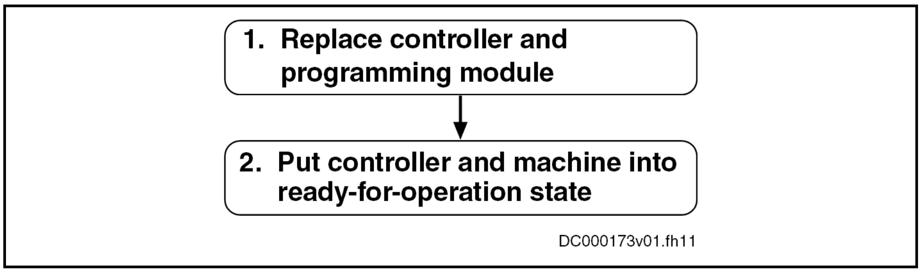

Fig. 10-1: Sequence of drive controller replacement

The "IndraDrive Service Tool (IDST)" allows accessing the drive system, e.g. for remote diagnostics. Besides, authorized users can handle different service cases with IDST, such as replacing drive components, loading parameters or updating/upgrading the drive firmware.

Further information on "IndraDrive Service Tool (IDST)" is described in the separate documentation „Rexroth IndraDrive Service Tools IMST/IDST“ (DOK-IM*MLD-IMSTIDSTV13-RE**-EN-P; mat. no. R911342651).

How to proceed when replacing drive controllers

Replacing the drive controller and the programming module

1. Open the main switch
2. Make sure the main switch cannot be switched on again.
3. Make sure drive controller is de-energized.

   WARNING! Lethal electric shock from live parts with more than 50 V! Before working on live parts: De-energize system and secure power switch against unintentional or unauthorized reconnection. Wait at least **30 minutes** after switching off the supply voltages to allow **discharging**. Make sure voltage has fallen below 50 V before touching live parts.
4. Separate connection lines from controller.
5. Dismount drive controller from control cabinet.
6. Dismount programming module / control panel
   - With IndraDrive C/M/Cs: Pull off programming module / control panel from defective device.

- With IndraDrive Mi: Remove programming module (X107) from defective device, note down positions of address selector switches S4 and S5 (address selector switches below connections X103.1 and X103.2).

7. Mount programming module / control panel
    - With IndraDrive C/M/Cs: Plug programming module / control panel of defective device onto new controller.
    - With IndraDrive Mi:
        1. Set the address selector switches in the same way as for the defective device.
        2. Dismount cover above slot X107.
        3. Plug programming module of defective device onto replacement device.
        4. Mount cover above slot X107.

           NOTE: Damage to the programming module caused by penetrating dirt or moisture. When mounting the cover of X107, make sure that the sealing ring is undamaged and is seated correctly.
8. Mount new controller.

☞ The controller has to be replaced by a device of identical type. This is the only way to ensure that the originally configured functions can be used in unchanged form.

---

9. Connect device according to machine circuit diagram

Putting drive controller and machine into ready-for-operation state

1. Restore control voltage.
2. Put machine into ready-for-operation state again according to the machine manufacturer's instructions.
3. Activate safety technology (only with active Safe Motion with Sx-option)

   With single-axis devices, the following message appears on the display of the control panel during the booting process:

   "**Load new Safety?**"

   With double-axis devices, the following message appears on the display of the control panel during the booting process:

   "**.1 Load new Safety?**" for Axis 1 or "**.2 Load new Safety?**" for Axis 2

   Pressing the "Enter" key at the control panel acknowledges the message. The safety technology parameters are now loaded from the control panel to memory of the optional safety technology module.

☞ IndraDrive Mi does not feature a control panel; this is why the parameter image of safety technology has to be activated by executing the command "P-0-3231.0.3, C8300 SMO: Command Activate parameter image", e.g., using IndraDrive Service Tool (IDST).

The error "F8330, SMO: Configuration data record has not been activated" generated during boot-up signals that the active image identifier on the programming module does not comply with the image identifier that was stored on the safety technology hardware. After the command C8300 has been successfully executed, the error must be cleared by the "clear error" command (C0500). The command execution is described in the Functional Description of the firmware, see chapter "Command processing".

4. Check functions of the drive.
5. Check safety technology parameters (only with active Safe Motion with Sx-option)

   Completing the process, it is necessary to check, with activated safety technology, whether the correct safety technology parameters have been loaded for the drive.

   The replacement of the device has to be recorded in the machine logbook. For this purpose, the data of the following safety technology parameters have to be accordingly documented and checked for correctness (these data can be queried via the control panel in the "SMO Info" menu; for IndraDrive Mi, the data have to be read, e.g. by means of the IndraDrive Service Tool (IDST), because IndraDrive Mi does not feature a control panel):

   - P-0-3230, SMO: Password level
   - P-0-3235.0.1, SMO: Active axis identifier
   - P-0-3234.0.1, SMO: Configuration checksum
   - P-0-3234.0.2, SMO: Operating hours at last change of configuration
   - P-0-3234.0.3, SMO: Configuration change counter
   - P-0-3234.0.4, SMO: Parameterization checksum
   - P-0-3234.0.5, SMO: Operating hours at last change of parameterization
   - P-0-3234.0.6, SMO: Parameterization change counter

Possible problems during controller replacement

Display defective or programming module defective

If the programming module / the display is defective, the parameter values saved after initial commissioning must be loaded.

NOTICE **The parameter values saved after initial commissioning are not generally suited for reestablishing the operatability of the drive after a device has been replaced!**

Check actual position values and active target position before setting drive enable!

When firmware and drive parameters are to be transmitted to the replacement controller, the required firmware and a parameter backup of the respective axis must be available.

1. Reestablish the control voltage supply of the controller.
2. Carry out firmware update, see also chapter "Firmware replacement"
3. Via the "IndraWorks" commissioning tool or the control master, load parameter file to controller:
   - "IndraWorks" commissioning tool

     Load parameter values saved after initial commissioning to controller.
   - "IDST" service tool

     Load parameter values saved after initial commissioning to controller.
   - Control master

     Load axis-specific parameter values saved after initial commissioning [according to list parameters "S-0-0192, IDN-list of all backup operation data" and "P-0-0195, IDN list of retain data (replacement of devices)"].

With active Safe Motion, initial or serial commissioning of the drive controller is required after the programming module has been replaced!

The steps necessary to do so are described in the documentation "Integrated safety technology"Safe Motion" (as of MPx-18)" under the keyword "Serial commissioning, copy of an axis".

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"!

10.1.6 Replacing the Cables

⚠ WARNING **Lethal electric shock by live parts with more than 50 V!**

Power connectors of the cables may only be separated or connected if the installation has been de-energized.

☞ Observe the following points before replacing cables:

- Observe the instructions of the machine manufacturer.
- When using ready-made Rexroth cables, only replace defective cables by cables of identical type.
- If you do not use ready-made Rexroth cables, check to ensure that the new cables match the connection diagram of the machine manufacturer; cable cross section and shielding must match, too!

When the mentioned points are observed, it is not required to repeat the acceptance test within the scope of the function "Integrated safety technology".

- Open main switch
- Make sure main switch cannot be switched on again
- Disconnect connections

☞ When replacing cables, cover the open ends of power lines with protective caps if sprinkling with cooling liquid/lubricant or pollution may occur (allowed pollution degree according to EN50178: 2).

- Replace cables

NOTICE **Property damage caused by bad power connectors!**

Only separate or connect clean and dry power connectors.

- Re-establish connections

10.1.7 Replacing components of safety technology

HAT02 - replacing the control module for inductive loads

☞ The HAT02 control module has to be replaced by a device of identical type. This is the only way to ensure that the originally configured functions can be used in unchanged form.

Proceed as follows for the replacement:

1. With HAT02.1-003: Set switches (S1 to S4) of new device in such a way that they are identical with the settings of the defective device.
2. Open main switch.
3. Make sure the main switch cannot be switched on again.
4. Disconnect plug-in connectors.
5. Replace control module.
6. Connect plug-in connectors.
7. Restore control voltage.
8. Put machine into ready-for-operation status again according to machine manufacturer's instructions.
9. Check function of control module and brake.

10. Record replacement of device (including switch positions S1 to S4) in machine logbook.

Replacing the HSZ01 safety zone module

When the safety zone module is replaced, it is not necessary to repeat safety technology commissioning and acceptance test.

☞ The same type of safety zone module (HSZ01) has to be used after the replacement.

10.1.8 Firmware replacement

Brief description

Basic principles

Explanation of terms

The following cases are distinguished for firmware replacement:

- **Release update**

  An old firmware release contained in the device (e.g. MPB20**V04**) is replaced by a new firmware release (e.g. MPB20**V06**).
- **Version upgrade**

  The old firmware version contained in the device is replaced by a new firmware version (example: MPB**18**V10 is replaced by MPB**20**V06).
- **Release downgrade**

  A new firmware release contained in the device (e.g. MPB20**V06**) is replaced by an old firmware release (e.g. MPB20**V04**).
- **Version downgrade**

  The new firmware version contained in the device is replaced by an old firmware version (example: MPB**20**V06 is replaced by MPB**18**V10).

☞ The following chapters regarding the release update, release downgrade, version upgrade und versions downgrade exclusively apply to devices of the IndraDrive Cs type, as well as control sections (CSB02, CSH02, CDB02, CSE02) and IndraDrive Mi (KSM02, KMS02, KMS03). This information does **not** apply to IndraDrive HCQ / HCT, but is described in the separate documentation "Rexroth IndraMotion MTX micro12VRS System Description" (DOK-MTXMIC-SYS*DES*V12-PR01-EN-P, mat. no. R911334369).

Procedure

Firmware for IndraDrive can be replaced using the following hardware and software:

- Computer with Firefox or Internet Explorer web browser or
- Computer with "IndraWorks" software or
- Computer with TFTP client
- IndraDrive Service Tool (IDST)

The "IndraDrive Service Tool (IDST)" allows accessing the drive system, e.g. for remote diagnostics. Besides, authorized users can handle different service cases with IDST, such as replacing drive components, loading parameters or updating/upgrading the drive firmware.

Further information on "IndraDrive Service Tool (IDST)" is described in the separate documentation „Rexroth IndraDrive Service Tools IMST/IDST“ (DOK-IM*MLD-IMSTIDSTV13-RE**-EN-P; mat. no. R911342651).

The "IndraWorks" commissioning software can be ordered from Rexroth.

The scope of supply of "IndraWorks" contains a documentation which describes the operation of the program.

To be noticed

After every firmware replacement (release update/downgrade and version upgrade/downgrade), check the following parameters for validity:

- P-0-2003, Selection of functional packages
- P-0-4089.0.1, Master communication: Protocol

It might possibly be necessary to set them valid during the first run-up after the firmware replacement.

IndraDrive HCQ / IndraDrive HCT

The firmware replacement for "IndraDrive HCQ" / "IndraDrive HCT" is described in the documentation "Rexroth IndraMotion, MTX micro 12VRS, System Description" (DOK-MTXMIC-SYS*DES*V12-PR01-EN-P, material number R911334369).

Preparations and conditions for firmware replacement

Preparing the firmware replacement

Make the following preparations for firmware replacement:

1. Drive controller must be on (24 V supply).
2. Drive controller should **not** be in operating mode (communication phase 4) (cf. P-0-0115).
3. It is recommended to save the backup parameters before replacing the firmware (see Functional Description "Loading, storing and saving parameters").

General notes on how to proceed

Observe the following points when carrying out the firmware replacement:

- For firmware replacement via IndraWorks or IndraDrive Service Tool (IDST), Ethernet communication with the drive has to be possible.
- Do not switch off the 24 V control voltage while replacing the firmware.
- The firmware replacement always has to be carried out completely.

Communication types

Depending on the activated bus system (cf. P-0-4089.0.1), the Engineering communication works in different ways. The settings and conditions have to be made and complied with according to the bus system used. For further information see "chapter TCP/IP communication".

Via the programming module, the active IP settings can be viewed or adjusted, if necessary (see Functional Description "Standard control panel").

After the IP settings have been changed, the device has to be restarted to activate the settings. If several devices have been connected via the master communication bus, make sure that an unequivocal IP address is assigned to each node.

IP configuration in the Easy Menu — See Functional Description "Standard control panel"

IP settings on the computer — See Microsoft help, keyword "LAN connection"

Firmware release update

General information

Before the firmware release update, it is recommended to save the backup parameters of the drive!

☞ If the firmware is replaced for a device with active Safe Motion, this procedure has to be recorded in the machine logbook, together with the axis identifier (P-0-3235.0.1, SMO: Active axis identifier), configuration type data (P-0-3234.0.1, SMO: Configuration checksum) and parameterization type data (P-0-3234.0.4, SMO: Parameterization checksum).

Firmware release update with a computer

☞ If the safety technology options Sx (S3, S4, S5, SB, SD) are used, the system checks whether firmware and parameter set are compatible. This prevents the safety technology from being operated with an incompatible parameter set. Incompatible changes typically do not occur in the case of a release update. In the case of an incompatibility, it is possible to either

- continue with the existing parameterization by reloading the originally available firmware, or
- continue with the new firmware by way of initial commissioning (incl. loading of basic parameters for SMO contained therein)

1. Connect the drive to the computer (recommended: Cat5e Ethernet cable)
2. Load firmware

   There are three possibilities of performing a firmware release update using a computer:

   - Using IndraWorks
   - With a TFTP client
   - Via the supplied IDST web interface.

     This option only applies to firmware updates of MPx18V10 and above. IDST is not available for older versions.

   1. *Firmware download with IndraWorks*

      1.1 Call "IndraWorks".

      1.2 Load project for the corresponding axis or create new project. To do this, address axis via Ethernet.

      1.3 Switch project "online".

      1.4 Select/highlight controller and call "Firmware management" in context menu.

      A new window opens and firmware currently available in drive is displayed.

      1.5 Highlight new firmware (*.ibf file) in the upper part of the dialog and start firmware download via "Download" button.

Firmware download runs automatically and all required firmware components are loaded to drive.

1.6 After firmware download has been completed, close "Firmware management" window.

2. *Firmware download with a TFTP client*

2.1 The firmware update service is made available via a TFTP server. The command for transmitting the firmware is the "put" command. The TFTP client has to transmit the file in the binary format.

☞ It is possible to carry out a firmware release update **without IndraWorks** with any TFTP client supporting this command (e.g., Windows command line program "tftp.exe").

Example (with "Microsoft Windows consoles TFTP client"):

To carry out a firmware release update, only a "put" request is transmitted. Do not use an optional alternative name for the file on the target. The IP address of IndraDrive has to be specified as the target (the standard is 192.168.0.1): `tftp -i 192.168.0.1 put FWA-INDRV_-MPB-17V12-D5.ibf`

The parameter "-i" means that the file is to be transmitted in binary form.

See also Functional Description: "Firmware download via TFTP server"

3. *Firmware download with IDST*

3.1 Enter IP address of IndraDrive in web browser

3.2 Log in as service user at web interface

3.3 In navigation tree on the left side select "Firmware update" dialog in "Service" folder

3.4 Select new firmware by clicking "Search" button, firmware update is started by clicking download button

3. Restart drive

   At the end of the update, IndraWorks and IDST automatically provide the option to restart IndraDrive using the reboot command S-0-1350. As an alternative, IndraDrive can be restarted by resetting the control voltage

4. Put machine into ready-for-operation status again according to machine manufacturer's instructions.
5. Check functions of the drive.
6. For axes with active Safe Motion: Record the firmware replacement in the machine logbook, together with the axis identifier (P-0-3235.0.1), configuration type data (P-0-3234.0.1) and parameterization type data (P-0-3234.0.4).

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*-MPB-**18**V10-D5 replaced by FWA-INDRV*-MPB-**20**V06-D5).

Before the firmware version upgrade is carried out, all parameters have to be saved (e.g., with "IndraWorks"). **After** the firmware has been replaced, the command "C07_1 Load defaults procedure command (factory settings)" is automatically executed. To bring the drive controller to the ready-for-operation state again, the parameter values have to be restored by loading the parameter file saved before.

Saving parameter values

Before the firmware upgrade, all application-specific parameter values have to be saved on a data carrier. The parameter backup can be carried out via:

- **"IndraWorks" commissioning software**

  → Saving parameter values on external data carrier

- or -

- IndraDrive Service Tool (IDST)

  → Saving parameter values on external data carrier

- or -

- **Control master**

  → Saving parameter values on master-side data carrier

Version upgrade with "IndraWorks"

Requirements

The following requirements should have been fulfilled in order that carrying out the firmware version upgrade with "IndraWorks" makes sense:

- Existing Ethernet connection between PC and drive controller
- The current parameterization of the axis was saved.

When upgrading from MPB16VRS to MPB17VRS, for example, the error F8100 is sometimes generated during the drive controller's first run-up. This error can be cleared via the display and will not occur again during the next booting process.

Firmware upgrade with "IndraWorks"

Carrying out the firmware version upgrade with "IndraWorks" requires the following steps:

1. **Load firmware**
   - 1.1 Call "IndraWorks".
   - 1.2 Load project for the corresponding axis or create new project. To do this, address axis via Ethernet.
   - 1.3 Switch project "online".
   - 1.4 Select/highlight controller and call "Firmware management" in context menu.

     A new window opens and firmware currently available in drive is displayed.
   - 1.5 Highlight new firmware (*.ibf file) in the upper part of the dialog and start firmware download via "Download" button.

     Firmware download runs automatically and all required firmware components are loaded to drive.
   - 1.6 After firmware download has been completed, close "Firmware management" window.
   - 1.7 Reboot drive controller

2. **Put drive into ready-for-operation state**

   ⇒ Switch project "online".

   After project has been switched "online", a message sometimes signals that "IndraWorks" could not establish communication to drive via Ethernet interface, since drive-internal settings for Ethernet communication were reset.

   ⇒ In this case, reconfigure communication via "Search for devices" button!

   ⇒ As firmware in drive no longer complies with version stored in project, a corresponding message is displayed. Select desired option in dialog to make drive available in project again and allow reestablishing communication to device.

   ⇒ Manually set functional package and master communication protocol via corresponding parameters.

   ⇒ Activate command "C0750 Load defaults procedure command (factory settings)". All buffered parameters are thereby set to their default values.

☞ For axes with **active Safe Motion**, the parameterization of the old firmware version can be applied. For this purpose, the scaling of the command "C0750 Load defaults procedure command (factory settings)" has to be set to without "Safe Motion (SMO)" in "P-0-4090, Configuration for loading default values". The Safe Motion then remains active even in the case of a version upgrade, and it is not necessary to recommission Safe Motion or repeat the acceptance test.

With active Safety bus communication, the device data sheets have to be updated in the safety control.

3. **Load parameter values**

   ⇒ Load parameter file which was saved!

   ⇒ Switch off drive and restart it so that the parameterization becomes active.

4. **Put machine into ready-for-operation state**

   ⇒ Put machine into ready-for-operation state again according to machine manufacturer's instructions!

   ⇒ Check functions of drive!

Firmware release downgrade

General information

Before the firmware release downgrade, it is recommended to save the backup parameters of the drive!

☞ If the firmware is replaced for a device with active Safe Motion, the saving of the parameters has to be recorded in the machine logbook, together with the axis identifier (P-0-3235.0.1), configuration type data (P-0-3234.0.1) and parameterization type data (P-0-3234.0.4).

If the safety technology options Sx (S3, S4, S5, SB, SD) are used, the system checks whether firmware and parameter set are compatible. This prevents the safety technology from being operated with an incompatible parameter set ("C0213 SMO: Incorrect parameterization" or "C8214 SMO: Incorrect configuration"). Incompatible parameter sets are involved when using Safe Motion functions no longer available in the currently loaded firmware (old firmware release).

In the case of an incompatibility, there are two options:

- Either continue with the existing parameterization by reloading the originally available firmware,
- or perform the complete initial commissioning with the new firmware, including the loading of the basic parameters for SMO.

Observe the following aspects when performing a firmware release downgrade from a firmware release MPx20V12 or higher and using the safety technology options Sx (S3, S4, S5, SB, SD):

After the release downgrade, the initial commissioning of Safe Motion always has to be carried out (including the loading of the default values of the SMO parameters). This is necessary because the size of the Safe Motion image was increased for MPx20V12, and it cannot be read by older firmware releases. It is therefore recommended to save the backup parameters of the drive before carrying out the firmware release downgrade.

If Safe Motion had been commissioned with a firmware release smaller than MPx20V12 and the parameter setting was not changed during its use with a firmware release MPx20V12 or higher, the Safe Motion image was not changed and it is not necessary to carry out the initial commissioning after the downgrade.

Firmware release downgrade with a computer

To carry out the firmware release downgrade, please refer to the description of the firmware release update. (chapter "Firmware release update with a computer" on page 403)

Firmware version downgrade

General information

When firmware in a drive controller is replaced by firmware of an **older version**, this is called firmware version downgrade (e.g., FWA-INDRV*-MPB-**20**V06-D5 replaced by FWA-INDRV*-MPB-**18**V10-D5).

Before the firmware version downgrade is carried out, all parameters have to be saved (e.g., with "IndraWorks"). **After** the firmware has been replaced, the command "C07_1 Load defaults procedure command (factory settings)" is automatically executed. To bring the drive controller to the ready-for-operation state again, the parameter values have to be restored by loading the parameter file saved before.

Saving parameter values

Before the firmware version downgrade, all application-specific parameter values have to be saved on a data carrier. The parameter backup can be carried out via:

- "IndraWorks" commissioning software

  → Saving parameter values on external data carrier

- or -

- IndraDrive Service Tool (IDST)

  → Saving parameter values on external data carrier

- or -

- Control master

  → Saving parameter values on master-side data carrier

Firmware version downgrade with "IndraWorks"

Requirements

The following requirements should have been fulfilled in order that carrying out the firmware version downgrade with "IndraWorks" makes sense:

- Existing Ethernet connection between PC and drive controller
- The current parameterization of the axis was saved.

Firmware version downgrade with "IndraWorks"

Carrying out the firmware version downgrade with "IndraWorks" requires the following steps:

1. Load firmware

   1.1 Call "IndraWorks".

   1.2 Load project for the corresponding axis or create new project. To do this, address axis via Ethernet.

   1.3 Switch project "online".

   1.4 Select/highlight controller and call "Firmware management" in context menu.

   A new window opens and firmware currently available in drive is displayed.

   1.5 Highlight new firmware (*.ibf file) in the upper part of the dialog and start firmware download via "Download" button.

   Firmware download runs automatically and all required firmware components are loaded to drive.

   1.6 After firmware download has been completed, close "Firmware management" window.

   1.7 Reboot drive controller

☞ For axes with **active Safe Motion**, the axis after the booting process detects an incompatible SMO parameter image and generates the error "F8324 SMO: Error in activation". The incompatible SMO parameter image can be deleted with the command "C0720 SMO: Load defaults procedure command" or within the scope of the "C0750 Load defaults procedure command (factory settings)". Afterwards, the Safe Motion has to be recommissioned.

Unless the command "C0720 SMO: Load defaults procedure command" or "C0750 Load defaults procedure command (factory settings)" has been started, the SMO parameter image is still completely available. If the axis is downgraded to the original firmware version, the axis can be operated without recommissioning the Safe Motion.

2. **Put drive into ready-for-operation state**

   ⇒ Switch project "online".

   After project has been switched "online", a message sometimes signals that "IndraWorks" could not establish communication to drive via Ethernet interface, as drive-internal settings for Ethernet communication were reset.

   ⇒ In this case, reconfigure communication via "Search for devices" button!

   ⇒ As firmware in drive no longer complies with version stored in project, a corresponding message is displayed. Select desired option in dialog to make drive available in project again and allow reestablishing communication to device.

   ⇒ Manually set functional package and master communication protocol via corresponding parameters.

   ⇒ Activate command "C0750 Load defaults procedure command (factory settings)". All buffered parameters are thereby set to their default values.

3. **Load parameter values**

   ⇒ Load parameter file which was saved.

   ⇒ Switch off drive and restart it so that the parameterization becomes active.

4. **Put machine into ready-for-operation state**

   ⇒ Put machine into ready-for-operation state again according to machine manufacturer's instructions.

   ⇒ Check functions of drive.

Possible problems during firmware replacement

General information

After an incomplete firmware update, the drive controller possibly is no longer operable.

Firmware replacement is carried out incompletely, if one of the following situations occurs during the sequence of firmware replacement:

- 24 V supply of control section is switched off
- Connection to drive is interrupted (e.g., defective interface cable)
- Update software / computer crashes

If there is no valid firmware available in the control section, the loader is started. The text "LOADER active! IP address: 192.168.0.1" appears on the display in light writing. With the loader, it is possible to replace the firmware of the control section.

☞ Upon successful firmware replacement in the control section, a restart has to be carried out.

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".
2. In menu, call firmware management under **Tools Drive ▸ Firmware management**.

   A new window opens in which firmware file last used is displayed on PC.

3. Select the "Download via Ethernet" tab.
4. Set IP address "192.168.0.1".
5. Highlight desired firmware (*.ibf file) and start firmware download via **Download** button.
6. Firmware download runs automatically and all required firmware components are loaded to drive.
7. After firmware download has been completed, close "Firmware management" window.
8. Restart drive.

10.2 Decommissioning Drive Components

Before the drive or a component is decommissioned, an impact and hazard analysis must be prepared. This analysis must assess how the decommissioning affects the safety of the installation.

Furthermore, the impact and hazard analysis must contain a risk assessment of the process of decommissioning.

On the basis of this impact and hazard analysis, decommission the drive or component (see also IEC 61508-1:2010, 7.17).

11 Declarations of conformity

11.1 IndraDrive Cs (HCS01) and safety zone module (HSZ01)

The "HCS01" drive controller of the "IndraDrive Cs" range complies with the protection goals of the Low-Voltage Directive 2006/95/EC.

We declare conformity with the Machinery Directive for the optional safety technology modules "S4" [SMO (Safe Motion), "S5" [SMO (Safe Motion) and "SB" [SMO (Safe Motion Bus)] as well as the safety zone module "HSZ01".

Rexroth
Bosch Group

EG-Konformitätserklärung - *Original*

Dok.-Nr.: DCTC-30123-006
Datum: 2016-09-07

- ☒ nach Maschinenrichtlinie 2006/42/EG
- ☐ nach Niederspannungsrichtlinie 2014/35/EU
- ☐ nach EMV-Richtlinie 2014/30/EU
- ☐ nach ATEX-Richtlinie 2014/34/EU

Hiermit erklärt der Hersteller, Bosch Rexroth AG, Bürgermeister-Dr.-Nebel-Straße 2, 97816 Lohr am Main/Germany, dass die nachstehenden Produkte

Bezeichnung: Sicherheitstechnik-Optionsmodule Sx [Safe Motion (SMO)] für das elektrische Antriebssystem „IndraDrive Cs“
Typen: HCS01.1E-...-A-...-Sx-... HCS01.1E-...-B-...-Sx-...

Bezeichnung: Sicherheitszonenmodul
Typ: HSZ01.1-D08-D04-NNNN

Ab Herstelldatum: 2016-09-07

in Übereinstimmung mit der oben genannten EU-Richtlinie entwickelt, konstruiert und gefertigt wurden.

Angewandte harmonisierte Normen:

Norm	Titel	Ausgabe
EN ISO 13849-1 *(ISO 13849-1)*	Sicherheit von Maschinen – Sicherheitsbezogene Teile von Steuerungen – Teil 1: Allgemeine Gestaltungsleitsätze	2015 *(2015)*
EN 62061 *(IEC 62061)*	Sicherheit von Maschinen – Funktionale Sicherheit sicherheitsbezogener elektrischer, elektronischer und programmierbarer elektronischer Steuerungssysteme	2005 + Cor.:2010 + A1:2013 + A2:2015 *(2005 + A1:2012 + A2:2015)*
EN 61800-5-2 *(IEC 61800-5-2)*	Elektrische Leistungsantriebssysteme mit einstellbarer Drehzahl – Teil 5-2: Anforderungen an die Sicherheit – Funktionale Sicherheit	2007 *(2007)*
EN 60204-1 *(IEC 60204-1)*	Sicherheit von Maschinen – Elektrische Ausrüstung von Maschinen – Teil 1: Allgemeine Anforderungen	2006 + A1:2009 *(2005 + A1:2008)*

Benannte Stelle, die das EG-Baumusterprüfverfahren nach oben genannter Richtlinie durchgeführt hat:
Name, Anschrift, Kennnummer: TÜV Rheinland Industrie Service GmbH, Alboinstr. 56, 12103 Berlin/Germany, 0035
EG-Baumusterprüfbescheinigungs-Nr.: 01/205/5359.02/16

Nachfolgende Person ist bevollmächtigt, die relevanten technischen Unterlagen zusammenzustellen:
Name, Anschrift: Christian Russo, DC-IA/EDY4, Bürgermeister-Dr.-Nebel-Str. 2, 97816 Lohr am Main / Germany

Weitere Erläuterungen:
Die Optionsmodule Sx und das Sicherheitszonenmodul sind entsprechend SIL 3 nach EN 62061 / EN 61800-5-2 und Kategorie 4 und PL e nach EN ISO 13849-1 ausgeführt.

Lohr am Main, den 2016-09-07 ppa. i.V.
Ort Datum
Joachim Hennig, Werkleitung LoP2
Eberhard Schemm, Entwicklungsbereichsleiter Antriebe

Änderungen im Inhalt der EG-Konformitätserklärung sind vorbehalten. Derzeit gültige Ausgabe auf Anfrage.

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Fig. 11-1: Declaration of conformity for the optional safety technology module"Sx" [SMO (Safe Motion)] and the safety zone module "HSZ01"

Rexroth
Bosch Group

EC declaration of conformity - *original*

(Translation of the original EC Declaration of Conformity)

Doc. No.: DCTC-30123-006
Date: 2016-09-07

- ☒ in accordance with Machinery Directive 2006/42/EC
- ☐ in accordance with Low Voltage Directive 2014/35/EU
- ☐ in accordance with EMC Directive 2014/30/EU
- ☐ in accordance with ATEX Directive 2014/34/EU

The manufacturer, Bosch Rexroth AG, Bürgermeister-Dr.-Nebel-Straße 2, 97816 Lohr am Main/Germany hereby declares that the products below

Name:	Optional safety technology modules Sx ["Safe Motion" (SMO)] for electric drive system "IndraDrive Cs"
Types:	HCS01.1E-...-A-...-Sx-... HCS01.1E-...-B-...-Sx-...
Name:	Safety Zone Module
Type:	HSZ01.1-D08-D04-NNNN
From date of manufacture:	2016-09-07

were developed, designed and manufactured in compliance with the above-mentioned EU directive.

Harmonized standards applied:

Standard	Title	Edition
EN ISO 13849-1 *(ISO 13849-1)*	Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design	2015 *(2015)*
EN 62061 *(IEC 62061)*	Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems	2005 + Cor.:2010 + A1:2013 + A2:2015 *(2005 + A1:2012 + A2:2015)*
EN 61800-5-2 *(IEC 61800-5-2)*	Adjustable speed electrical power drive systems – Part 5-2: Safety requirements - Functional	2007 *(2007)*
EN 60204-1 *(IEC 60204-1)*	Safety of machinery – Electrical equipment of machines – Part 1: General requirements	2006 + A1:2009 *(2005 + A1:2008)*

Notified body that has conducted the EC type-examination procedure in accordance with the above-mentioned directive
Name, address, identification number: TÜV Rheinland Industrie Service GmbH, Alboinstr. 56, 12103 Berlin/Germany, 0035
No. of EC type-examination certificate: 01/205/5359.02/16

The individual below is authorized to compile the relevant technical files:
Name, address: Christian Russo, DC-IA/EDY4, Bürgermeister-Dr.-Nebel-Str. 2, 97816 Lohr am Main / Germany

Further explanations:
The optional safety function modules Sx and the safety zone module fulfill the requirements of SIL 3 according to EN 61800-5-2 / EN 62061 and Category 4 / PL e according to EN ISO 13489-1.

Place/date/signature as indicated in the original declaration.

We reserve the right to make changes to the content of the EC Declaration of Conformity. Current issue on request.

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Fig. 11-2: Translation of the original declaration of conformity for the optional safety technology module "Sx" [SMO (Safe Motion)] and the safety zone module "HSZ01"

The declaration of conformity is also available with signatures in the English language.

If you have access to the Bosch Rexroth Intranet, please download the declaration of conformity here. Otherwise, please contact our sales representative.

11.2 IndraDrive M / IndraDrive C (HCS, HMS) and safety zone module (HSZ01)

The "HCS" / "HMS" controllers of the "IndraDrive M" / "IndraDrive C" ranges comply with the protection goals of the Low-Voltage Directive 2006/95/EC.

We declare conformity with the Machinery Directive for the optional safety technology modules "S4" [SMO (Safe Motion), "S5" [SMO (Safe Motion) and "SB" [SMO (Safe Motion Bus)] as well as the safety zone module "HSZ01".

Rexroth
Bosch Group

EG-Konformitätserklärung - *Original*

Dok.-Nr.: DCTC-30123-005
Datum: 2016-09-07

- ☒ nach Maschinenrichtlinie 2006/42/EG
- ☐ nach Niederspannungsrichtlinie 2014/35/EU
- ☐ nach EMV-Richtlinie 2014/30/EU
- ☐ nach ATEX-Richtlinie 2014/34/EU

Hiermit erklärt der Hersteller, Bosch Rexroth AG, Bürgermeister-Dr.-Nebel-Straße 2, 97816 Lohr am Main/Germany, dass die nachstehenden Produkte

Bezeichnung: Sicherheitstechnik-Optionsmodule Sx [Safe Motion (SMO)]
für die elektrischen Antriebssysteme „IndraDrive C“ und „IndraDrive M“
Typen: CSB02.1B-...-Sx-... CSH02.1B-...-Sx-... CDB02.1B-...-Sx-Sx-...

Bezeichnung: Sicherheitszonenmodul
Typ: HSZ01.1-D08-D04-NNNN

Ab Herstelldatum: 2016-09-07

in Übereinstimmung mit der oben genannten EU-Richtlinie entwickelt, konstruiert und gefertigt wurden.

Angewandte harmonisierte Normen:

Norm	Titel	Ausgabe
EN ISO 13849-1 *(ISO 13849-1)*	Sicherheit von Maschinen – Sicherheitsbezogene Teile von Steuerungen – Teil 1: Allgemeine Gestaltungsleitsätze	2015 *(2015)*
EN 62061 *(IEC 62061)*	Sicherheit von Maschinen – Funktionale Sicherheit sicherheitsbezogener elektrischer, elektronischer und programmierbarer elektronischer Steuerungssysteme	2005 + Cor.:2010 + A1:2013 + A2:2015 *(2005 + A1:2012 + A2:2015)*
EN 61800-5-2 *(IEC 61800-5-2)*	Elektrische Leistungsantriebssysteme mit einstellbarer Drehzahl – Teil 5-2: Anforderungen an die Sicherheit – Funktionale Sicherheit	2007 *(2007)*
EN 60204-1 *(IEC 60204-1)*	Sicherheit von Maschinen – Elektrische Ausrüstung von Maschinen – Teil 1: Allgemeine Anforderungen	2006 + A1:2009 *(2005 + A1:2008)*

Benannte Stelle, die das EG-Baumusterprüfverfahren nach oben genannter Richtlinie durchgeführt hat:
Name, Anschrift, Kennnummer: TÜV Rheinland Industrie Service GmbH, Alboinstr. 56, 12103 Berlin/Germany, 0035
EG-Baumusterprüfbescheinigungs-Nr.: 01/205/5359.03/16

Nachfolgende Person ist bevollmächtigt, die relevanten technischen Unterlagen zusammenstellen:
Name, Anschrift: Christian Russo, DC-IA/EDY4, Bürgermeister-Dr.-Nebel-Str. 2, 97816 Lohr am Main / Germany

Weitere Erläuterungen:
Die Optionsmodule Sx sind entsprechend SIL 3 nach EN 62061 / EN 61800-5-2 und Kategorie 4 und PL e nach EN ISO 13849-1 ausgeführt.

Lohr am Main , den 2016-09-07 ppa. i.V.
Ort Datum Joachim Hennig Eberhard Schemm
Werkleitung LoP2 Entwicklungsbereichsleiter Antriebe

Änderungen im Inhalt der EG-Konformitätserklärung sind vorbehalten. Derzeit gültige Ausgabe auf Anfrage.

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DCTC-30123-005_KOE_N_DE_2016-09-07.docx

Fig. 11-3: Declaration of conformity for the optional safety technology module "Sx" [SMO (Safe Motion)] and the safety zone module "HSZ01"

Declarations of conformity

Rexroth
Bosch Group

EC declaration of conformity

(Translation of the original EC Declaration of Conformity)

Doc. No.: DCTC-30123-005
Date: 2016-09-07

- ☒ in accordance with Machinery Directive 2006/42/EC
- ☐ in accordance with Low Voltage Directive 2014/35/EU
- ☐ in accordance with EMC Directive 2014/30/EU
- ☐ in accordance with ATEX Directive 2014/34/EU

The manufacturer, Bosch Rexroth AG, Bürgermeister-Dr.-Nebel-Straße 2, 97816 Lohr am Main/Germany hereby declares that the products below

Name:	Optional safety technology modules Sx ["Safe Motion" (SMO)] for electric drive systems "IndraDrive C" and "IndraDrive M"		
Types:	CSB02.1B-...-Sx-...	CSH02.1B-...-Sx-...	CDB02.1B-...-Sx-Sx-...

Name:	Safety Zone Module
Type:	HSZ01.1-D08-D04-NNNN
From date of manufacture:	2016-09-07

were developed, designed and manufactured in compliance with the above-mentioned EU directive.

Harmonized standards applied:

Standard	Title	Edition
EN ISO 13849-1 *(ISO 13849-1)*	Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design	2015 *(2015)*
EN 62061 *(IEC 62061)*	Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems	2005 + Cor.:2010 + A1:2013 + A2:2015 *(2005 + A1:2012 + A2:2015)*
EN 61800-5-2 *(IEC 61800-5-2)*	Adjustable speed electrical power drive systems – Part 5-2: Safety requirements - Functional	2007 *(2007)*
EN 60204-1 *(IEC 60204-1)*	Safety of machinery – Electrical equipment of machines – Part 1: General requirements	2006 + A1:2009 *(2005 + A1:2008)*

Notified body that has conducted the EC type-examination procedure in accordance with the above-mentioned directive
Name, address, identification number: TÜV Rheinland Industrie Service GmbH, Alboinstr. 56, 12103 Berlin/Germany, 0035
No. of EC type-examination certificate: 01/205/5359.03/16

The individual below is authorized to compile the relevant technical files:
Name, address: Christian Russo, DC-IA/EDY4, Bürgermeister-Dr.-Nebel-Str. 2, 97816 Lohr am Main / Germany

Further explanations:
The optional safety function modules Sx and the safety zone module fulfill the requirements of SIL 3 according to EN 61800-5-2 / EN 62061 and Category 4 / PL e according to EN ISO 13489-1.

Place/date/signature as indicated in the original declaration.

We reserve the right to make changes to the content of the EC Declaration of Conformity. Current issue on request.

DCTC-30123-005_KOE_N_EN_2016-09-07.docx

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Fig. 11-4: Translation of the original declaration of conformity for the optional safety technology module "Sx" [SMO (Safe Motion)] and the safety zone module "HSZ01"

The declaration of conformity is also available with signatures in the English language.

If you have access to the Bosch Rexroth Intranet, please download the declaration of conformity here. Otherwise, please contact our sales representative.

11.3 IndraDrive Mi

11.3.1 KSM02, KMS02, KCU02

The distributed servo drive "KSM02" and the distributed drive controller "KMS02" of the "IndraDrive Mi" range comply with the protection goals of the Low-Voltage Directive 2006/95/EC.

We declare conformity with the Machinery Directive for the optional safety technology module "S3" [Safe Motion (without SBC)] and"SD" [Safe Motion (with SBC)].

Declarations of conformity

Rexroth
Bosch Group

EG-Konformitätserklärung - *Original*

Dok.-Nr.: DCTC-30129-005
Datum: 2016-07-22

☒ nach Maschinenrichtlinie 2006/42/EG
☐ nach Niederspannungsrichtlinie 2014/35/EU
☐ nach EMV-Richtlinie 2014/30/EU
☐ nach ATEX-Richtlinie 2014/34/EU

Hiermit erklärt der Hersteller, Bosch Rexroth AG, Bürgermeister-Dr.-Nebel-Straße 2, 97816 Lohr am Main/Germany, dass die nachstehenden Produkte

Bezeichnung:	Sicherheitstechnik-Optionsmodule S3 und SD [Safe Motion (mit SBC)] für das elektrische Antriebssystem „IndraDrive Mi“		
Typen:	KSM02.1B-...-S3-... KMS02.1B-...-S3-...	KSM02.1B-...-SD-... KMS02.1B-...-SD-...	KCU02.1N-ET-ET*-025...
Ab Herstelldatum:	2016-07-22		

in Übereinstimmung mit der oben genannten EU-Richtlinie entwickelt, konstruiert und gefertigt wurden.

Angewandte harmonisierte Normen:

Norm	Titel	Ausgabe
EN ISO 13849-1 *(ISO 13849-1)*	Sicherheit von Maschinen – Sicherheitsbezogene Teile von Steuerungen – Teil 1: Allgemeine Gestaltungsleitsätze	2015 *(2015)*
EN 62061 *(IEC 62061)*	Sicherheit von Maschinen – Funktionale Sicherheit sicherheitsbezogener elektrischer, elektronischer und programmierbarer elektronischer Steuerungssysteme	2005 + Cor.:2010 + A1:2013 + A2:2015 *(2005 + A1:2012 + A2:2015)*
EN 61800-5-2 *(IEC 61800-5-2)*	Elektrische Leistungsantriebssysteme mit einstellbarer Drehzahl – Teil 5-2: Anforderungen an die Sicherheit – Funktionale Sicherheit	2007 *(2007)*
EN 60204-1 *(IEC 60204-1)*	Sicherheit von Maschinen – Elektrische Ausrüstung von Maschinen – Teil 1: Allgemeine Anforderungen	2006 + A1:2009 *(2005 + A1:2008)*

Benannte Stelle, die das EG-Baumusterprüfverfahren nach oben genannter Richtlinie durchgeführt hat:
Name, Anschrift, Kennnummer: TÜV Rheinland Industrie Service GmbH, Alboinstr. 56, 12103 Berlin/Germany, 0035
EG-Baumusterprüfbescheinigungs-Nr.: 01/205/5367.01/16

Nachfolgende Person ist bevollmächtigt, die relevanten technischen Unterlagen zusammenstellen:
Name, Anschrift: Christian Russo, DC-IA/EDY4, Bürgermeister-Dr.-Nebel-Str. 2, 97816 Lohr am Main/Germany

Weitere Erläuterungen:
Die Optionsmodule S3 und SD sind entsprechend SIL 3 nach EN 62061 / EN 61800-5-2 und Kategorie 4 und PL e nach EN ISO 13849-1 ausgeführt.

Lohr am Main , den 2016-07-22 ppa. i.V.
Ort Datum

Joachim Hennig
Werkleitung LoP2

Eberhard Schemm
Entwicklungsbereichsleiter Antriebe

Änderungen im Inhalt der EG-Konformitätserklärung sind vorbehalten. Derzeit gültige Ausgabe auf Anfrage.

DCTC-30129-005_KOE_N_DE_2016-07-22.docx

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Fig. 11-5: Declaration of conformity for the optional safety technology module "Sx" [SMO (Safe Motion)]

Rexroth
Bosch Group

EC declaration of conformity

(Translation of the original EC Declaration of Conformity)

Doc. No.: DCTC-30129-005
Date: 2016-07-22

- ☒ in accordance with Machinery Directive 2006/42/EC
- ☐ in accordance with Low Voltage Directive 2014/35/EU
- ☐ in accordance with EMC Directive 2014/30/EU
- ☐ in accordance with ATEX Directive 2014/34/EU

The manufacturer, Bosch Rexroth AG, Bürgermeister-Dr.-Nebel-Straße 2, 97816 Lohr am Main/Germany hereby declares that the products below

Name:	Optional safety technology modules S3 and SD ["Safe Motion" (with SBC)] for electric drive system "IndraDrive Mi"		
Types:	KSM02.1B-...-S3-... KMS02.1B-...-S3-...	KSM02.1B-...-SD-... KMS02.1B-...-SD-...	KCU02.1N-ET-ET*-025...
From date of manufacture:	2016-07-22		

were developed, designed and manufactured in compliance with the above-mentioned EU directive.

Harmonized standards applied:

Standard	Title	Edition
EN ISO 13849-1 *(ISO 13849-1)*	Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design	2015 *(2015)*
EN 62061 *(IEC 62061)*	Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems	2005 + Cor.:2010 + A1:2013 + A2:2015 *(2005 + A1:2012 + A2:2015)*
EN 61800-5-2 *(IEC 61800-5-2)*	Adjustable speed electrical power drive systems – Part 5-2: Safety requirements - Functional	2007 *(2007)*
EN 60204-1 *(IEC 60204-1)*	Safety of machinery – Electrical equipment of machines – Part 1: General requirements	2006 + A1:2009 *(2005 + A1:2008)*

Notified body that has conducted the EC type-examination procedure in accordance with the above-mentioned directive
Name, address, identification number: TÜV Rheinland Industrie Service GmbH, Alboinstr. 56, 12103 Berlin/Germany, 0035
No. of EC type-examination certificate: 01/205/5367.01/16

The individual below is authorized to compile the relevant technical files:
Name, address: Christian Russo, DC-IA/EDY4, Bürgermeister-Dr.-Nebel-Str. 2, 97816 Lohr am Main/Germany

Further explanations:
The optional safety function modules S3 and SD fulfill the requirements of SIL 3 according to EN 61800-5-2 / EN 62061 and Category 4 / PL e according to EN ISO 13489-1.

Place/date/signature as indicated in the original declaration.

DCTC-30129-005_KOE_N_EN_2016-07-22.docx

We reserve the right to make changes to the content of the EC Declaration of Conformity. Current issue on request.

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Fig. 11-6: *Translation of the original declaration of conformity for the optional safety technology module "Sx" [SMO (Safe Motion)]*

The declaration of conformity is also available with signatures in the English language.

If you have access to the Bosch Rexroth Intranet, please download the declaration of conformity here. Otherwise, please contact our sales representative.

11.3.2 KMS03, KMV03

The near motor servo drive "KMS03" and the supply unit "KMV03" of the "IndraDrive Mi" drive family comply with the protection goals of the Low Voltage Directive 2006/95/EC.

We declare conformity with the Machinery Directive for the optional safety technology module "SD" [Safe Motion (with SBC)].

Rexroth
Bosch Group

EG-Konformitätserklärung - *Original*

Dok.-Nr.: DCTC-30129-004
Datum: 2016-02-17

☒ nach Maschinenrichtlinie 2006/42/EG
☐ nach Niederspannungsrichtlinie 2014/35/EU
☐ nach EMV-Richtlinie 2014/30/EU
☐ nach ATEX-Richtlinie 2014/34/EU

Hiermit erklärt der Hersteller, Bosch Rexroth AG, Bürgermeister-Dr.-Nebel-Straße 2, 97816 Lohr am Main / Germany,

dass die nachstehenden Produkte

Bezeichnung: Sicherheitstechnik-Optionsmodul SD [Safe Motion (mit SBC)]
für das elektrische Antriebssystem „IndraDrive Mi“

Typ: KMS03.1*...-SD-...
KMV03.1*...

Ab Herstelldatum: 2016-02-17

in Übereinstimmung mit der oben genannten EU-Richtlinie entwickelt, konstruiert und gefertigt wurden.

Angewandte harmonisierte Normen:

Norm	Titel	Ausgabe
EN ISO 13849-1 *(ISO 13849-1)*	Sicherheit von Maschinen – Sicherheitsbezogene Teile von Steuerungen – Teil 1: Allgemeine Gestaltungsleitsätze	2015 *(2015)*
EN 62061 *(IEC 62061)*	Sicherheit von Maschinen – Funktionale Sicherheit sicherheitsbezogener elektrischer, elektronischer und progammierbarer elektronischer Steuerungssysteme	2005 + Cor.:2010 + A1:2013 + A2:2015 *(2005 + A1:2013 + A2:2015)*
EN 61800-5-2 *(IEC 61800-5-2)*	Elektrische Leistungsantriebssysteme mit einstellbarer Drehzahl – Teil 5-2: Anforderungen an die Sicherheit – Funktionale Sicherheit	2007 *(2007)*
EN 60204-1 *(IEC 60204-1)*	Sicherheit von Maschinen – Elektrische Ausrüstung von Maschinen – Teil 1: Allgemeine Anforderungen	2006 + A1:2009 *(2005 + A1:2008)*

Benannte Stelle, die das EG-Baumusterprüfverfahren nach oben genannter Richtlinie durchgeführt hat:
Name, Anschrift: TÜV Rheinland Industrie Service GmbH, Alboinstr. 56, 12103 Berlin / Germany
Kennnummer: 0035
EG-Baumusterprüfbescheinigungs-Nr.: 01/205/5502.00/16

Nachfolgende Person ist bevollmächtigt, die relevanten technischen Unterlagen zusammenstellen:
Name, Anschrift: Christian Russo, DC-IA/EDY4, Bürgermeister-Dr.-Nebel-Str. 2, 97816 Lohr am Main / Germany

Weitere Erläuterungen:
Das Optionsmodul SD ist entsprechend SIL 3 nach EN 62061 / EN 61800-5-2 und Kategorie 4 und PL e nach EN ISO 13849-1 ausgeführt.

Lohr am Main, den 2016-02-17 ppa. i.V.
Ort Datum
Joachim Hennig
Werkleitung LoP2
Eberhard Schemm
Entwicklungsbereichsleiter Antriebe

Änderungen im Inhalt der EG-Konformitätserklärung sind vorbehalten. Derzeit gültige Ausgabe auf Anfrage.

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Fig. 11-7: Declaration of Conformity for the optional safety technology module "SD" [Safe Motion (with SBC)]

Rexroth
Bosch Group

EC declaration of conformity

(Translation of the original EC Declaration of Conformity)

Doc. No.: DCTC-30129-004
Date: 2016-02-17

- ☒ in accordance with Machinery Directive 2006/42/EC
- ☐ in accordance with Low Voltage Directive 2014/35/EU
- ☐ in accordance with EMC Directive 2014/30/EU
- ☐ in accordance with ATEX Directive 2014/34/EU

The manufacturer, Bosch Rexroth AG, Bürgermeister-Dr.-Nebel-Straße 2, 97816 Lohr am Main / Germany

hereby declares that the products below

Name: Optional safety technology module SD ["Safe Motion" (with SBC)]
for electric drive system "IndraDrive Mi"

Type: KMS03.1*...-SD-...
KMV03.1*...

From date of manufacture: 2016-02-17

were developed, designed and manufactured in compliance with the above-mentioned EU directive.

Harmonized standards applied:

Standard	Title	Edition
EN ISO 13849-1 *(ISO 13849-1)*	Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design	2015 *(2015)*
EN 62061 *(IEC 62061)*	Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems	2005 + Cor.:2010 + A1:2013 + A2:2015 *(2005 + A1:2013 + A2:2015)*
EN 61800-5-2 *(IEC 61800-5-2)*	Adjustable speed electrical power drive systems – Part 5-2: Safety requirements - Functional	2007 *(2007)*
EN 60204-1 *(IEC 60204-1)*	Safety of machinery – Electrical equipment of machines – Part 1: General requirements	2006 + A1:2009 *(2005 + A1:2008)*

Notified body that has conducted the EC type-examination procedure in accordance with the above-mentioned directive
Name, address, identification number: TÜV Rheinland Industrie Service GmbH, Alboinstr. 56, 12103 Berlin / Germany, 0035
No. of EC type-examination certificate: 01/205/5502.00/16

The individual below is authorized to compile the relevant technical files:
Name, address: Christian Russo, DC-IA/EDY4, Bürgermeister-Dr.-Nebel-Str. 2, 97816 Lohr am Main / Germany

Further explanations:
The optional safety function module SD fulfils the requirements of SIL 3 according to EN 61800-5-2 / EN 62061 / IEC 61508 and Category 4 / PL e according to EN ISO 13489-1.

Place/date/signature as indicated in the original declaration.

DCTC-30129-004_KOE_N_EN_2016-02-17.docx

We reserve the right to make changes to the content of the EC Declaration of Conformity. Current issue on request.

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Fig. 11-8: Translation of the original Declaration of Conformity for the optional safety technology module "SD" [Safe Motion (with SBC)]

The declaration of conformity is also available with signatures in the English language.

If you have access to the Bosch Rexroth Intranet, please download the declaration of conformity here. Otherwise, please contact our sales representative.

11.4 IndraDrive ML (HMU05), safety zone module (HSZ01) and optional cards (HPC01.1)

The drive controller "HMU05" of the "IndraDrive ML" drive family and the power line connection module "HNA05" comply with the protection goals of the Low Voltage Directive 2006/95/EC.

Optional safety technology module "S4"

We declare conformity with the Machinery Directive for the following components:

Rexroth
Bosch Group

EG-Konformitätserklärung - *Original*

Dok.-Nr.: DCTC-30133-002
Datum: 2015-06-30

- ☒ nach Maschinenrichtlinie 2006/42/EG
- ☐ nach Niederspannungsrichtlinie 2006/95/EG
- ☐ nach EMV-Richtlinie 2004/108/EG
- ☐ nach Druckgeräte-Richtlinie 97/23/EG
- ☐ nach ATEX-Richtlinie 94/9/EG
- ☐ nach RoHS-Richtlinie 2011/65/EU

Hiermit erklärt der Hersteller Bosch Rexroth AG, Bürgermeister-Dr.-Nebel-Straße 2, 97816 Lohr am Main / Germany, dass die nachstehenden Produkte

Bezeichnung: Sicherheitstechnik-Optionsmodul S4 für IndraDrive CL/ML mit den Sicherheitsfunktionen „Safe Motion (SMO)“
Typen: CSB02.5*...-S4-...; CSH02.5*...-S4...; HMU05.1*...-Pxx; HMU05.1*...-N1N

Bezeichnung: Sicherheitszonenmodul
Typ: HSZ01.1...

Bezeichnung: Optionskarten
Typen: HPC01.1-MN02; HPC01.1-P001

Ab Herstelldatum: 2015-06-30

in Übereinstimmung mit der oben genannten EU-Richtlinie entwickelt, konstruiert und gefertigt wurden.

Angewandte harmonisierte Normen:

Norm	Titel	Ausgabe
EN ISO 13849-1 *(ISO 13849-1)*	Sicherheit von Maschinen – Sicherheitsbezogene Teile von Steuerungen – Teil 1: Allgemeine Gestaltungsleitsätze	2008+AC:2009 *(2006+AC:2009)*
EN 62061 *(IEC 62061)*	Sicherheit von Maschinen – Funktionale Sicherheit sicherheitsbezogener elektrischer, elektronischer und programmierbarer elektronischer Steuerungssysteme	2005 + A1: 2013 *(2005 + A1:2013)*
EN 61800-5-2 *(IEC 61800-5-2)*	Elektrische Leistungsantriebssysteme mit einstellbarer Drehzahl – Teil 5-2: Anforderungen an die Sicherheit – Funktionale Sicherheit	2007 *(2007)*
EN 60204-1 *(IEC 60204-1)*	Sicherheit von Maschinen – Elektrische Ausrüstung von Maschinen – Teil 1: Allgemeine Anforderungen	2006 + A1:2009 *(2005 + A1:2008)*

Benannte Stelle, die das EG-Baumusterprüfverfahren nach oben genannter Richtlinie durchgeführt hat:
Name, Anschrift: TÜV Rheinland Industrie Service GmbH, Alboinstr. 56, 12103 Berlin / Germany
Kennnummer: 0035
EG-Baumusterprüfbescheinigungs-Nr.: 01/205/5428.00/14 und 01/205/5428.01/15

Nachfolgende Person ist bevollmächtigt, die relevanten technischen Unterlagen zusammenzustellen:
Name, Anschrift: Christian Russo, DC-IA/EDY4, Bürgermeister-Dr.-Nebel-Str. 2, 97816 Lohr am Main / Germany

Weitere Erläuterungen:
Das Optionsmodul S4 ist entsprechend SIL 3 nach EN 62061 / EN 61800-5-2 und Kategorie 4 und PL e nach EN ISO 13849-1 ausgeführt.

Lohr am Main (Ort), den 2015-06-30 (Datum)

ppa. Joachim Hennig, Werkleitung LoP2

i.V. Eberhard Schemm, Entwicklungsbereichsleiter Antriebe

Änderungen im Inhalt der EG-Konformitätserklärung sind vorbehalten. Derzeit gültige Ausgabe auf Anfrage.

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Fig. 11-9: Declaration of conformity for the optional safety technology module "S4" [SMO (Safe Motion)], the universal inverter HMU05, the safety *zone module "HSZ01" and the optional cards HPC01.1-MN02/HPC01.1-P001*

Rexroth
Bosch Group

EC declaration of conformity

(Translation of the original Declaration of Conformity)

Doc. No.: DCTC-30133-002
Date: 2015-06-30

- ☒ in accordance with Machinery Directive 2006/42/EC
- ☐ in accordance with Low Voltage Directive 2006/95/EC
- ☐ in accordance with EMC Directive 2004/108/EC
- ☐ in accordance with Pressure Equipment Directive 97/23/EC
- ☐ in accordance with ATEX Directive 94/9/EC
- ☐ in accordance with RoHS Directive 2011/65/EC

The manufacturer Bosch Rexroth AG, Bürgermeister-Dr.-Nebel-Straße 2, 97816 Lohr am Main / Germany, hereby declares that the products below

Name: Optional safety technology module S4 for IndraDrive CL/ML with the safety functions "Safe Motion (SMO)"
Types: CSB02.5*...-S4-...; CSH02.5*...-S4...; HMU05.1*...-Pxx; HMU05.1*...-N1N

Name: Safety zone module
Type: HSZ01.1...

Name: Optional PCBs
Types: HPC01.1-MN02; HPC01.1-P001

From the date of manufacture: 2015-06-30

were developed, designed and manufactured in compliance with the above-mentioned EU directive.

Harmonized standards applied:

Standard	Title	Edition
EN ISO 13849-1 *(ISO 13849-1)*	Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design	2008+AC:2009 *(2006+AC:2009)*
EN 62061 *(IEC 62061)*	Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems	2005 + A1: 2013 *(2005 + A1:2013)*
EN 61800-5-2 *(IEC 61800-5-2)*	Adjustable speed electrical power drive systems – Part 5-2: Safety requirements - Functional	2007 *(2007)*
EN 60204-1 *(IEC 60204-1)*	Safety of machinery – Electrical equipment of machines – Part 1: General requirements	2006 + A1:2009 *(2005 + A1:2008)*

Notified body that has conducted the EC type-examination procedure in accordance with the above-mentioned directive
Name, address: TÜV Rheinland Industrie Service GmbH, Alboinstr. 56, 12103 Berlin / Germany
Identification number: 0035
No. of EC type-examination certificate: 01/205/5428.00/14 and 01/205/5428.01/15

The individual below is authorized to compile the relevant technical files:
Name, address: Christian Russo, DC-IA/EDY4, Bürgermeister-Dr.-Nebel-Str. 2, 97816 Lohr am Main / Germany

Further explanations:
The optional module S4 has been implemented in accordance with SIL 3 according to EN 62061 / EN 61800-5-2 and Category 4 and PL e according to EN ISO 13489-1.

Place/date/signature as indicated in the original declaration

We reserve the right to make changes to the content of the EC Declaration of Conformity. Current issue on request.

DCTC-30133-002_KOE_N_EN_20145-06-30.docx

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Fig. 11-10: Translation of the original Declaration of conformity for the optional safety technology module "S4" [SMO (Safe Motion)], the universal inverter HMU05, the safety zone module "HSZ01" and the optional cards HPC01.1-MN02/HPC01.1-P001

The declaration of conformity is also available with signatures in the English language.

If you have access to the Bosch Rexroth Intranet, please download the declaration of conformity here. Otherwise, please contact our sales representative.

Optional safety technology modules "S5" and "SB"

The type examination had not been completed before the documentation was published. After the type examination has been successfully completed, Bosch Rexroth will declare conformity with the Machinery Directive for the optional safety technology module "S5" [SMO (Safe Motion) and "SB" [SMO (Safe Motion Bus)] in the "HMU05" drive controller. For the status quo, please contact our service department.

11.5 HAT02 control module

We declare conformity with the Machinery Directive for the "HAT02" control module.

Rexroth
Bosch Group

EG-Konformitätserklärung - *Original*

Dok.-Nr.: DCTC-30123-004
Datum: 2015-04-01

- ☒ nach Maschinenrichtlinie 2006/42/EG
- ☐ nach Niederspannungsrichtlinie 2006/95/EG
- ☐ nach EMV-Richtlinie 2004/108/EG
- ☐ nach Druckgeräte-Richtlinie 97/23/EG
- ☐ nach ATEX-Richtlinie 94/9/EG
- ☐ nach RoHS-Richtlinie 2011/65/EU

Hiermit erklärt der Hersteller,
Bosch Rexroth AG, Bürgermeister-Dr.-Nebel-Straße 2, 97816 Lohr am Main / Germany,

dass die nachstehenden Produkte

Bezeichnung: Ansteuereinheit HAT02.1 als Zubehör für die elektrischen Antriebssysteme „IndraDrive“

Typen: HAT02.1-002
HAT02.1-003

Ab Herstelldatum: 2015-04-01

in Übereinstimmung mit der oben genannten EU-Richtlinie entwickelt, konstruiert und gefertigt wurden.

Angewandte harmonisierte Normen:

Norm	Titel	Ausgabe
EN ISO 13849-1 *(ISO 13849-1)*	Sicherheit von Maschinen – Sicherheitsbezogene Teile von Steuerungen – Teil 1: Allgemeine Gestaltungsleitsätze	2008+AC:2009 *(2006+AC:2009)*
EN 62061 *(IEC 62061)*	Sicherheit von Maschinen – Funktionale Sicherheit sicherheitsbezogener elektrischer, elektronischer und programmierbarer elektronischer Steuerungssysteme	2005 + A1: 2013 *(2005 + A1:2012)*
EN 61800-5-2 *(IEC 61800-5-2)*	Elektrische Leistungsantriebssysteme mit einstellbarer Drehzahl – Teil 5-2: Anforderungen an die Sicherheit – Funktionale Sicherheit	2007 *(2007)*
EN 60204-1 *(IEC 60204-1)*	Sicherheit von Maschinen – Elektrische Ausrüstung von Maschinen – Teil 1: Allgemeine Anforderungen	2006 + A1:2009 *(2005 + A1:2008)*

Benannte Stelle, die das EG-Baumusterprüfverfahren nach oben genannter Richtlinie durchgeführt hat:
Name, Anschrift: TÜV Rheinland Industrie Service GmbH, Alboinstr. 56, 12103 Berlin / Germany
Kennnummer: 0035
EG-Baumusterprüfbescheinigungs-Nr.: 01/205/5436.00/15

Nachfolgende Person ist bevollmächtigt, die relevanten technischen Unterlagen zusammenzustellen:
Name, Anschrift: Christian Russo, DC-IA/EDY4, Bürgermeister-Dr.-Nebel-Str. 2, 97816 Lohr am Main / Germany

Weitere Erläuterungen:
Die Ansteuereinheit ist entsprechend SIL 3 nach EN 62061 / EN 61800-5-2 und Kategorie 4 und PL e nach EN ISO 13849-1 ausgeführt.

Lohr am Main, den 2015-04-01 ppa. i.V.
Ort Datum
Joachim Hennig
Werkleitung LoP2
Eberhard Schemm
Entwicklungsbereichsleiter Antriebe

Änderungen im Inhalt der EG-Konformitätserklärung sind vorbehalten. Derzeit gültige Ausgabe auf Anfrage.

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DCTC-30123-004_KOE_N_DE_2015-04-01.docx

Fig. 11-11: Declaration of conformity for the "HAT02" control module

Declarations of conformity

Rexroth
Bosch Group

EC declaration of conformity

(Translation of the original EC Declaration of Conformity)

Doc. No.: DCTC-30123-004
Date: 2015-04-01

- ☒ in accordance with Machinery Directive 2006/42/EC
- ☐ in accordance with Low Voltage Directive 2006/95/EC
- ☐ in accordance with EMC Directive 2004/108/EC
- ☐ in accordance with Pressure Equipment Directive 97/23/EC
- ☐ in accordance with ATEX Directive 94/9/EC
- ☐ in accordance with RoHS Directive 2011/65/EC

The manufacturer,
Bosch Rexroth AG
Bürgermeister-Dr.-Nebel-Straße 2
97816 Lohr am Main / Germany

hereby declares that the products below

Name: Control module HAT02.1 as an accessory
for the electric drive systems “IndraDrive”

Types: HAT02.1-002
HAT02.1-003

From the date of manufacture: 2015-04-01

were developed, designed and manufactured in compliance with the above-mentioned EU directive.

Harmonized Standards applied:

Standard	Title	Edition
EN ISO 13849-1 *(ISO 13849-1)*	Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design	2008+AC:2009 *(2006+AC:2009)*
EN 62061 *(IEC 62061)*	Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems	2005 + A1: 2013 *(2005 + A1:2012)*
EN 61800-5-2 *(IEC 61800-5-2)*	Adjustable speed electrical power drive systems – Part 5-2: Safety requirements - Functional	2007 *(2007)*
EN 60204-1 *(IEC 60204-1)*	Safety of machinery – Electrical equipment of machines – Part 1: General requirements	2006 + A1:2009 *(2005 + A1:2008)*

Notified body that has conducted the EC type-examination procedure in accordance with the above-mentioned directive
Name, address: TÜV Rheinland Industrie Service GmbH, Alboinstr. 56, 12103 Berlin / Germany
Identification number: 0035
No. of EC type-examination certificate: 01/205/5436.00/15

The individual below is authorized to compile the relevant technical files:
Name, address: Christian Russo, DC-IA/EDY4, Bürgermeister-Dr.-Nebel-Str. 2, 97816 Lohr am Main / Germany

Further explanations:
The control module has been implemented in accordance with SIL 3 according to EN 62061 / EN 61800-5-2 and Category 4 and PL e according to EN ISO 13489-1.

Place/date/signature as indicated in the original declaration.

We reserve the right to make changes to the content of the EC Declaration of Conformity. Current issue on request.

Fig. 11-12: Translation of the original declaration of conformity for the "HAT02" control module

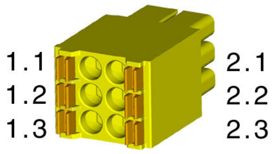
The declaration of conformity is also available with signatures in the English language.

If you have access to the Bosch Rexroth Intranet, please download the declaration of conformity here. Otherwise, please contact our sales representative.

12 Project planning

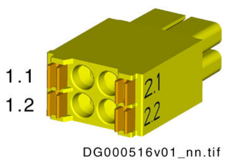
12.1 Interfaces of the optional modules

12.1.1 X41, Safety Technology Safe Motion (option S4, S5)

View	Connec-tion	Signal name	Function
	1.1	SI_Out_Ch2	Safe output channel 2
	1.2	0V	Power supply of inputs/outputs (U_{ext})
	1.3	SI_Out_Ch1	Safe output channel 1
	2.1	SI_In_Ch2	Input 2
	2.2	24V	Power supply of inputs/outputs (U_{ext})
	2.3	SI_In_Ch1	Input 1
Spring terminal (connector)	**Unit**	**Min.**	**max.**
Connection cable Stranded wire	mm²	1	1.5
	AWG	16	16
Stripped length	mm	-	10
Polarity reversal protection for power supply	-	Present	
Overvoltage protection	-	Present	

Tab. 12-1: X41, Safe Motion safety technology

12.1.2 X48, SBC safety technology (option S4, S5, SB)

View	Connec-tion	Signal name	Function
	1.1	Ext_SI_bSBC_Ch2	Channel 2 brake control output
	1.2	Ext_Diag_I_Brake	Channel 1 and channel 2 diagnostic input
	2.1	Ext_SI_bSBC_Ch1	Channel 1 brake control output
	2.2	-	n. c.

Tab. 12-2: Pin assignment

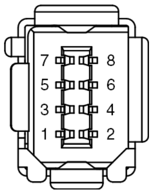
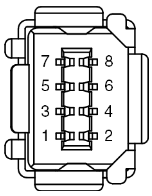
Mechanical data

Spring terminal (connector)	Unit	min.	max.
Connection cable Stranded wire	mm²	0.2	1.5
	AWG	24	16
Stripped length	mm	-	10

Tab. 12-3: Mechanical data

- The power is supplied via X33.
- "SBC safety technology" additionally requires an external HAT02 control module.

12.1.3 X42, X43, Safe Motion safety technology (communication; S4, S5 options)

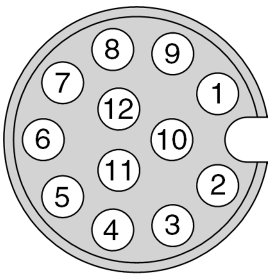
View	Identification	Function
X42:  X43: 	X42 X43	Connection points for connecting the HSZ01 [1)] safety zone module and the safety zone nodes: X42: Input X43: Output
Connection cable	• Maximum total length of **all** cables of a safety zone: **2500 m** • Maximum length of **one** cable between two connection points: **100 m** • Number of safety zone nodes (without HSZ01): – Maximum: 35 – Minimum: 1 • Ready-made cables that can be ordered: – **RKB0061** Short cables to connect devices arranged side by side in the control cabinet. Available lengths: 0.25 m; 0.35 m; 0.55 m Minimum bending radius with permanent routing: 4xD (= 4x6.3 mm = 25.2 mm) Minimum bending radius with flexible routing: 8xD (= 8x6.3 mm = 50.4 mm) Order code for a 0.55 m long cable: RKB0061/00,55 – **RKB0062** Long cables to connect remote communication nodes, also outside of the control cabinet. Available lengths: 1 m, 2 m, 3 m, … 15 m, 20 m, 30 m, 50 m, 75 m, 100 m Minimum bending radius with permanent routing: 4xD (= 4x6.3 mm = 25.2 mm) Minimum bending radius with flexible routing: 8xD (= 8x6.3 mm = 50.4 mm) Order code for a 5 m long cable: RKB0062/005,0 The cables RKB0061 and RKB0062 replace the previously used cables RKB0051 and RKB0052.	

1) See Project Planning Manual "IndraDrive Additional Components and Accessories" (R911306140).

Tab. 12-4: X42, X43

12.1.4 X141, safety technology "Safe Motion" (Option S3, SD)

> ☞ Devices with "Safe Motion" safety technology must not be operated in a "Safe Torque Off" safety zone.
>
> For any "mixed operation", drives with "Safe Motion" safety technology in the drive train must be connected behind the safety zones. The safety zone plug RBS0023 must not be used.

View	Connection	Signal name	Function
 DA000400v01_nn.FH11 Female connector M12 (12-pin, D-coded)	1	SI_In_Ch1	Input 1
	2	SI_In_Ch2	Input 2
	3	Zone_Br	X141.3 has to be accordingly controlled for the desired function: • "Release brake": Short circuit to X141.9 (input voltage: 24 V ±20%)
	4	+24V	Power supply of the inputs and outputs
	5	SI_In_Ch1_Zone	Input 1 from preceding axis
	6	0V_Zone	0 V from preceding axis
	7	SI_In_Ch2_Zone	Input 2 from preceding axis
	8	SI_Out_Ch1	Safe output channel 1
	9	24V_Br	Internal interface only; 24 V for "release brake" function
	10	0V	Power supply of the inputs and outputs
	11	GND	GND for "zone detection" function
	12	SI_Out_Ch2	Safe output channel 2
Ready-made connection cable	RKB0033 Can be used for processing of the inputs and controlling of the outputs. Can be used for "releasing the brake".		

Tab. 12-5: Function, pin assignment, properties

12.2 Motor temperature monitoring and motor holding brake

This chapter contains the interfaces of the relevant device relevant for motor temperature monitoring and motor holding brake:

- IndraDrive Cs (HCS01): X6
- IndraDrive Mi (KMS02): X156
- IndraDrive Mi (KMS03): XG3

12.2.1 X6, Motor Temperature Monitoring and Motor Holding Brake

⚠ WARNING **Dangerous movements! Danger to persons from falling or dropping axes!**

The standard motor holding brake provided or an external motor holding brake controlled directly by the drive controller are not sufficient on their own to guarantee personal safety!

Personal safety must be achieved using higher-level, fail-safe measures:

- Block off danger zones with safety fences or safety guards
- Additionally secure vertical axes against falling or dropping after switching off the motor power by, for example,
  - mechanically securing the vertical axes
  - adding external braking/arrester/clamping mechanisms
  - ensuring sufficient equilibration of the vertical axes

⚠ WARNING **Lethal electric shock by live parts with more than 50 V!**

The input of the motor temperature evaluation is **not** galvanically isolated from the housing. If the voltage applied to the input is impermissibly high (e.g. because of a flashover of the motor winding voltage), this voltage may come into contact with the housing. Ensure that the temperature sensor of the connected motor has a **double** isolation against the motor winding.

NOTICE **Excessive voltage at the input of the motor temperature evaluation may cause damage to the device!**

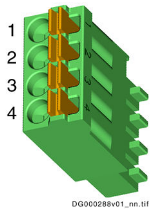
The voltage allowed at the input of the motor temperature evaluation must correspond to the allowed control voltage of the device. If the voltage applied to the input is impermissibly high, the device may be damaged.

Function

Connection point X6 contains the connections for

- monitoring the motor temperature
- controlling the motor holding brake

☞ Via an integrated contact element (BR), the power section switches the voltage of the **external** 24-V supply to the output for controlling the motor holding brake.

View	Connection	Signal name	Function
	1	MotTemp+	Motor temperature evaluation input
	2	MotTemp-	
	3	+24VBr	Output for controlling the motor holding brake
	4	0VBr	
Spring terminal (connector)	**Unit**	**Min.**	**Max.**
Connection cable Stranded wire	mm^2	0,25	1,5
	AWG	24	16
Stripped length	mm	10	
Current carrying capacity of outputs X6	A	-	1,25
Time constant of load	ms	-	50
Number of switching operations at maximum time constant of load		Wear-free electronic contact	
Switching frequency	Hz	-	0,5
Short circuit protection		X6.3 against X6.4 (output for controlling the motor holding brake)	
Overload protection		X6.3 against X6.4 (output for controlling the motor holding brake)	

Tab. 12-6: Function, pin assignment

Motor holding brake: selection

Maximum current carrying capacity of outputs X6: 1.25 A

$\Rightarrow R_{br\,(min)} = U_{br\,(max)}$ / 1.25 A

$R_{br\,(min)}$: Minimum allowed resistance of the motor holding brake

$U_{br\,(max)}$: Maximum supply voltage of the motor holding brake

If $U_{br\,(max)}$ = 24 V +5% = 25.2 V, this results in:

$R_{br\,(min)}$ = 20.16 Ω (applicable to all operating and ambient conditions)

Motor holding brake: installation instructions

Make sure the **power supply** for the motor holding brake at the motor is sufficient. You have to take into account that voltage drops on the supply line. Use connection lines with the highest possible cross section of the single strands.

Use an **external contact element in accordance with the required safety category**, if you wish to supply motor holding brakes with higher currents than the allowed current load at X6. Make sure to comply with the required minimum current consumption of 100 mA when using the external contact element. Otherwise, the brake current monitoring unit signals an error.

Connection diagram

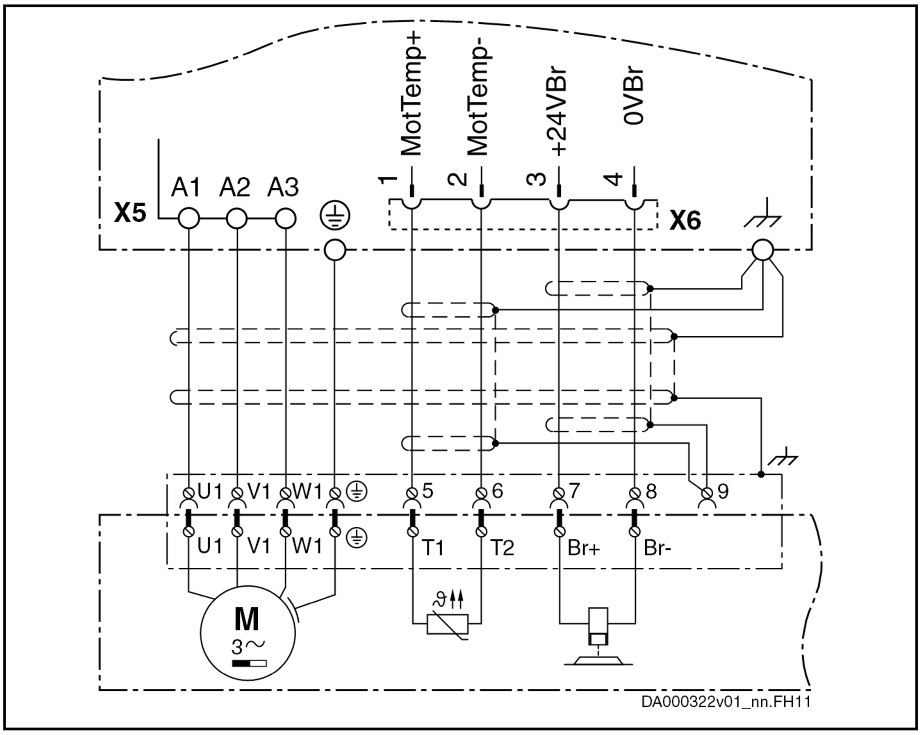
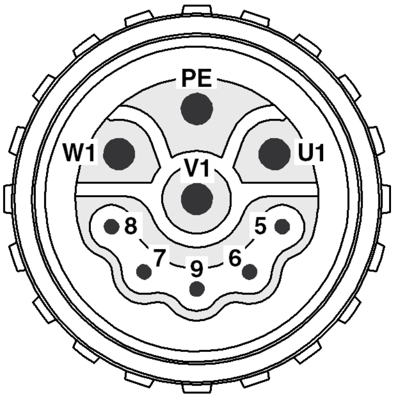


Fig. 12-1: Connection of motor temperature monitoring and motor holding brake

12.2.2 X156, Motor Connection

View	Connection	Signal name	Function
	U1, V1, W1	-	Power output
	PE	-	Equipment grounding conductor
	5	MotTemp+	Temperature measurement input
	6	MotTemp-	
	7	Br+ / +24V	Output for controlling the motor holding brake of the "applied without current" type
	8	Br- / 0V	
	9	GND_shld	Shield
9-pin, female connector	**Unit**	**Min.**	**Max.**
Output for controlling the motor holding brake (X156.7/8)			
Output current (A)	A	0,15 1)	1
Continuous power overvoltage protection (B)	W	n.s.	1,5
Energy absorption (B)	Ws	n.s.	3

Cable	RKL4305		
Allowed length	m	n.s.	7,5

1) With deactivated brake current monitoring: 0 A

Tab. 12-7: X156, Motor

12.2.3 XG3, motor temperature monitoring and motor holding brake

⚠ WARNING **Dangerous movements! Danger to persons from falling or dropping axes!**

The standard motor holding brake provided or an external motor holding brake controlled directly by the drive controller are not sufficient on their own to guarantee personal safety!

Personal safety must be achieved using higher-level, fail-safe measures:

- Block off danger zones with safety fences or safety guards
- Additionally secure vertical axes against falling or dropping after switching off the motor power by, for example,
  - mechanically securing the vertical axes
  - adding external braking/arrester/clamping mechanisms
  - ensuring sufficient equilibration of the vertical axes

⚠ WARNING **Lethal electric shock from live parts with more than 50 V!**

The motor temperature evaluation input is **not** electrically isolated from the housing. If excessive voltage is applied to the input (e.g., from motor winding voltage flashover), this voltage can travel to the housing. Make sure the temperature sensor of the connected motor is **double** insulated from the motor winding.

NOTICE **Risk of damage to device from excess voltage at motor temperature evaluation input!**

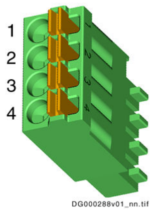
Only the allowed control voltage for the device is allowed at the motor temperature evaluation input. Excess voltage at the input can damage the device.

Function

Connection point XG3 contains the connections for

- Monitoring motor temperature
- Controlling motor holding brake

☞ Via an integrated contact element (BR), the power section switches the voltage of the **external** 24 V supply to the output for controlling the motor holding brake.

View	Connection	Signal name	Function
	1	MotTemp+	Motor temperature evaluation input
	2	MotTemp-	
	3	+24VBr	Output for controlling motor holding brake
	4	0VBr	

Tab. 12-8: Pin assignment

Mechanical data

Spring terminal (connector)	Unit	min.	max.
Connection cable Stranded wire	mm^2	0.25	1.5
	AWG	24	16
Stripped length	mm	10	

Tab. 12-9: Mechanical data

Electrical data (output for controlling motor holding brake [XG3.3/4])

Spring terminal (connector)	Unit	min.	max.
Output current	A	0.15 [1)]	1.29
Overvoltage protection continuous power	W	n.s.	1.5
Energy absorption	Ws	n.s.	3

1) With deactivated brake current monitoring: 0 A

Tab. 12-10: Electrical data (output for controlling motor holding brake [XG3.3/4])

Motor holding brake: Selection

Maximum current rating of XG3 outputs: 1.29 A

⇒ $R_{br\,(min)} = U_{br\,(max)}$ / 1.29 A

$R_{br\,(min)}$: minimum allowed resistance of motor holding brake

$U_{br\,(max)}$: maximum supply voltage of motor holding brake

If $U_{br\,(max)}$ = 24 V +5% = 25.2 V, then:

$R_{br\,(min)}$ = 19.53 Ω (applies to all operating and ambient conditions)

Motor holding brake: Notes on installation

Make sure there is enough **power supply** to the motor for the motor holding brake. Note that voltage drops on the supply line. Use connection lines with the largest possible cross section of single strands.

Use an **external contact element in accordance with the required safety category** if you want to supply motor holding brakes with higher currents than the current load allowed at XG3. Make sure to comply with the required minimum current consumption of 100 mA when using an external contact element. Otherwise, the brake current monitor will signal an error.

Connection diagram

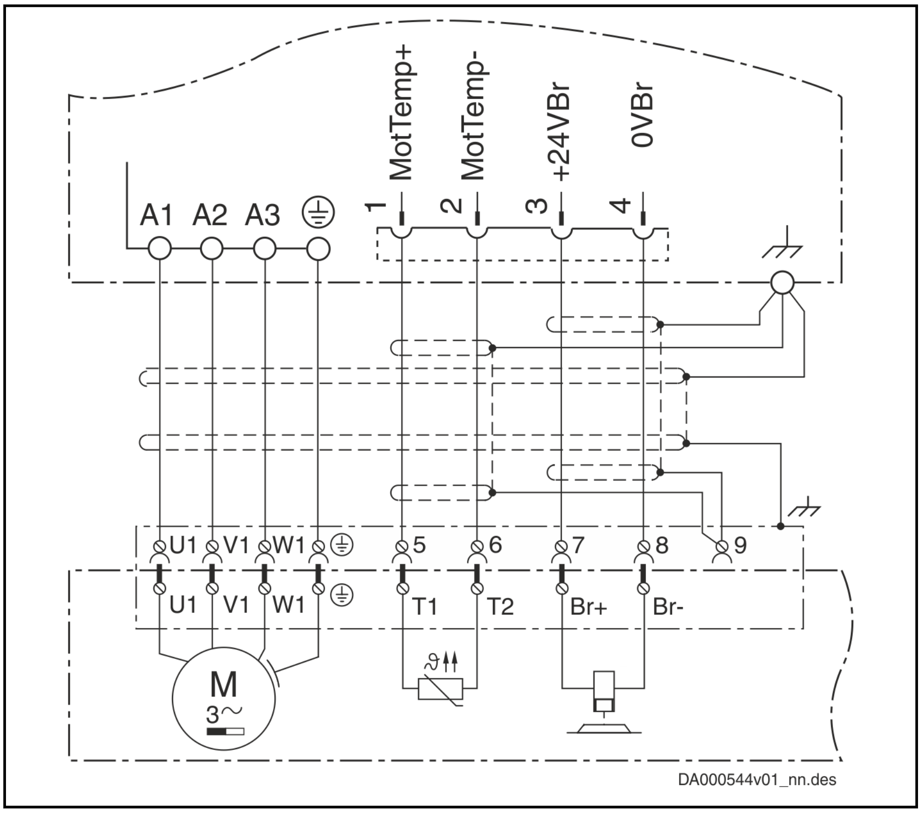


Fig. 12-2: Connection of motor temperature monitoring and motor holding brake

12.3 Diagnostic displays

12.3.1 Diagnostic display Optional safety technology modules "Sx"

CSos

In case of safe bus communication via CSos, the LEDs H25 / H26 have the following meaning:

H25 / H26 Color / flashing pattern [1)]	Significance
-- Off	Safety technology **not active**
GN GN -- -- Flashing green	Safety technology active, no connection (safety default)
GN Permanently lit green	Safety technology active, at least one safe connection
RD GN GN RD Flashing red-green	• Waiting for TUNID[2)] • Self test and initialization • Identifying the axis identifier
RD -- GN -- RD -- GN -- Flashing red-green	TUNID[2)] not set yet
RD RD -- -- Flashing red	Abortion of connections
RD -- RD -- GN -- GN -- Flashing red-green	Indentifying the safety technology
RD Permanently lit red	critical safety technology error

1) Flashing pattern: One square corresponds to a duration of 250 ms; the arrow marks the end of a cycle; abbreviations on the squares: GN = LED permanently lit green, RD = LED permanently lit red, -- = LED is off

2) TUNID = Target Unique Network Identifier

Tab. 12-11: LED display in case of safe bus communication via CSos

FSoE

In case of safe bus communication via FSoE, the LEDs H25 / H26 have the following meaning:

Significance		H25	H26
FSoE status	Initialization / reset	RD Red	-- Off
	Session / Connection / Parameter	RD GN Flashing red-green	See tab. 12-13 "FSoE status, detailed diagnosis " on page 438
	Data	GN Green	See tab. 12-13 "FSoE status, detailed diagnosis " on page 438
Indentifying the safety technology		RD -- RD -- GN -- GN -- Flashing red-green	
critical safety technology error		RD Red	

Tab. 12-12: LED display in case of safe bus communication via FSoE

H26 GN green	Meaning / cause	Remedy
Continuous light	Normal; communication ok	-
Flickers alternately with 1 pulse	Error S parameter (TwinSafe parameter)	As it is very difficult to read out the flashing sample, the drive will - with these errors - also generate error F3452. Check configuration and correct it, if necessary. If error occurs again in spite of correct configuration, please contact our service department; they can read out the exact cause of error by means of detailed diagnostics.
Flickers alternately with 2 pulses	Error I parameter (individual parameters)	
Flickers alternately with 5 pulses	Watchdog error	
Flickers alternately with 6 pulses	CRC error	
Flickers alternately with 7 pulses	Sequence number error	
Flickers alternately with 8 pulses	Communication error	

Tab. 12-13: FSoE status, detailed diagnosis

PROFIsafe

In case of safe bus communication via PROFIsafe, the LEDs H25 / H26 have the following meaning:

<table>
<tr><th>PROFIsafe F-Device state</th><th>H25</th><th colspan="2">H26</th></tr>
<tr><td>PSD_INIT</td><td>RD
Red</td><td colspan="2">--
Off</td></tr>
<tr><td>PSD_PARAM</td><td>RD GN
Flashing red-green</td><td colspan="2">RD
Red</td></tr>
<tr><td rowspan="4">PSD_DATEX</td><td rowspan="4">GN
Green</td><td>GN
Green</td><td>Without errors</td></tr>
<tr><td>GN --
Flashing green</td><td>Receive zero telegram from the F-Host (all bytes of the received telegram contain "0"). The telegram has been discarded by the F-Device.</td></tr>
<tr><td>RD GN
Flashing red-green</td><td>F-Device passivated. Fail Safe values are provided.</td></tr>
<tr><td>--
Off</td><td>Watchdog or communication error</td></tr>
<tr><td>PSD_HARD_FAIL</td><td>--
Off</td><td colspan="2">--
Off</td></tr>
</table>

Tab. 12-14: LED display in case of safe bus communication via PROFIsafe

12.3.2 Diagnostic display, Rexroth IndraDrive Mi

Project planning

KSM/KMS diagnostic display

H14 LED

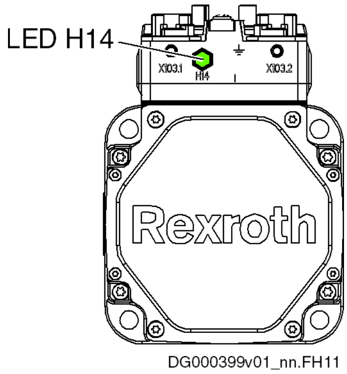


Fig. 12-3: H14 LED (KSM example)

At the device, there is an LED which displays the drive status.

With the MPx-20 firmware, the color and flashing pattern of the H14 LED were changed. For the significance of the LED please refer to the corresponding table.

MPx-19 and below: H14 LED displays

H14 Color / flashing pattern [1]		Significance (drive status)	Measures
	Off -- -- -- --	Supply unit not switched on	Check and, if necessary, switch on the 24-V supply
		Cable interrupted	Check cable and connector X18
		Hardware defective	Replace hardware
	Flashing green GN GN -- --	Drive is error-free (phases 2, 3 and 4); in phase 4, drive is ready for drive enable ("Bb")	If necessary, read exact status via "S-0-0095, Diagnostic message"
	Green GN GN GN GN	Power on and DC bus voltage available ("Ab")	Drive is error-free in operation and runs according to inputs
		Drive in control ["AF", "AH" or drive command active (Cxxxs)]	
	Flashing green-yellow GN GN YE YE	Switching command active (C01xx/C02xx) Switching command error (C01xx/C02xx)	If necessary, read exact status via "S-0-0095, Diagnostic message"
		Firmware update running Loader active	Do not interrupt the 24-V supply and do not unplug connectors while the firmware is being updated
	YE -- -- GN	Drive command error (Cxxxx)	

H14 Color / flashing pattern [1]	Significance (drive status)	Measures
Flashing yellow YE -- -- --	Drive warning (E2xxx … E3xxx)	Read exact status via "S-0-0095, Diagnostic message" and execute service function
YE YE -- --	Communication warning (E4xxx)	
YE YE YE --	Travel range warning (E6xxx … E7xxx)	
YE -- YE --	Drive controller identification	
Yellow YE YE YE YE	Fatal warning (E8xxx)	Do not interrupt the 24-V supply and do not unplug connectors while the firmware is being updated
Flashing red-yellow RD RD YE YE	Drive is error-free (phase 0), but not yet ready for drive enable ("Bb")	If necessary, read exact status via "S-0-0095, Diagnostic message"
RD YE YE YE	Drive is error-free (phase 1), but not yet ready for drive enable ("Bb")	
RD -- -- YE	Communication error (F4xxx)	
Flashing red-green RD -- GN --	Baud rate scan (P-1)	If necessary, read exact status via "S-0-0095, Diagnostic message"
Flashing red RD RD -- --	Error (F2xxx, F3xxx, F6xxx, F7xxx, F8xxx)	Read exact status via "S-0-0095, Diagnostic message" and execute service function
RD -- RD --	Firmware update:	Repeat firmware update
Red RD RD RD RD	Booting phase	Wait until booting phase is over (approx. 2 minutes)
	System error (F9xxx, E0800)	• Switch off and on; replace hardware, if necessary • Check whether the programming module is inserted; if necessary replace KSM/KMS crosswise to check whether the programming module is defective

1) A square in the illustrated flashing patterns corresponds to a time period of 250 ms.

Tab. 12-15: LED Displays H14

MPx-20 and above: H14 LED displays

LED Color / flashing pattern [1]		Significance *Measures*
	Off --	Supply unit not switched on *Check 24V supply and switch it on, if not yet done*
		Cable interrupted *Check cable and connector*
		Hardware defective *Replace hardware*
	Flashing green GN --	Firmware update active
	GN -- -- -- -- -- --	• Transition command active • PM (parameter mode)
	GN -- GN -- -- -- -- -- --	• **bb** (control section ready for oper., mains voltage not available) • **ZKS** (DC bus short circuit)
	GN -- GN -- GN -- -- -- -- -- --	• **Ab** (drive ready for operation, power on) • **Bb** (control section and power section ready for operation, mains voltage available) • **charg** (DC bus charging active)
	Green GN	• **AH** (Drive Halt) • **AF** (Drive in control) • **Lb** (supply unit in rectifier mode) • **LB** (supply unit in voltage control) • **I LB** (supply unit in current control)
	Flashing red-green GN -- RD -- -- -- -- -- --	Bus state (e.g., not active, pre-operational, …)
	GN RD	Loader active
	GN GN -- -- GN GN -- -- RD RD -- -- RD RD -- --	Identification

LED Color / flashing pattern [1)]	Significance *Measures*
Flashing red RD --	Firmware update error *Repeat firmware update*
RD -- -- -- -- -- --	• All warnings • Command errors *Read detailed state via "S-0-0095, Diagnostic message"*
RD -- RD -- -- -- -- -- --	All errors (except F4xxx) *Read detailed state via "S-0-0095, Diagnostic message" and carry out service function*
RD -- RD -- RD -- -- -- -- -- --	Communication error (F4xxx) *If necessary, read detailed state via "S-0-0095, Diagnostic message"*
Red RD	Booting phase *Wait until booting phase is over (approx. 2 minutes)*
	System error (F9xxx) • *Switch off and on; replace hardware, if necessary* • *Check whether programming module has been plugged*

1) Flashing pattern: One square corresponds to a duration of 250 ms; the arrow marks the end of a cycle; abbreviations on the squares: GN = LED permanently lit green, RD = LED permanently lit red, -- = LED is off

Tab. 12-16: LED displays

H25 H26 LED

Use

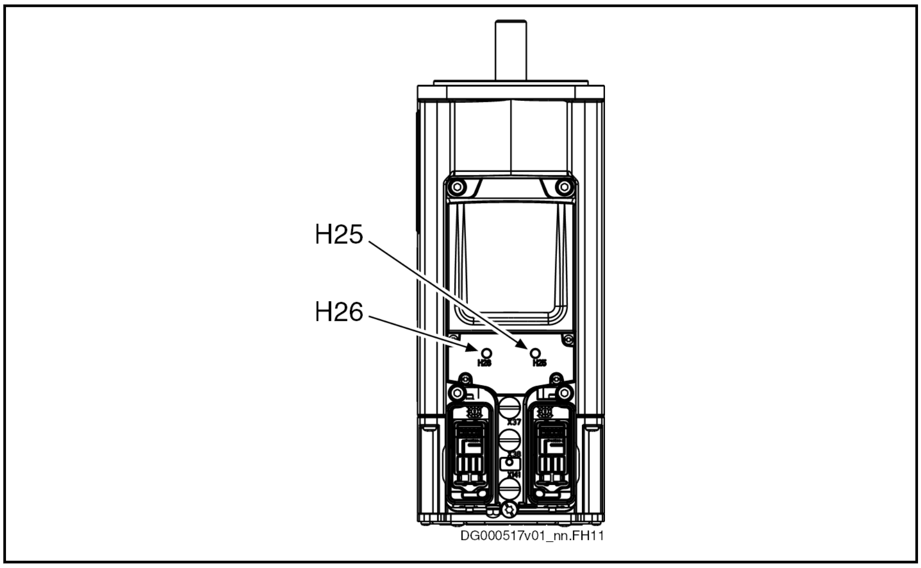


Fig. 12-4: H25 H26 LED (KSM example)

- **H25** → safety technology
- **H26** → network

  The significance of the network displays depends on the field bus system.

☞ The LEDs do not provide any reliable information on the internal state of the device! The LEDs only provide general diagnostic information for commissioning or troubleshooting.

H25 LED, displays

Color / flashing pattern [1]	Safety technology status [3] (Safety Supervisor State / Event)	Connection status [3]
-- Off	• Not active • Safety bus communication not configured	• Not ready • Safety bus communication not configured
GN GN -- -- ↺ Flashing green	Active, no connection (safety default)	Ready and no active connection
GN Permanently lit green	Active, at least one safe connection	Ready and at least one active connection
RD GN GN RD ↺ Flashing red-green	• Waiting for TUNID [2] • Self test and initialization • Identifying the axis identifier	• Waiting for TUNID [2] • Self test and initialization • Identifying the axis identifier
RD -- RD -- GN -- GN -- ↺ Flashing red-green	Indentifying the safety technology	-
RD -- GN -- RD -- GN -- ↺ Flashing red-green	TUNID [2] not yet set	-
RD RD -- -- ↺ Flashing red	Abortion of connections	Faulty abortion of at least one active connection
RD Permanently lit red	Critical error	Critical connection error

1) Flashing pattern: One square corresponds to a duration of 250 ms; the arrow marks the end of a cycle; abbreviations on the squares: GN = LED permanently lit green, RD = LED permanently lit red, -- = LED is off
2) TUNID = Target Unique Network Identifier
3) The LED display is only active with safety bus communication via the master communication

Tab. 12-17: LED display

H26 LED, displays Ethernet/IP

LED: Color / flashing pattern	Significance
Off	The device does not have a valid IP address or has been switched off.
Flashing green	The device has run up with a valid IP address, but does not have a cyclic connection.
Permanently lit green	The I/O connection has been established without error.
Flashing red	The existing I/O connection was unexpectedly aborted (e.g., watchdog).
Permanently lit red	The "Duplicate-IP-Adress-Check" showed that the IP address which was set already exists in the network.
Flashing red-green	The device is running up and carries out a self test.

Tab. 12-18: Diagnostic LED

EtherCAT

LED: Color / flashing pattern [1)]	Significance	Description
-- Off	Status INIT	• Cyclic process data and acyclic data channel are not transmitted • No error
GN -- Flashing green	Status PRE-OPERATIONAL	Acyclic data channel is transmitted
GN -- -- -- -- -- Green, one LED lighting up	Status SAFE-OPERATIONAL	Acyclic data channel is transmitted
GN Permanently lit green	Status OPERATIONAL	Cyclic process data and acyclic data channel are transmitted
RD -- Flashing red	Configuration error	General EtherCAT configuration error
RD -- -- -- -- -- Red, one LED lighting up	Synchronization error	• The drive controller has not been synchronized to the EtherCAT master • Communication error of the drive controller
RD -- RD -- -- -- -- -- Red, two LEDs lighting up	Timeout - watchdog	• Timeout while cyclic process data are monitored • Watchdog of the EtherCAT master

1) Flashing pattern: One square corresponds to a duration of 200 ms; the arrow marks the end of a cycle; abbreviations on the squares: GN = LED permanently lit green, RD = LED permanently lit red, -- = LED is off

Tab. 12-19: Diagnostic LED

sercos III

LED: Color / flashing pattern [1]	Description	Prio [2]
-- Off	NRT mode (no sercos communication) [3]	6
OG Permanently lit orange	CP0 (communication phase 0 active)	6
GN OG OG OG OG OG OG OG OG OG OG OG ↺ Flashing orange-green	CP1 (communication phase 1 active)	6
GN OG GN OG OG OG OG OG OG OG OG OG ↺ Flashing orange-green	CP2 (communication phase 2 active)	6
GN OG GN OG GN OG OG OG OG OG OG OG ↺ Flashing orange-green	CP3 (communication phase 3 active)	6
GN Permanently lit green	CP4 (communication phase 4 active)	6
GN -- GN -- GN -- GN -- GN -- GN -- ↺ Flashing green	Transition from Fast forward to Loopback	5
RD OG RD OG RD OG RD OG RD OG RD OG ↺ Flashing red-orange	Application error (Sub-device/device error [C1D])	4
RD GN RD GN RD GN RD GN RD GN RD GN ↺ Flashing red-green	MST warning [4] (S-0-1045, sercos: Device Status [S-Dev], bit15)	3
RD Permanently lit red	Communication error (Sub-device/device error [C1D])	2
OG -- OG -- OG -- OG -- OG -- OG -- ↺ Flashing orange	Identification (S-0-1044, sercos: Device Control [C-Dev], bit15)	1
RD -- RD -- RD -- RD -- RD -- RD -- ↺ Flashing red	Internal watchdog	0

1) Flashing pattern: One square corresponds to a duration of 250 ms; the arrow marks the end of a cycle; abbreviations on the squares: GN = LED permanently lit green, OG = LED permanently lit orange, RD = LED permanently lit red, -- = LED is off

2) Display priority (1 = highest priority); the state of the highest priority is displayed

3) NRT = None Real Time

4) MST = Master synchronization telegram

Tab. 12-20: Diagnostic LED

PROFINET IO

LED: Color / flashing pattern	Significance
Off	The device does not have a valid IP address or has been switched off.
Flashing green	The device has run up with a valid IP address, but does not have a cyclic connection.
Permanently lit green	The I/O connection has been established without error.
Flashing red	The existing I/O connection was unexpectedly aborted (e.g., watchdog).
Permanently lit red	The "Duplicate-IP-Adress-Check" showed that the IP address which was set already exists in the network.
Flashing red-green	The device is running up and carries out a self test.

Tab. 12-21: Diagnostic LED

KCU02 diagnostic display

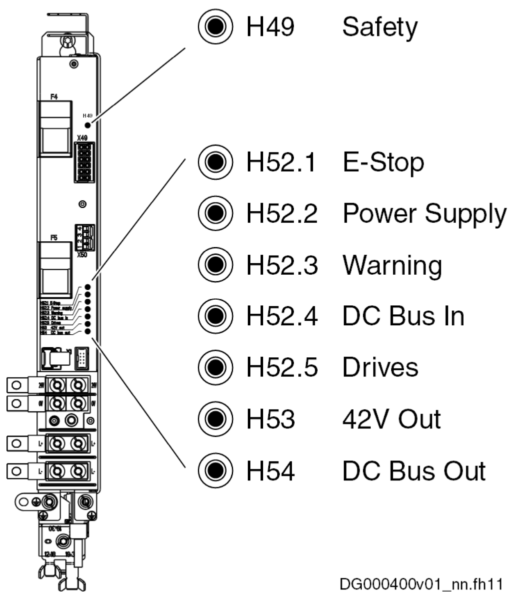


Fig. 12-5: LEDs at KCU02

Project planning

LED	Color / status	Significance	Measures
H49 Safety	Green	Safety technology signals without error	None
	Red	Safety technology signals with error (Error is saved until the device is switched off.)	Check safety technology wiring for short circuit.
H52.1 E-Stop	Off	E-Stop not activated	None
	Red	E-Stop active (/E_Stop)	Deactivate E-Stop, if necessary (see connection point X50)
H52.2 Power Supply	Green	Supply unit without error, regular status	None
	Red	Supply unit signals error (/Bb_V)	Check power supply, see also "F2086 Error supply module"
H52.3 Warning	Green	Supply unit without warning (/Warn), regular status	None
	Red	Supply unit signals warning	Check supply unit, see also "E2086 Prewarning supply module overload"
H52.4 DC Bus In	Off	DC bus voltage (L+; L-) too low	Switch power on at supply unit
		Module bus not connected (if H54 green)	Connect module bus (connection point X1)
	Green	DC bus voltage (L+; L-) without error (Ud), regular status	None
H52.5 Drives	Green	No error at module bus, regular status	None
	Red	Module bus error (/Bb_A)	• Check module bus wiring • Check control voltage supply of the devices; see also "F2087 Module group communication error"
	Red/ green Flashing	Drive system carries out error reaction (Bb_A)	Bring device at module bus to readiness for operation; see also diagnostic message "E2810 Drive system not ready for operation"
H53 42V Out	Green	Control voltage at output X53 okay	None
	Red	Control voltage at output X53 faulty or control voltage outside of tolerance Error is saved until switch-off	Overload at output: • Check control voltage supply • Check voltage at X53 • Reduce load • Remove short circuit

LED	Color / status		Significance	Measures
H54 DC Bus Out		Off	DC bus (L+, L-) not ready for power output	None
		Green	DC bus (L+, L-) ready for power output	None
		Red	DC bus voltage (L+; L-) at output X54 not okay	Check fuses F4, F5 and replace them, if necessary

Tab. 12-22: KCU02 LED displays

KMV diagnostic display

LED H14

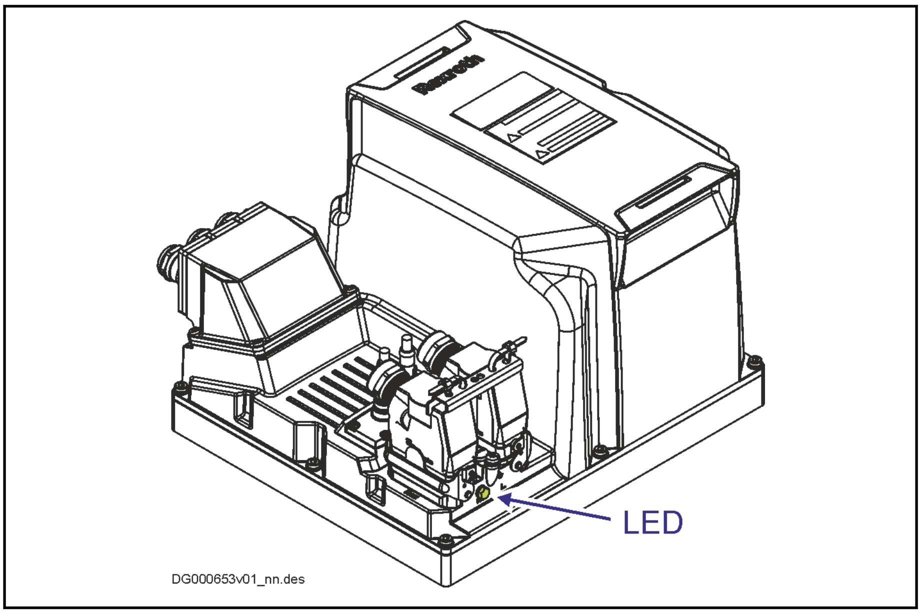


Fig. 12-6: LED H14

At the device, there is a bicolor LED which displays the drive status.

LED Color / flashing pattern [1)]		Significance *Measures*
	Off --	Supply unit not switched on *Check 24V supply and switch it on, if not yet done*
		Cable interrupted *Check cable and connector*
		Hardware defective *Replace hardware*

Project planning

LED Color / flashing pattern [1)]	Significance *Measures*
Flashing green GN --	Firmware update active
GN -- -- -- -- -- --	• Transition command active • PM (parameter mode)
GN -- GN -- -- -- -- -- --	• bb (control section ready for oper., mains voltage not available) • ZKS (DC bus short circuit)
GN -- GN -- GN -- -- -- -- -- --	• Ab (drive ready for operation, power on) • Bb (control section and power section ready for operation, mains voltage available) • charg (DC bus charging active)
Green GN	• AH (Drive Halt) • AF (Drive in control) • Lb (supply unit in rectifier mode) • LB (supply unit in voltage control) • I LB (supply unit in current control)
Flashing red-green GN -- RD -- -- -- -- -- --	Bus state (e.g., not active, pre-operational, …)
GN RD	Loader active
GN GN -- -- GN GN -- -- RD RD -- -- RD RD -- --	Identification
Flashing red RD --	Firmware update error *Repeat firmware update*
RD -- -- -- -- -- --	• All warnings • Command errors *Read detailed state via "S-0-0095, Diagnostic message"*
RD -- RD -- -- -- -- -- --	All errors (except F4xxx) *Read detailed state via "S-0-0095, Diagnostic message" and carry out service function*
RD -- RD -- RD -- -- -- -- -- --	Communication error (F4xxx) *If necessary, read detailed state via "S-0-0095, Diagnostic message"*

LED Color / flashing pattern [1)]		Significance *Measures*
	Red RD	Booting phase *Wait until booting phase is over (approx. 2 minutes)*
		System error (F9xxx) • *Switch off and on; replace hardware, if necessary* • *Check whether programming module has been plugged*

1) Flashing pattern: One square corresponds to a duration of 250 ms; the arrow marks the end of a cycle; abbreviations on the squares: GN = LED permanently lit green, RD = LED permanently lit red, -- = LED is off

Tab. 12-23: LED displays

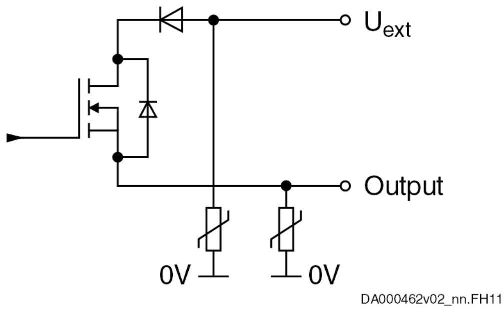
12.4 Technical data

12.4.1 Digital inputs type A (standard)

See "Digital inputs type A (standard)"

12.4.2 Digital outputs SZE, SZA, DYN, SI_Out (safety technology S options S3, S4, S5, SD; HSZ01 safety zone module)

The digital outputs are compatible with digital inputs of types 1, 2 and 3 (IEC 61131).

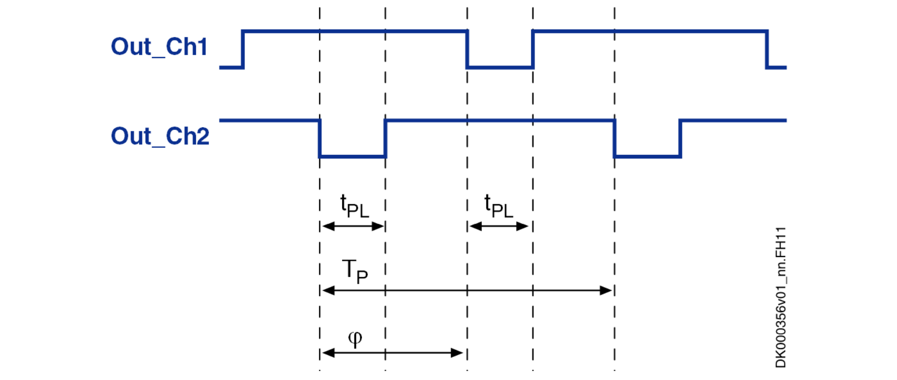
Data	Unit	min.	max.
Output voltage ON	V	U_{ext} - 1	U_{ext}
Output voltage OFF	V		2
Allowed output current per output	mA		350
Allowed energy content of connected inductive loads, e.g. relay coils	mJ		400 [1) 2)]
Capacitive load	nF		320
Short circuit protection		Present	
Overload protection		Present	
Block diagram output:			
Error detection	The following errors are detected: • Wiring error with short circuit to high • Wiring error with short circuit to low • Wiring error with short circuit between the two channels • Internal errors In the case of an error, the control panel shows the corresponding error message: F83xx		

1) At a maximum switching frequency of 1 Hz
2) In the case of inductive loads with currents > 200 mA or in the case of inductive loads with a greater energy content, an external free-wheeling arm has to be installed. The effective terminal voltage has to be < 25 V.

Tab. 12-24: Digital outputs

Time behavior

Description	Unit	min.	max.
SZA/SZE test pulse width (t_{PL})	µs	100	200
DYN test pulse width (t_{PL})	µs	500	1000
Periodic time (T_P)	ms	500	1000
Phase shift between two test pulses on both channels (φ)	ms	50	-



Tab. 12-25: Time behavior

12.4.3 Digital output SDL (HSZ01 safety zone module)

The digital outputs are compatible with digital inputs of type 1 (IEC 61131).

Data	Unit	min.	typ.	max.
Output voltage ON SDL_Ch1	V	U_{ext} - 1	24	U_{ext}
Output voltage ON SDL_Ch2	V	-		0.5
Output current ON	mA			1250
Output current OFF	mA			0.8
Allowed energy content of connected inductive loads, e.g. relay coils; only allowed as single pulse	mJ			2000 [1) 2)]
Short circuit protection			Present	
Overload protection			Present	
Overtemperature protection			Present	
Monitoring of internal switches T_Ch1 and T_Ch_2			Present	

1) With a maximum switching frequency of 0.5 Hz
2) In the case of greater inductive loads, an external free-wheeling arm has to be installed. The effective terminal voltage has to be < 20 V.

Tab. 12-26: Digital outputs

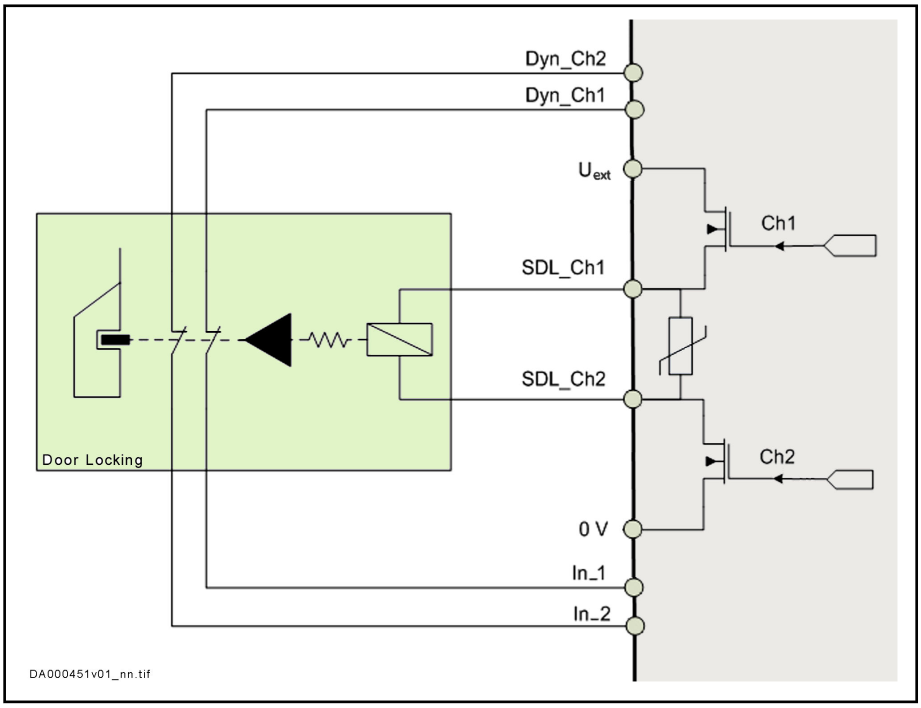


Fig. 12-7: Safe door locking SDL

12.5 Accessories

12.5.1 HSZ01 - safety zone module

Brief description, use, features

Brief description, use

Type	Use
HSZ01	The safety zone module HSZ01 belongs to the Rexroth IndraDrive product range and provides the following safety functions: • Safety Zone Acknowledge (SZA) • Safety Zone Error (SZE) • Safety Zone Input (SZI) • Safe Door Locking (SDL)

Tab. 12-27: Use

Features

- **35 safety zone nodes** are possible (HSZ01 not included)
- **2 × 8 digital inputs** for dual-channel collective selection of the safety functions at the safety zone nodes or 16 inputs for single-channel selection
- **2 × 1 digital dynamized output** (1 output pair) for **safety zone acknowledge**, if all safety zone nodes signal safety
- **2 × 1 digital dynamized output** (1 output pair) for **safety zone error**, if at least one safety zone node signals an error
- **2 × 1 digital dynamized output** (1 output pair) for **monitoring** the wiring
- **2 × 1 digital output** (1 output pair) for controlling the safe **door locking**
- **Galvanic isolation** exists between the inputs and outputs of the safety zone module and the other nodes of a safety zone

C-UL-US listing

The components are listed by **UL** (Underwriters Laboratories Inc.®).

Proof of certification can be found online:

www.ul.com/database

Under "UL File Number" enter the file number or under "Company Name" enter the company name "Bosch Rexroth AG".

<table>
<tr><td rowspan="3">c UL us
Listed
POW. CONV. EQ.
97Y4
DX000009v01_nn.tif</td><td>• UL standard: UL 508C
• CSA standard: Canadian National Standard C22.2 No. 274-13</td></tr>
<tr><td>**Company Name**
BOSCH REXROTH AG
Category Name:
Power Conversion Equipment</td></tr>
<tr><td>**File numbers**
Rexroth IndraDrive components:
• E134201</td></tr>
</table>

Tab. 12-28: C-UL listing

Type code and identification

Type code

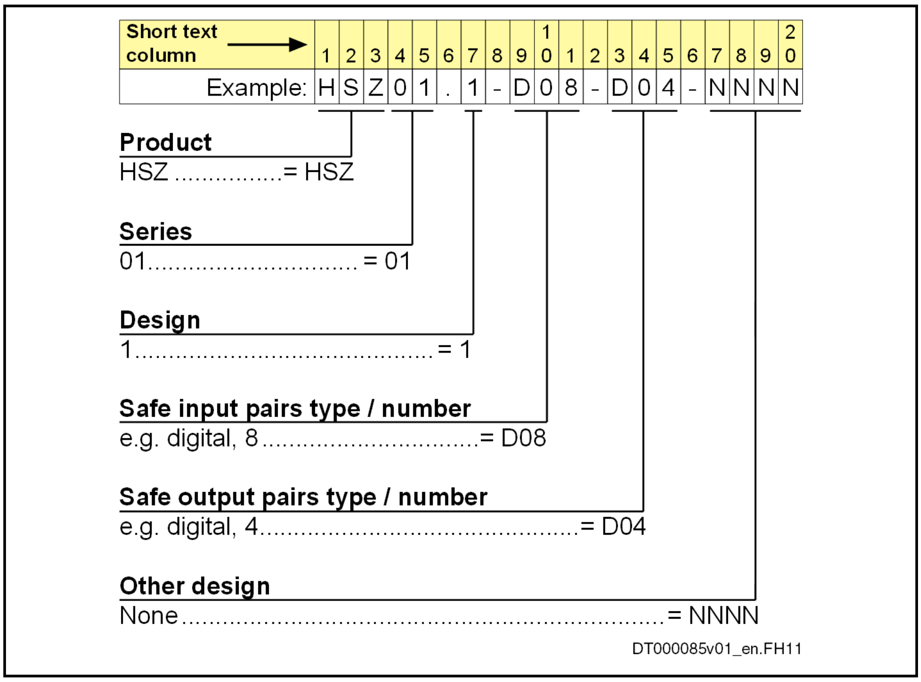
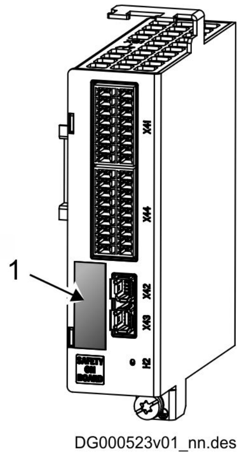


Fig. 12-8: Type code

☞ The figure illustrates the basic structure of the type code. Our sales representative will help you with the current status of available versions.

Identification

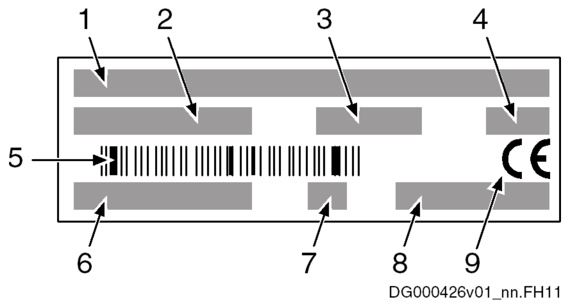
Type plate arrangement



1 Type plate

Fig. 12-9: Type plate arrangement

Type plate (device)



1 Device type
2 Part number
3 Production week; 11W36, for example, means year 2011, week 36
4 Factory identifier
5 Bar code
6 Serial number
7 Hardware index
8 Country of manufacture
9 Identification

Fig. 12-10: Type plate (device)

Scope of supply

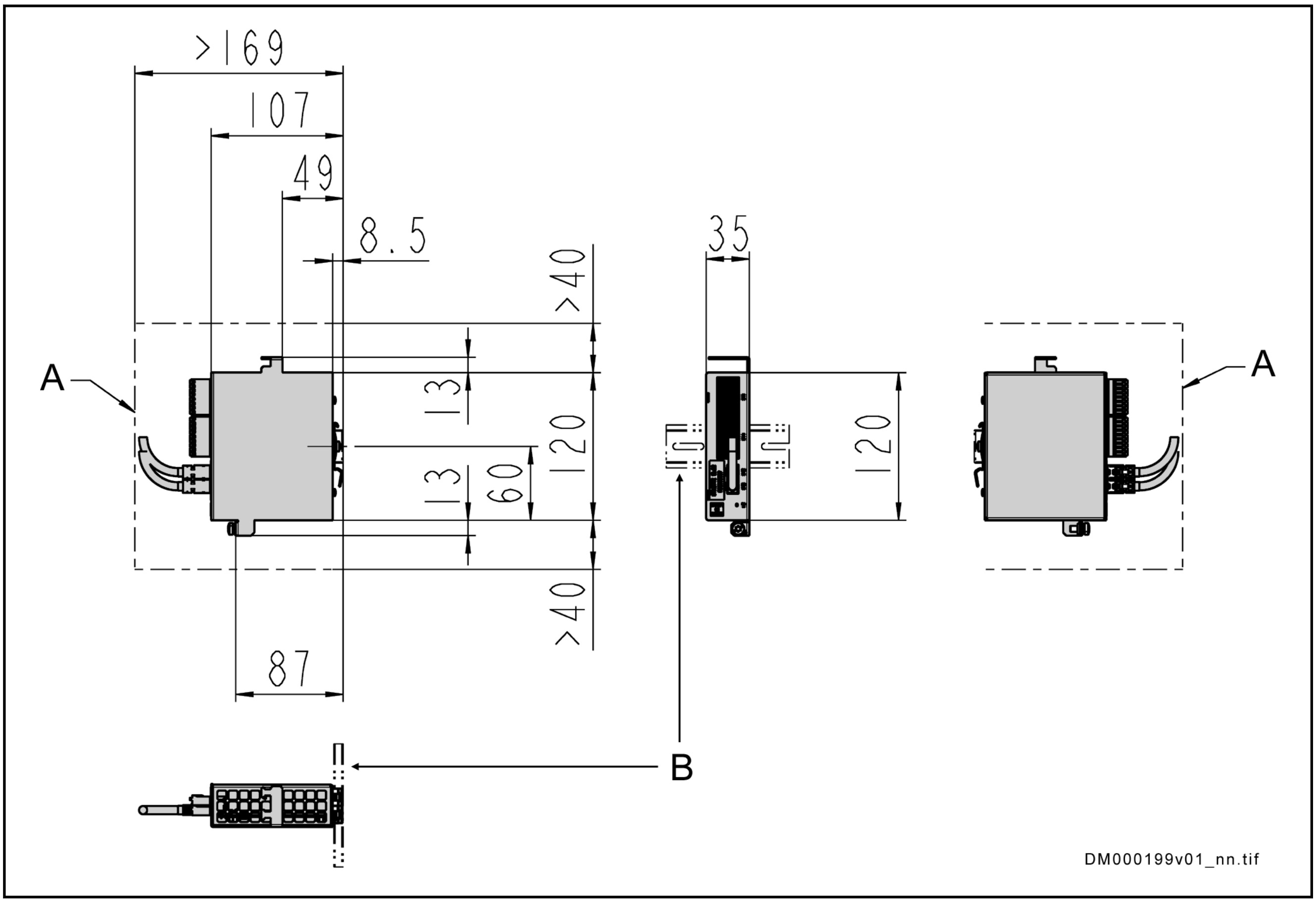
Scope of supply

- HSZ01 safety zone module
- Connector X41
- Connector X44

Project planning

Dimensions

Mounted on a top-hat rail



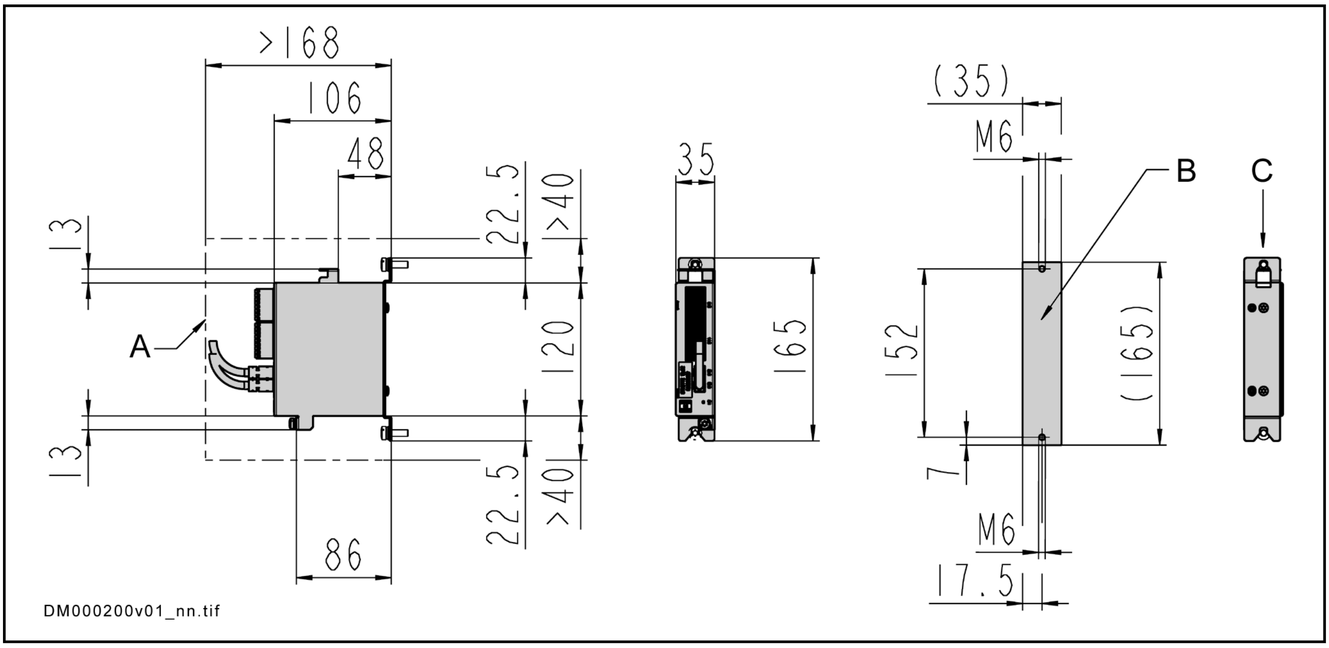
All dimensions in mm

A Minimum mounting clearance

B Top-hat rail (35 mm × 7.5 mm [according to EN50022])

Fig. 12-11: Dimensions

Mounted with accessories HAS05.1-014-NNN-NN



	All dimensions in mm
A	Minimum mounting clearance
B	Drilling pattern
C	HAS05.1-014-NNN-NN

Fig. 12-12: Dimensions

See also chapter 12.5.2 "HAS05.1-014, Mounting Plate for Safety Zone Module" on page 474.

Technical data

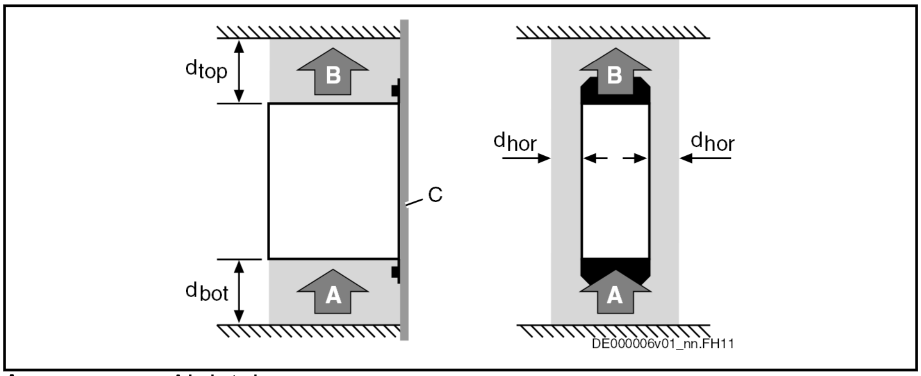
Technical data

Description	Symbol	Unit	HSZ01.1-D08-D04-NNNN
Degree of protection			IP20
Conductive dirt contamination			Not allowed (You can protect the devices against conductive dirt contamination, e.g., by mounting them in control cabinets with a degree of protection of IP54 in accordance with IEC529.)
Allowed mounting position			Vertical in a control cabinet
Weight	m	kg	0.65
Minimum distance from the top of the device 1)	d_{top}	mm	40
Minimum distance from the bottom of the device 2)	d_{bot}	mm	40
Minimum distance from the side of the device 3)	d_{hor}	mm	-
Allowed ambient temperature range	T_{a_work}	°C	0 … 55
Allowed relative humidity		%	5 … 85
Cooling type 4)			n
Control voltage supply			
Control voltage input 5)	U_{ext}	V	19.2 … 30
Internal consumption	P_{ext}	W	0.5
Output current 6)	I_{max}	A	3.4

1) 2) 3) See fig. "Air intake and air outlet at device"
4) n: natural convection; f: forced cooling
5) When selecting a control voltage supply, observe the requirements of the door locking device
6) Sum of all output currents at the outputs (without SDL_Ch2)

Tab. 12-29: HSZ01 - technical data

Distances



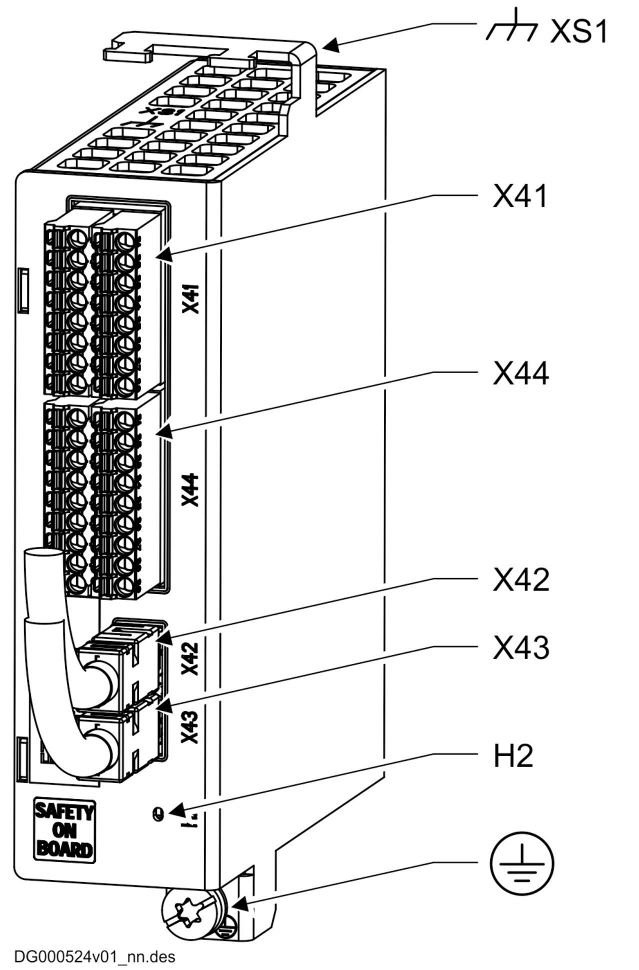
A	Air intake
B	Air outlet
C	Mounting surface in control cabinet
d_{top}	Distance top
d_{bot}	Distance bottom
d_{hor}	Distance horizontal

Fig. 12-13: Air intake and air outlet at device

Project planning

Connection points

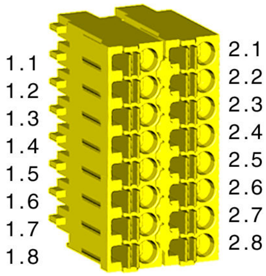
Position of connection points

View	Connection point	Description
	XS1	Shield connection
	X41	Digital inputs
	X42	Communication, input
	X43	Communication, output
	X44	Digital outputs Control voltage supply connection
		Equipment grounding conductor
	H2 (LED)	Status display (bicolor LED)

Tab. 12-30: Connection points

X41, digital inputs

Data

View	Identification	Function
	X41	Safe Motion
Spring terminal (connector)	**Unit**	**max.**
Connection cable	mm^2	1.5
Stranded wire	AWG	16
Stripped length	mm	10

Tab. 12-31: Data

Time behavior

Maximum **delay** when selecting and deselecting a digital input: **2.5 ms**

The delay results from the addition of the following times:

- Filter time of the digital input
- Time for adjusting the signal
- Transmission time to the drive controller

The reaction time of the drive controller is **not** contained in the specified time.

Project planning

Pin assignment, function

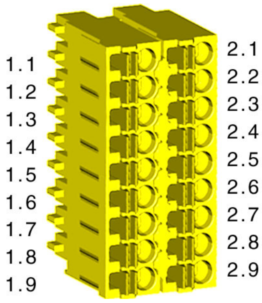
Connection	Signal name	Function	Dynamization [1)]	Input pair	Technical data
1.1	In_1	Input 1	DYN_Ch1	1	See chapter "Digital inputs" on page 470
1.2	In_2	Input 2	DYN_Ch2		
1.3	In_3	Input 3	DYN_Ch1	2	
1.4	In_4	Input 4	DYN_Ch2		
1.5	In_5	Input 5	DYN_Ch1	3	
1.6	In_6	Input 6	DYN_Ch2		
1.7	In_7	Input 7	DYN_Ch1	4	
1.8	In_8	Input 8	DYN_Ch2		
2.1	In_9	Input 9	DYN_Ch1	5	
2.2	In_10	Input 10	DYN_Ch2		
2.3	In_11	Input 11	DYN_Ch1	6	
2.4	In_12	Input 12	DYN_Ch2		
2.5	In_13	Input 13	DYN_Ch1	7	
2.6	In_14	Input 14	DYN_Ch2		
2.7	In_15	Input 15	DYN_Ch1	8	
2.8	In_16	Input 16	DYN_Ch2		

1) Assigned dynamization output of HSZ01 in the case of selection via a passive safety unit

Tab. 12-32: Function, pin assignment, properties

X44, digital outputs, control voltage supply

Data

View	Identification	Function
	X44	Safe Motion
Spring terminal (connector)	**Unit**	**max.**
Connection cable Stranded wire	mm^2	1.5
	AWG	16
Stripped length	mm	10

Tab. 12-33: Data

Pin assignment, function

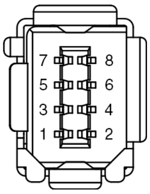
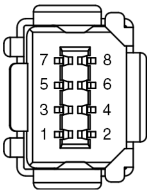
Function	Connection	Signal name	Technical data
Power supply	2.1	24V	Voltage: DC 19.2 … 30 V 1)
Power supply	1.1	0V	Reference potential of power supply
Channel 1 zone error output	1.7	SZE_Ch1	• **High** on both outputs: All nodes are without error • **Low** on both outputs: At least one node has an error See also 2) and chapter "Digital outputs (SZE, SZA, DYN)" on page 471
Channel 2 zone error output	2.7	SZE_Ch2	
Channel 1 zone safety output	1.8	SZA_Ch1	• **High** on both outputs: All nodes are safe • **Low** on both outputs: At least one node is not safe See also 2) and chapter "Digital outputs (SZE, SZA, DYN)" on page 471
Channel 2 zone safety output	2.8	SZA_Ch2	
Safe door locking output, channel 1	1.9	SDL_Ch1	Output pair for controlling a door locking device. When the door latch is correctly controlled, SDL_Ch1 = High and SDL_Ch2 = Low. See also chapter "Digital Outputs (SDL)" on page 473
Safe door locking output, channel 2	2.9	SDL_Ch2	
Channel 1 dynamization output	1.2	DYN_Ch1	**One** output pair for dynamization of the external wiring. To simplify the wiring, the connection of the output pair exists several times. See also 2) and chapter "Digital outputs (SZE, SZA, DYN)" on page 471
Channel 2 dynamization output	2.2	DYN_Ch2	
Channel 1 dynamization output	1.3	DYN_Ch1	
Channel 2 dynamization output	2.3	DYN_Ch2	
Channel 1 dynamization output	1.4	DYN_Ch1	
Channel 2 dynamization output	2.4	DYN_Ch2	
Channel 1 dynamization output	1.5	DYN_Ch1	
Channel 2 dynamization output	2.5	DYN_Ch2	
Channel 1 dynamization output	1.6	DYN_Ch1	
Channel 2 dynamization output	2.6	DYN_Ch2	

1) If the door locking device requires a tighter tolerance of the voltage, the power supply unit used has to comply with the tolerance of the door locking device.

2) If a relay is used, the minimum withstand voltage of the relay has to be > 2 V (2 V = maximum output voltage OFF of the digital output).

Tab. 12-34: Function, pin assignment, properties

X42 and X43, Safe Motion safety technology (communication)

View	Identification	Function
 X42:  X43:	X42 X43	Connection points for connecting the HSZ01 [1)] safety zone module and the safety zone nodes: X42: Input X43: Output
Connection cable	• Maximum total length of **all** cables of a safety zone: **2500 m** • Maximum length of **one** cable between two connection points: **100 m** • Number of safety zone nodes (without HSZ01): – Maximum: 35 – Minimum: 1 • Ready-made cables that can be ordered: – **RKB0061** Short cables to connect devices arranged side by side in the control cabinet. Available lengths: 0.25 m; 0.35 m; 0.55 m Minimum bending radius with permanent routing: 4xD (= 4x6.3 mm = 25.2 mm) Minimum bending radius with flexible routing: 8xD (= 8x6.3 mm = 50.4 mm) Order code for a 0.55 m long cable: RKB0061/00,55 – **RKB0062** Long cables to connect remote communication nodes, also outside of the control cabinet. Available lengths: 1 m, 2 m, 3 m, … 15 m, 20 m, 30 m, 50 m, 75 m, 100 m Minimum bending radius with permanent routing: 4xD (= 4x6.3 mm = 25.2 mm) Minimum bending radius with flexible routing: 8xD (= 8x6.3 mm = 50.4 mm) Order code for a 5 m long cable: RKB0062/005,0 The cables RKB0061 and RKB0062 replace the previously used cables RKB0051 and RKB0052.	

1) See Project Planning Manual "IndraDrive Additional Components and Accessories" (R911306140).

Tab. 12-35: X42, X43

Digital inputs and outputs

Digital inputs

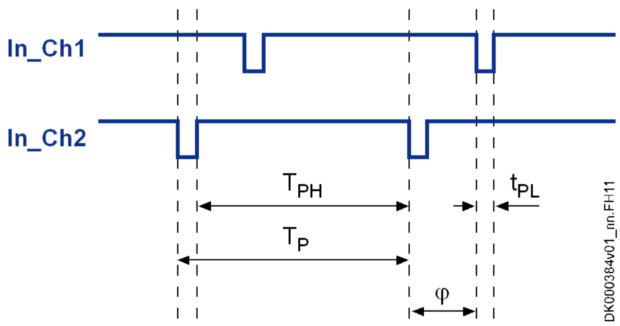
The digital inputs correspond to IEC 61131, type 1.

Data	Unit	min.	max.
Allowed input voltage	V	-3	30
High	V	15	30
Low	V	-3	5
Current consumption	mA	2	5

Tab. 12-36: Digital inputs

Requirements on the time behavior of the input signals

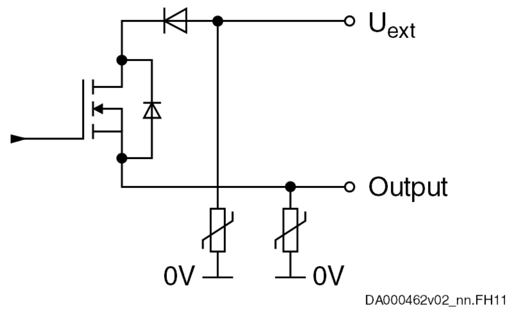
Description	Unit	min.	max.
Test pulse width (t_{PL})	µs	0	1000
Percentage of High time ($T_{PH}/T_P \times 100\%$)	%	90	100
Phase shift between two test pulses on both channels (φ)	ms	-	-



Tab. 12-37: Requirements on the time behavior of the input signals

Digital outputs (SZE, SZA, DYN)

The digital outputs are compatible with digital inputs of types 1, 2 and 3 (IEC 61131).

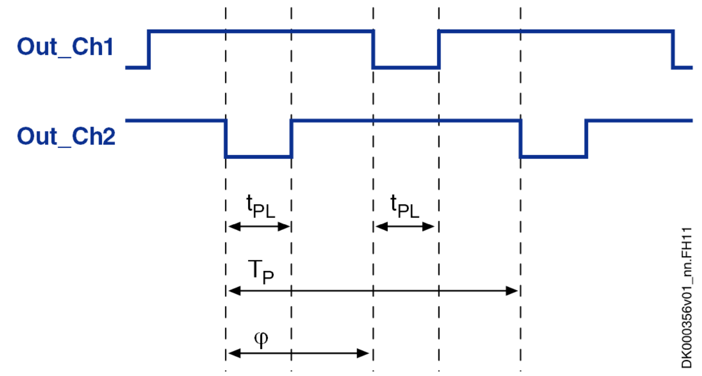
Data	Unit	min.	max.
Output voltage ON	V	U_{ext} - 1	U_{ext}
Output voltage OFF	V		2
Allowed output current per output	mA		350
Allowed energy content of connected inductive loads, e.g. relay coils	mJ		400 [1) 2)]
Capacitive load	nF		320
Short circuit protection		Present	
Overload protection		Present	
Block diagram output:			
Error detection	The following errors are detected: • Wiring error with short circuit to high • Wiring error with short circuit to low • Wiring error with short circuit between the two channels • Internal errors In the case of an error, the control panel shows the corresponding error message: F83xx		

1) At a maximum switching frequency of 1 Hz
2) In the case of inductive loads with currents > 200 mA or in the case of inductive loads with a greater energy content, an external free-wheeling arm has to be installed. The effective terminal voltage has to be < 25 V.

Tab. 12-38: Digital outputs

Time behavior

Description	Unit	min.	max.
SZA/SZE test pulse width (t_{PL})	µs	100	200
DYN test pulse width (t_{PL})	µs	500	1000
Periodic time (T_P)	ms	500	1000
Phase shift between two test pulses on both channels (φ)	ms	50	-



Tab. 12-39: Time behavior

Digital Outputs (SDL)

The digital outputs are compatible with digital inputs of type 1 (IEC 61131).

Data	Unit	min.	typ.	max.
Output voltage ON SDL_Ch1	V	U_{ext} - 1	24	U_{ext}
Output voltage ON SDL_Ch2	V	-		0.5
Output current ON	mA			1250
Output current OFF	mA			0.8
Allowed energy content of connected inductive loads, e.g. relay coils; only allowed as single pulse	mJ			2000 [1] [2]
Short circuit protection		Present		
Overload protection		Present		
Overtemperature protection		Present		
Monitoring of internal switches T_Ch1 and T_Ch_2		Present		

1) With a maximum switching frequency of 0.5 Hz
2) In the case of greater inductive loads, an external free-wheeling arm must be installed. The effective terminal voltage must be < 20 V.

Tab. 12-40: Digital outputs

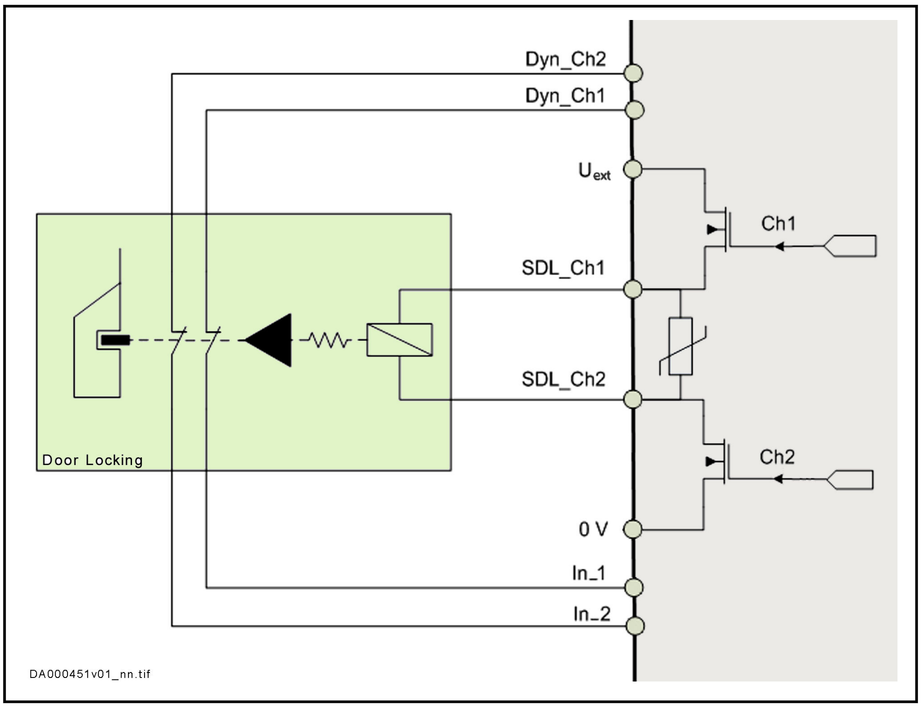


Fig. 12-14: Safe Door Locking SDL

Project planning

LED H2

LED	Color	Description
H2	Off	• Power supply missing • Device defective
	Permanently lit green	Device functions without error
	Flashing red	Errors present: See diagnostic display (e. g. F3152) on the drive controller Fixing: See firmware documentation "Diag. Messages"
	Permanently lit red	• Hardware error • Firmware error • Communication error Diagnostic display: F7033

Tab. 12-41: LED H2

12.5.2 HAS05.1-014, Mounting Plate for Safety Zone Module

Use

As a standard, the safety zone module HSZ01 is equipped to be mounted on a top-hat rail.

The accessories HAS05.1-014-NNN-NN (material number: R911340518) allow mounting the safety zone module HSZ01 without a top-hat rail.

Mounting

1. Remove top-hat rail terminal connectors at the back of safety zone module HSZ01.
2. With supplied screws (M4), screw plate from accessories to back of safety zone module HSZ01 (tightening torque: 1.4 Nm).
3. With supplied screws (M6), mount safety zone module HSZ01 vertically in control cabinet (tightening torque: 6 Nm).

   When mounting the safety zone module HSZ01, observe the minimum distances to be complied with.

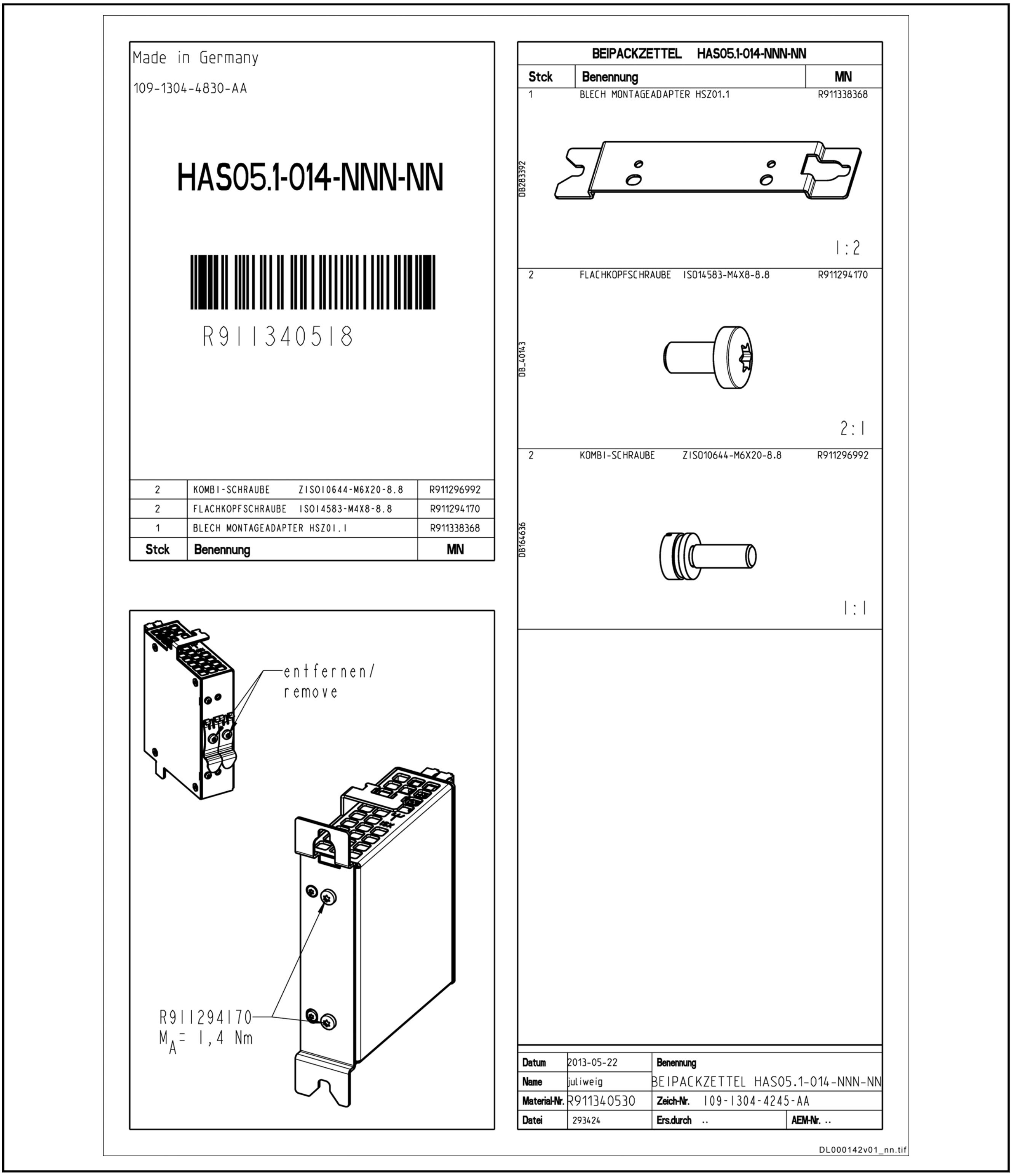


Fig. 12-15: Product Insert

12.5.3 HAT02 - control module for inductive loads

Brief description, use and design

Brief description

The HAT02 control module belongs to the Rexroth IndraDrive product range and complies with the following "Safety Integrity Level" (SIL) and "Performance Level" (PL):

- SIL3 according to EN 61508, IEC EN 62061 and IEC 61800-5-2, with dual-channel selection
- Category 4, PL e according to EN ISO 13849-1, with dual-channel selection

HAT02 control modules are mounted on a top-hat rail in the control cabinet.

Use

Type	Use
HAT02.1-**002**	Safely controlling an inductive load, such as a self-applying motor holding brake, hydraulic/pneumatic valve, contactor.
HAT02.1-**003**	Safely controlling an inductive load, such as a self-applying motor holding brake, hydraulic/pneumatic valve, contactor. *Additional functions:* • Safety-related evaluation of up to two signaling contacts • Adjustable withstand voltage (power reduction) • Adjustable overexcitation time

Tab. 12-42: Use

Operating the HAT02.1-002 and/or HAT02.1-003 control module requires components with the firmware MPx-18 and/or MPx-20V12 or higher, such as Cxx02 or HCS01 control sections.

The Cxx02 control sections must have been manufactured from **production week 14W39** onward (see control section type plate).

The error F8353 occurs with older Cxx02 control sections (production week ≤ 14W38). The error already occurs when the device is switched on. The safe state is always ensured.

C-UL-US listing

The components are listed by **UL** (Underwriters Laboratories Inc.®).

Proof of certification can be found online:

www.ul.com/database

Under "UL File Number" enter the file number or under "Company Name" enter the company name "Bosch Rexroth AG".

Listed **POW. CONV. EQ.** **97Y4** DX000009v01_nn.tif	• UL standard: UL 508C • CSA standard: Canadian National Standard C22.2 No. 274-13
	Company Name BOSCH REXROTH AG Category Name: Power Conversion Equipment
	File numbers Rexroth IndraDrive components: • E134201

Tab. 12-43: C-UL listing

Commissioning

When the HAT02 control module is commissioned, the overall function with the inductive load (e.g. motor holding brake) has to be checked prior to the first safety-relevant use. The drive has to be able to execute the function of the inductive load (e.g. opening and closing a brake) via the HAT02.

Replacing the component

Observe the following aspects when replacing the component:

- The order numbers of the components have to be identical.
- Additionally for HAT02.1-003:

  The positions of the rotary coding switches have to be identical.
- After the installation:

  Make an acceptance test

Project planning

Type code and identification

Type code

Short type designation	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Example:	H	A	T	0	2	.	1	-	0	0	2	-	N	N	N	-	N	N																						
	①			②			③		④				⑤				⑥																							

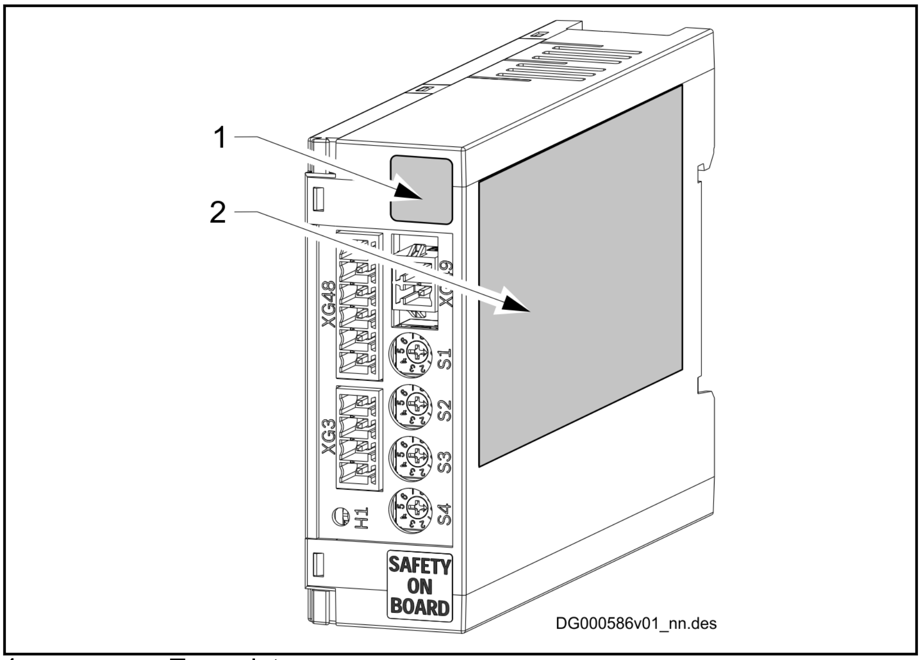
①	**Product:** HAT = Control module for inductive loads
②	**Series:** 02 = 02
③	**Design:** 1 = 1
④	**Brake type:** 002 = Safe switching of inductive loads 003 = Safe switching of inductive loads with state monitoring and overexcitation
⑤	**Other properties:** NNN = None
⑥	**Other design:** NN = None

Tab. 12-44: HAT02 type code

☞ The figure illustrates the basic structure of the type code. Our sales representative will help you with the current status of available versions.

Identification

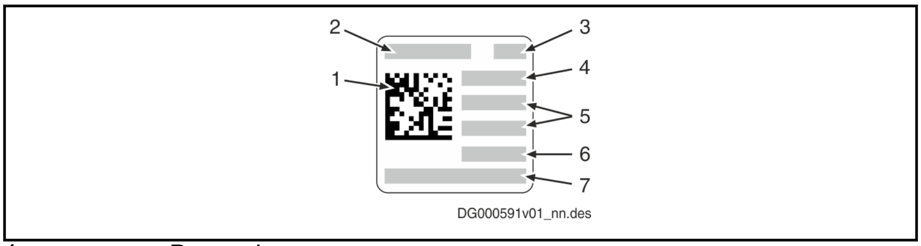
Plates



1 Type plate
2 Data plate

Fig. 12-16: Plates at device

Type plate



1 Bar code
2 Type
3 Hardware index
4 Production week (example: 13W38 means: year 2013, week 38)
5 Material number
6 Factory identifier
7 Serial number

Fig. 12-17: Type plate

Data plate

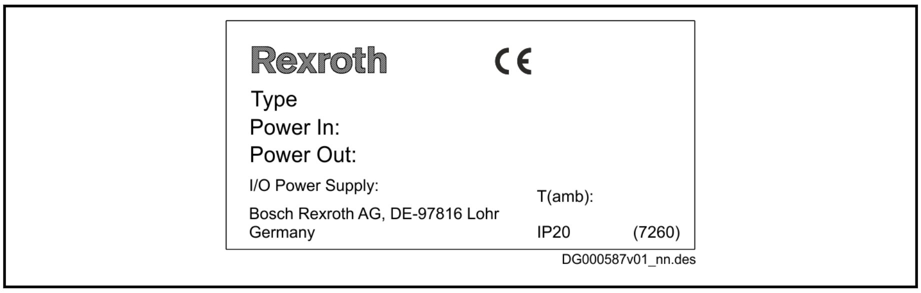


Fig. 12-18: Data plate

Scope of supply

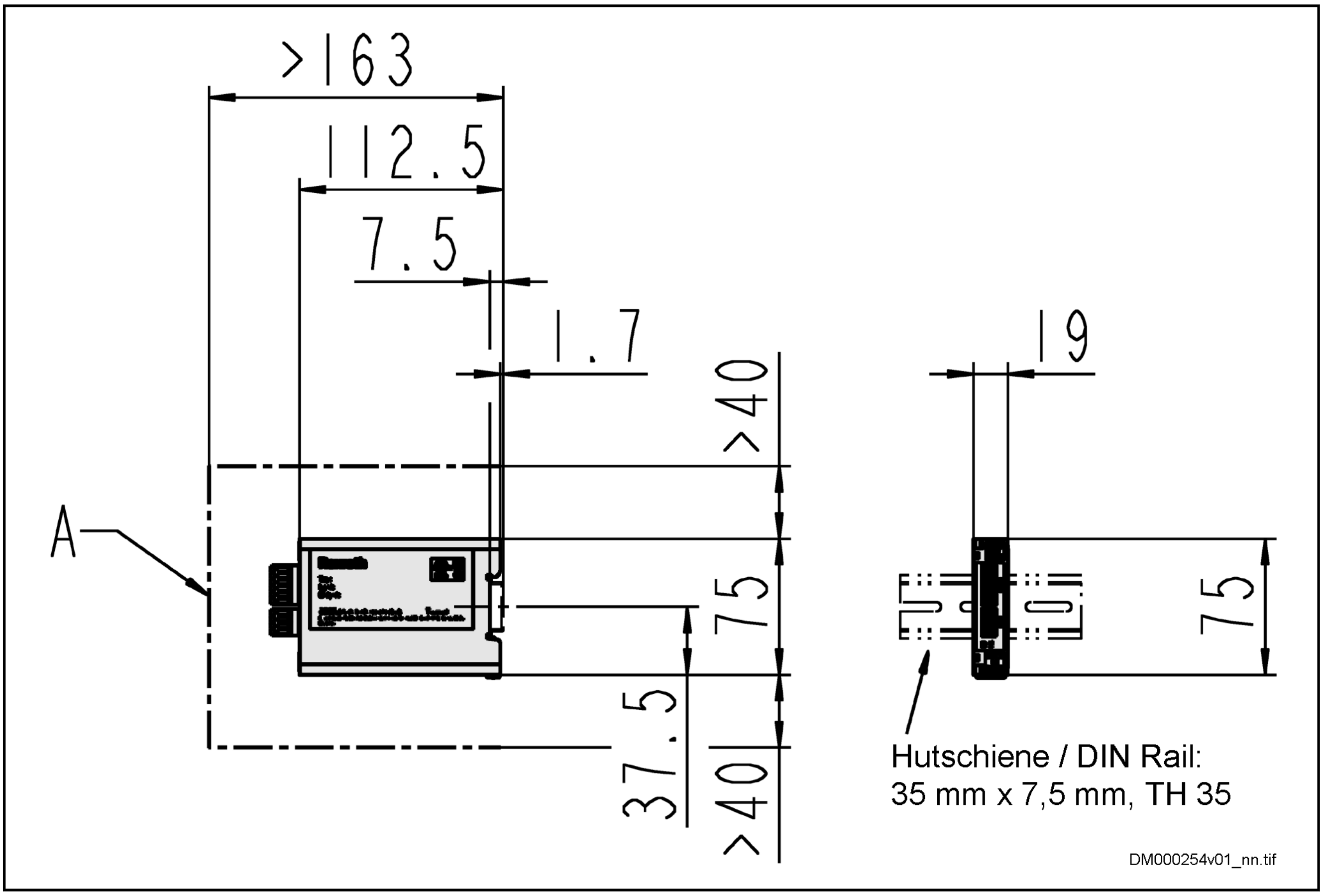
The scope of supply of the HAT02 control module contains:

HAT02.1-002	HAT02.1-003
Connector: XG3, XG48	Connector: XG3, XG48, XG49

Tab. 12-45: Scope of supply HAT02

Dimensions

HAT02.1-002



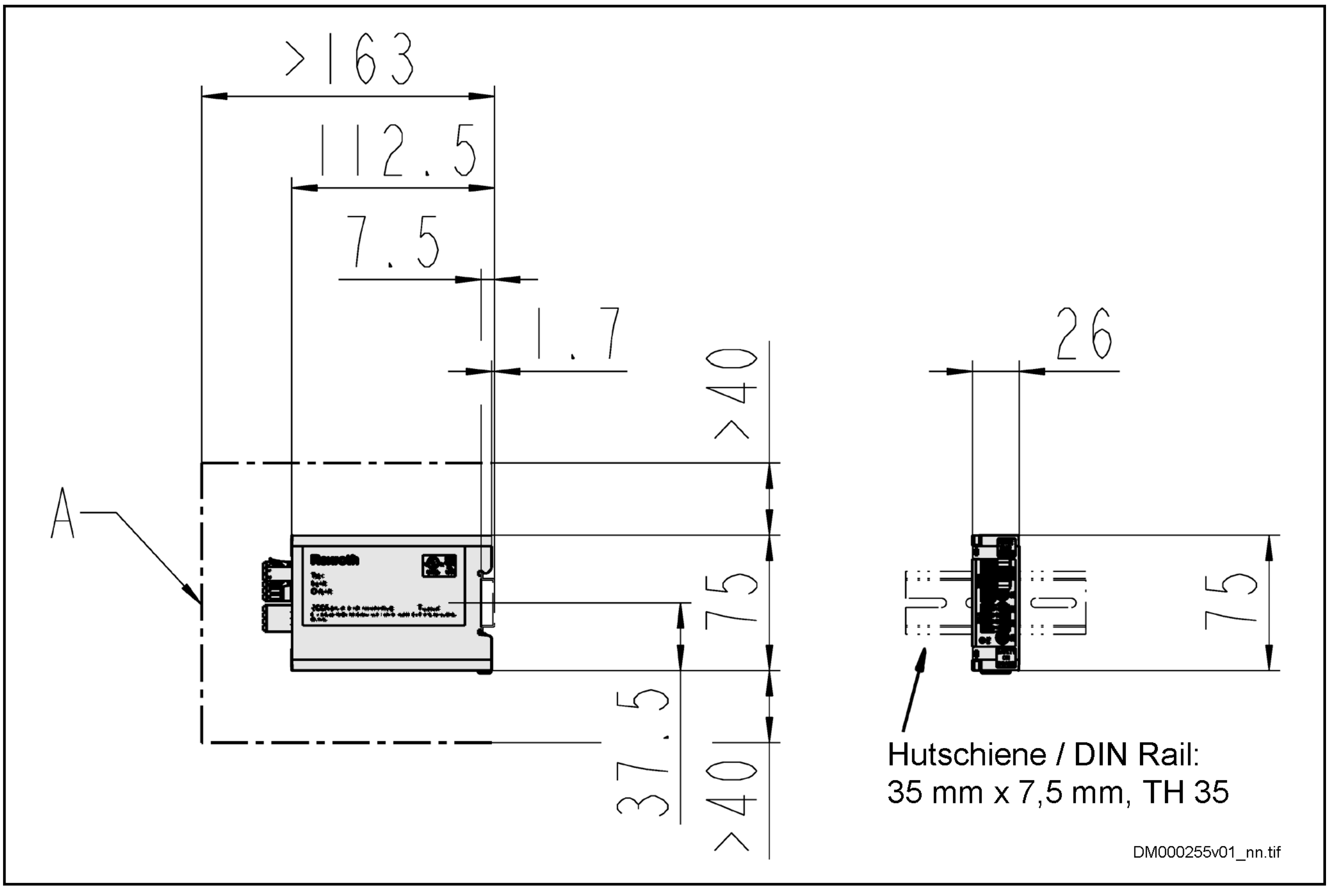
All dimensions in mm

A Minimum mounting clearance

Fig. 12-19: HAT02.1-002, dimensions

Project planning

HAT02.1-003



All dimensions in mm

A Minimum mounting clearance

Fig. 12-20: HAT02.1-003, dimensions

Technical data

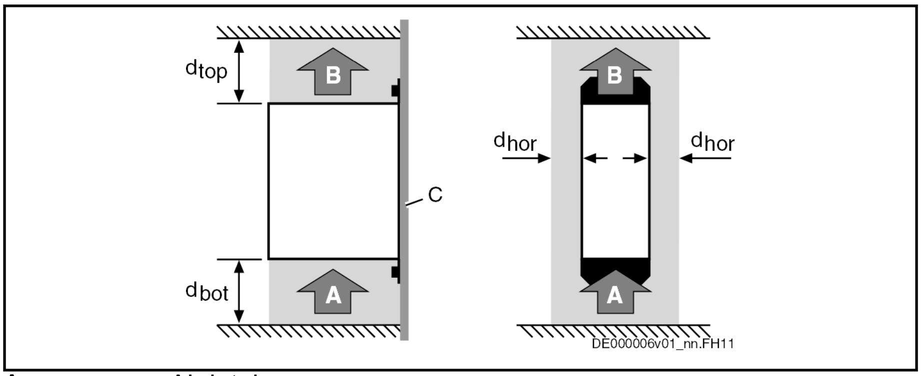
Technical data

Description	Symbol	Unit	HAT02
Mass	m	g	HAT02.1-002: 70 HAT02.1-003: 100
Degree of protection	-	-	IP20
Allowed mounting position	-	-	Vertical
Minimum distance from the top of the device [1)]	d_{top}	mm	40
Minimum distance from the bottom of the device [2)]	d_{bot}	mm	40
Minimum distance on the side of the device	d_{hor}	mm	-
Allowed ambient temperature range	T_{a_work}	°C	0 … 55
Cooling type	-	-	Natural convection

1) 2) See fig. "Air intake and air outlet at device"

Tab. 12-46: HAT02 - technical data

Distances



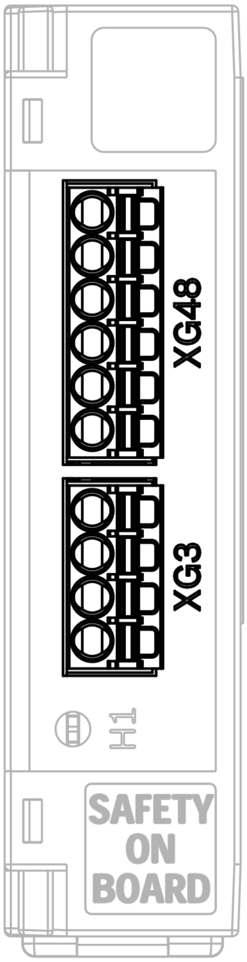
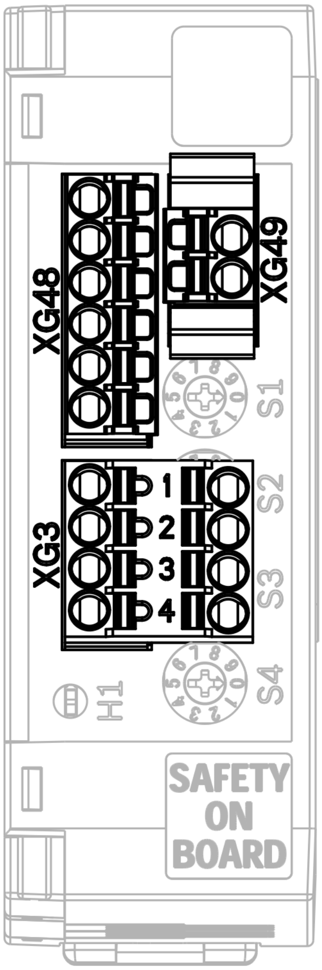
A Air intake
B Air outlet
C Mounting surface in control cabinet
d_{top} Distance top
d_{bot} Distance bottom
d_{hor} Distance horizontal

Fig. 12-21: Air intake and air outlet at device

Project planning

Connection points

Front view

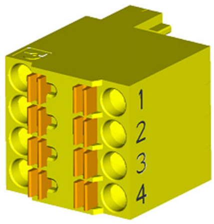
HAT02.1-002-NNN-NN	HAT02.1-003-NNN-NN	Connection point	Description
 DG000584v01_nn.des	 DG000585v01_nn.des	XG3	24 V power supply Brake connection
		XG48	Brake control input Signal exchange with control section
		XG49	Switching state signal input

Tab. 12-47: Connection points

XG3, 24 V power supply, brake connection

⚠ WARNING **In the case of error, injury and property damage due to inadmissibly high voltage!**

For selection and the 24 V supply of devices with integrated safety technology, use a 24 V power supply unit with protection by **SELV**[1] in accordance with IEC 60950-1 or **PELV**[2] in accordance with IEC 60204-1.

View	Connection	Signal name	Function
	1	Brake+	Brake connection
	2	Brake-	
	3	24V_Brake	Control module and brake power supply
	4	0V_Brake	

Tab. 12-48: Pin assignment

Mechanical data

Spring terminal	Unit	min.	max.
Connection cable, stranded wire	mm^2	0.2	1.5
Connection cable	AWG	24	16
Stripped length	mm	10	

Tab. 12-49: Mechanical data

Electrical data (control module and brake power supply)

Description	Symbol	Unit	min.	max.
Voltage input	U_{24V_Brake}	V	19.2 [1]	30
Internal consumption	I_{24V_Brake}	A		0.1
Output driver current consumption	I_{max}	A		6
Polarity reversal protection			Present	

1) Observe allowed voltage tolerance of connected load

Tab. 12-50: Electrical data

1) *Safety Extra Low Voltage*

2) *Protective Extra Low Voltage*

☞ The **power supply** is monitored. The monitored undervoltage threshold is lower than the specified minimum value, and the overvoltage threshold is higher than the specified maximum value.

When selecting the voltage supply of the brake, make sure that it is within the permissible range. Otherwise, the brake may be destroyed.

In the safety concept of the machine, possible faults of the voltage supply are to be taken into consideration. The voltage supply can be indirectly checked by evaluating the feedback contacts attached to the brake.

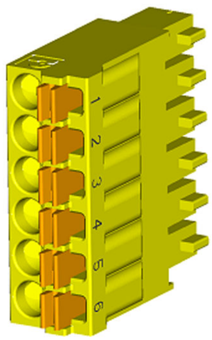
Electrical data (brake control Brake+/Brake-)

Description	Symbol	Unit	min.	max.
Output voltage On (Brake+/Brake-)	U_{On}	V	24V_Brake - 1	24V_Brake [1)]
Output current Off	I_{Off}	mA		5
Output current On	I_{On}	A	0.1	6
Switching frequency at output	f	Hz		1
Energy content inductive load (f ≤ 0.1 Hz)	E_{Ind}	J		18 [2) 3)]
Test pulse duration (switching off) [4)]	$t_{Testpuls}$	µs	100	700
Short circuit protection			Present	
Overload protection			Present	

1) 24V_Brake corresponds to the power supply of the user interface. The voltage is accordingly reduced in the case of operation with voltage reduction.
2) An external connection with < 20 V free-wheeling voltage is required for inductive loads with a greater energy content.
3) A higher switching frequency is possible in the case of a smaller energy content.
4) Free-wheeling voltage during the test: approx. 1 V

Tab. 12-51: Electrical data

XG48, signal exchange with control section, brake control input

View	Connec-tion	Signal name	Function
	1	Ext_SI_bSBC_Ch1	Channel 1 brake control input
	2	0V_EA	Reference potential of diag-nostic inputs and output
	3	Ext_SI_bSBC_Ch2	Channel 2 brake control input
	4	24V_EA	Diagnostic output power sup-ply
	5	Ext_Diag_I_Brake	Channel 1 and channel 2 di-agnostic output
	6	GND	Ground connection

Tab. 12-52: Pin assignment

Mechanical data

Spring terminal	Unit	min.	max.
Connection cable, stranded wire	mm^2	0.2	1.5
Connection cable	AWG	24	16
Stripped length	mm	10	

Tab. 12-53: Mechanical data

Electrical data (power supply for control section signal exchange)

Description	Symbol	Unit	min.	max.
Voltage input	U_{24V_EA}	V	19.2	30
Internal consumption	I_{24V_EA}	mA		5
Output driver current consumption	I_{max}	mA		200
Polarity reversal protection			Present	

Tab. 12-54: Electrical data

The voltage at XG48.4/2 (24V_EA/0V_EA) and the voltage at the drive controller (e.g., X33.1/2) have to be provided by the same voltage source.

Wire the voltage source at the drive controller.

Electrical data (Ext_SI_bSBC_Ch1, Ext_SI_bSBC_Ch2 inputs)

Description	Symbol	Unit	min.	max.
Allowed input voltage	U_{In}	V	-3	30
Input voltage high	U_{In_High}	V	18	30
Input voltage low	U_{In_Low}	V	-3	5
Current consumption	I_{In_High}	mA	4	7
Reference potential			0V_EA	

Tab. 12-55: Electrical data

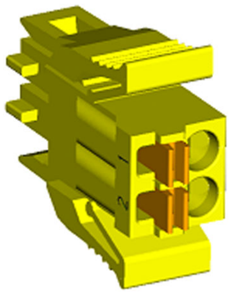
Electrical data (Ext_Diag_I_Brake output)

Description	Symbol	Unit	min.	max.
Output voltage On	U_{On}	V	24V_EA - 1	24V_EA [1)]
Output current Off	I_{Off}	mA		0.1
Output current On	I_{On}	mA		200
Energy content inductive load (f ≤ 1 Hz)	E_{Ind}	mJ		400
Short circuit protection			Present	
Overload protection			Present	
Reference potential			0V_EA	

1) 24V_EA corresponds to the device/brake power supply

Tab. 12-56: Electrical data

XG49, switching state signal input

View	Connection	Signal name	Function
	1	Feedback_1	Input for switching state signal 1; reference potential is XG3.4 (0V_Brake)
	2	Feedback_2	Input for switching state signal 2; reference potential is XG3.4 (0V_Brake)

Tab. 12-57: Pin assignment

Mechanical data

Spring terminal	Unit	min.	max.
Connection cable, stranded wire	mm^2	0.2	1.5
Connection cable	AWG	24	16
Stripped length	mm	10	

Tab. 12-58: Mechanical data

Electrical data (Feedback_1, Feedback_2 inputs)

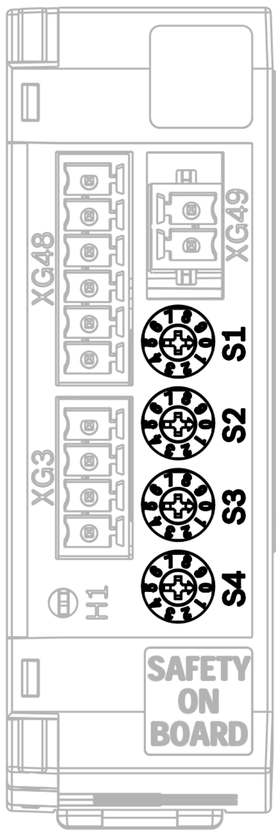
Description	Symbol	Unit	min.	max.
Allowed input voltage	U_{In}	V	-3	30
Input voltage high	U_{In_High}	V	18	30
Input voltage low	U_{In_Low}	V	-3	5
Current consumption 1)	I_{In_High}	mA	7.5	12
Reference potential			0V_Brake	

1) With 24 V, the current consumption is > 10 mA

Tab. 12-59: Electrical data

Rotary coding switches S1, S2, S3, S4 (HAT02.1-003 only)

Overview

HAT02.1-003, rotary coding switch		Function
 DG000588v01_nn.des	S1	Withstand voltage
	S2	Overexcitation duration
	S3	Switching state signal evaluation
	S4	Waiting time

Tab. 12-60: HAT02.1-003, rotary coding switch

☞ The **switch positions** are only read upon system start. If the switch positions are changed, the voltage supply "24V_Brake" at XG3 is to be briefly interrupted subsequently.

The switch positions are to be protected against unintentional adjustment:

- Fix rotary coding switch using adhesive tape or
- Lock control cabinet

S1, withstand voltage

The withstand voltage is set with S1. After the overexcitation duration (S2) is over, the output voltage Brake+/Brake- is reduced by the supply voltage 24V_Brake to the withstand voltage that was set.

This enables 2 functions:

- Overexcitation
- Power reduction

The functions can be combined.

Overexcitation

The voltage applied to the inductive load is higher than the one applied to the nominal voltage. Thus, the load reacts faster. After the overexcitation duration (rotary coding switch S2), the voltage is reduced to the nominal voltage.

☞ If the **set withstand voltage is too high**, the inductive load can thermally overload. This is to be taken into consideration when selecting the inductive load and regarding the safety concept of the machine.

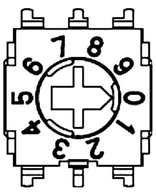
Power reduction

First the nominal voltage is applied to the inductive load for a specified duration (rotary coding switch S2). Afterwards, the voltage is set to a value lower than the nominal voltage. Thereby, the power dissipation at the load can be reduced.

☞ If the **set withstand voltage is too low**, the inductive load may be activated (brake or valve closes). Depending on the generated current, this cannot be detected by the integrated current measurement. The error can be detected via the feedback contacts.

Please note that the **actual withstand voltage at the load** may be lower than the voltage set for XG3 (due to voltage drop at the cable and tolerances of the voltage supply).

The withstand voltage reduction is **not a safety function.**

View	Position	Withstand voltage ±20%
	0	24V_Brake (XG3.3)
	1	95% of 24V_Brake (XG3.3)
	2	90% of 24V_Brake (XG3.3)
	3	85% of 24V_Brake (XG3.3)
	4	80% of 24V_Brake (XG3.3)
	5	70% of 24V_Brake (XG3.3)
	6	60% of 24V_Brake (XG3.3)
	7	50% of 24V_Brake (XG3.3)
	8	40% of 24V_Brake (XG3.3)
	9	30% of 24V_Brake (XG3.3)

Tab. 12-61: S1, withstand voltage

The power supply of the withstand voltage has to be selected in such a way as to guarantee under the worst installation and operation conditions that sufficient voltage is available in order to release the holding brake.

The **voltage drop ΔU on the brake supply lines** can be approximately calculated for copper conductors using the following formula:

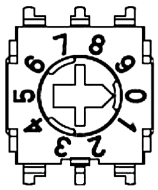
$\Delta U = 2 \times l \times \rho_{Cu} \times I_N \div q$
ΔU: Voltage drop
l: Line length [m]
ρ_{Cu}: Specific resistance copper 0.0178 [$\Omega \times mm^2/m$]
I_N: Rated current [A]
q: Conductor cross-section [mm^2]

Tab. 12-62: Voltage drop ΔU on the brake supply line

S2, overexcitation duration

S2 determines how long the voltage of 24V_Brake (XG3.3) is applied to the inductive load before the selected withstand voltage (S1) has been reached.

Prerequisite: Position of switch S1 ≠ 0.

View	Position	Overexcitation duration [s] ±10%
	0	0.02
	1	0.04
	2	0.08
	3	0.15
	4	0.3
	5	0.6
	6	1
	7	1.5
	8	2
	9	2.5

Tab. 12-63: S2, overexcitation duration

S3, switching state signal evaluation

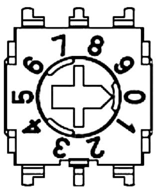
Signaling contacts directly mounted to the mechanics allow checking whether a brake or a valve has really switched or not.

Examples of signaling contacts: Microswitch, proximity switch, Hall sensor

The 24 V power supply of the signaling contacts has to have the same ground reference as 24V_Brake and 0V_Brake.

The S3 position depends on the type (N/C-N/O contact) and state (open/closed) of the signaling contacts.

A maximum of 2 signaling contacts can be connected at XG49. An error in the feedback signal leads to the drive error F8353.

View	Position	Evaluation [3)]
	0	N/C Feedback_1, N/O Feedback_2 (closed and open) [1)]
	1	N/C Feedback_1, N/C Feedback_2 (closed and open) [1)]
	2	N/C Feedback_1 (closed and open) [1)]
	3	N/O Feedback_1 (closed and open) [1)]
	4	N/C Feedback_1, N/O Feedback_2 (closed) [2)]
	5	N/C Feedback_1, N/C Feedback_2 (closed) [2)]
	6	N/C Feedback_1 (closed) [2)]
	7	N/O Feedback_1, N/O Feedback_2 (closed and open) [1)]
	8	Reserved
	9	Evaluation switched off [4)]

1 Evaluation with brake applied (currentless) and with brake released
2 Evaluation with brake applied (currentless)
3 N/C-N/O: Contact or PNP output
4 In this switch position it is not allowed to apply feedback signals to X49.

Tab. 12-64: S3, switching state signal evaluation

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

An error detected by evaluation leads to the system error F8353 which causes the axis to be decelerated and STO to be selected. In the case of an error when applying the brake, the motor would thus not have available energy.

Take this into consideration for the safety review of the function, in particular for non-redundant holding systems.

☞ The switching state monitoring is intended for error detection (diagnosis) of the Safe brake control SBC.

By evaluating the feedback contacts in HAT02.1-003, a diagnostic coverage of DC = 60% (low) can be obtained for a brake with accordingly suitable feedback contacts.

S4, waiting time

During the transition of the inductive load from the inactivated state to the activated state, or vice versa, it is necessary to wait for a certain time before the switching state signals can be evaluated. This time is the waiting time.

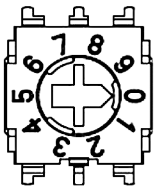
The **waiting times** of self-applying motor holding brakes are as follows:

- $(t_{V\_On\_max} + t_{Br\_Off\_max}) \times f$
- $(t_{V\_Off\_max} + t_{Br\_On\_max}) \times f$

The higher one of the two determined values is decisive for the waiting time.

Description	Significance
$t_{V\_On\_max}$	Maximum valve ON time (if brake controlled via a hydraulic/ pneumatic valve)
$t_{V\_Off\_max}$	Maximum valve OFF time (if brake controlled via a hydraulic/ pneumatic valve)
$t_{Br\_On\_max}$	Maximum clamping delay of brake
$t_{Br\_Off\_max}$	Maximum release delay of brake
f	Factor (see data sheet of brake)

Tab. 12-65: Data for determining the waiting time

View	Position	Waiting time [s]
	0	0.02
	1	0.03
	2	0.05
	3	0.09
	4	0.15
	5	0.3
	6	0.6
	7	1.2
	8	2.5
	9	5

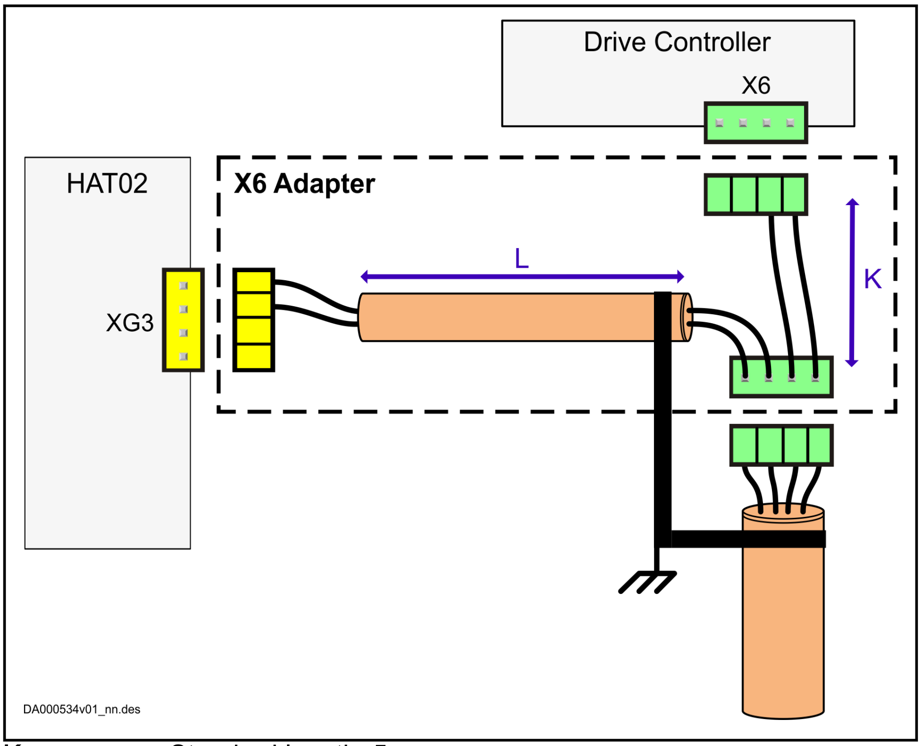
Tab. 12-66: S4, waiting time

In the case of an active evaluation of signaling contacts at the load (switching state signal S3 = 0 … 7), the delay times stored in the parameters "S-0-206, Drive on delay time" and "S-0-207, Drive off delay time" have to be set as follows:

- "S-0-0206, Drive on delay time" ≥ waiting time × 1.1 + 20 ms
- "S-0-0207, Drive off delay time" ≥ waiting time × 1.1 + 20 ms

X6 adapter (RKL0091, RKL0092)

When a motor holding brake is wired via the motor cable, the motor holding brake connections are diverted at the drive controller and connected to the HAT02 control module via a shielded connection. The shield is connected at one end to the motor cable shield at the drive controller.



K Standard length: 5 cm
L Length: depending on the application

Fig. 12-22: X6 adapter for diverting the motor holding brake connections

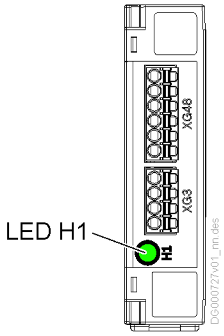
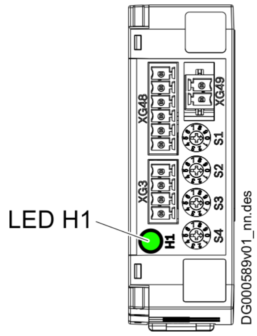
Depending on the drive controller performance, there are two types:

Type A	Type B
HMS01.1N-W0020 … -W0070 HMS02.1N-W0028, -W0054 HCS02.1E-W0012 … -W0070 HMD01.1N-W0012 … -W0036 HCS03.1E-W0070 Order code: RKL0091 (R911347795)	HMS01.1N-W0100 … -W0350 HCS03.1E-W0100 … -W0350 Order code: **RKL0092** (R911369814)

Tab. 12-67: X6 adapter, types

Project planning

LED H1

HAT02.1-002	HAT02.1-003
	

Tab. 12-68: LED H1

HAT02.1-002 with hardware index < AC1				
LED		Significance	Action	Reset [1)]
	Off	24 V voltage is missing	Check supply voltage	
		Device defective	Replace device	
	Green	Device ready for operation		
	Flashing green	Supply voltage (24V_Brake) outside of tolerance range	Check supply voltage	R
	Flashing green-yellow	Overtemperature	Check ambient temperature	R
	Yellow	Wiring error at Brake+ or Brake- 24V_Brake outside of tolerance range during boot-up	Check Brake+/- wiring Check supply voltage	PO
		Wire break at Brake+/-	Check Brake+/- wiring	R
		Short circuit Brake+ against 0V	Check Brake+/- wiring	PO
		Short circuit Brake+ against Brake-	Check Brake+/- wiring	PO
	Flashing yellow	Load current too high	Check current consumption at Brake+/-	PO
	Red	Device defective	Replace device	PO
	Flashing red	Error on interface to drive controller	Check XG48 wiring	PO
		Error in load control	Check Brake+/- wiring	R
		Device defective	Replace device	PO

1) **R:** Reset via drive; **PO:** "Power Off/On"; switch supply voltage (24V_Brake) off and back on

Tab. 12-69: LED display (HAT02.1-002)

HAT02.1-003; HAT02.1-002 with hardware index ≥ AC1			
LED	Significance	Action [2]	Reset [1]
Off --	Supply voltage missing	Check supply voltage	-
	Device defective	Replace device	-
Green GN	Without errors	-	-
Flashing green 8× GN -- GN -- GN -- GN -- GN -- GN -- GN -- GN	Bake driver status evaluation error	Check Brake+/- wiring	R
Flashing green 7× GN -- GN -- GN -- GN -- GN -- GN -- GN	Unexpected feedback	Check wiring at Feedback 1 and Feedback 2	R
Flashing green 6x GN -- GN -- GN -- GN -- GN -- GN	Overvoltage at 24V_Brake	Check supply voltage	R
Flashing green 5x GN -- GN -- GN -- GN -- GN	Overvoltage at 24V_Brake	Check supply voltage	R
Flashing green 4x GN -- GN -- GN -- GN	Overtemperature	Check ambient temperature	R
Flashing green 3x GN -- GN -- GN	Wire break at Brake+/-	Check Brake+/- wiring	R
Flashing green 2x GN -- GN	Faulty level of switching state signals Feedback 2	Check wiring at Feedback 2	R
Flashing green 1x GN	Faulty level of switching state signals Feedback 1	Check wiring at Feedback 1	R
Flashing red 6x RD -- RD -- RD -- RD -- RD -- RD	Wiring error at Brake+ or Brake-	Check Brake+/- wiring	PO
	24V_Brake outside of tolerance range during bootup	Check supply voltage	
Flashing red 5x RD -- RD -- RD -- RD -- RD	Short circuit Brake+ against 0V	Check Brake+/- wiring	PO
Flashing red 4x RD -- RD -- RD -- RD	Overload (load current too high)	Check current consumption at Brake+/-	PO
Flashing red 3x RD -- RD -- RD	Invalid switch position	Check switch position	PO

HAT02.1-003; HAT02.1-002 with hardware index ≥ AC1			
LED	Significance	Action 2)	Reset 1)
Flashing red 2x RD -- RD	Error on interface to drive controller	Check XG48 wiring	PO
Flashing red 1x RD	Error in load control	Check Brake+/- wir-ing	R
Red RD	HAT02 defective	Replace HAT02	PO

1) R = Reset at the drive system (HAT02 does not save);
PO = Switch off reset by supply HAT02 (24V_Brake), then switch back on and reset at the drive controller

2) In case no error was detected during the described action: Re-place HAT02

Tab. 12-70: LED display (HAT02.1-003)

The **error state** is displayed as long as the error is present. At least, however, until the SBC function is deselected the next time.

An error state detected by HAT02 is saved in the drive system and generates the error "F8353 SBC system error". The error has to be acknowledged at the drive controller.

12.5.4 Cables

The ready-made cables RKB0061/RKB0062 are available for connecting the safety zone module HSZ01 and the safety zone nodes.

See "X42 and X43, safety technology Safe motion (communication)"

Length	Order code	Material number
0.25 m	RKB0061/00,25	R911372773
0.35 m	RKB0061/00,35	R911372772
0.55 m	RKB0061/00,55	R911372771
1 m	RKB0062/001,0	R911372775
2 m	RKB0062/002,0	R911372776
3 m	RKB0062/003,0	R911372777
4 m	RKB0062/004,0	R911372779
5 m	RKB0062/005,0	R911372780
6 m	RKB0062/006,0	R911372781
7 m	RKB0062/007,0	R911372782
8 m	RKB0062/008,0	R911372783
9 m	RKB0062/009,0	R911372784
10 m	RKB0062/010,0	R911372785
11 m	RKB0062/011,0	R911372786

Length	Order code	Material number
12 m	RKB0062/012,0	R911372787
13 m	RKB0062/013,0	R911372788
14 m	RKB0062/014,0	R911372789
15 m	RKB0062/015,0	R911372790
20 m	RKB0062/020,0	R911372791
30 m	RKB0062/030,0	R911372792
50 m	RKB0062/050,0	R911372793
75 m	RKB0062/075,0	R911372794
100 m	RKB0062/100,0	R911372795

Tab. 12-71: Ordering information

Technical data of the bulk cable[1)] for RKB0061 and RKB0062

Description	Symbol	Unit	
Cable description			Highly flexible Industrial Ethernet cable Cat.5e
Brief description of cable			4x2x AWG26/19
RoHS			Compliant with EU Directive 2011/65/EU
Recognized UL and CSA			cURus; UR+CSA UL file no. E244280
AWM Style			21576
Diameter	D	mm	6.3
Cross section, control cores		mm^2	0.1
Cable jacket, material			PUR (weakly adhesive, matt) (acc. to EN 50363-10-2)
Cable jacket, color			Black
Specific cable weight	m	kg/m	48
Temperature range, storage		°C	-30 ... +80
Ambient temperature, operation (permanent routing)		°C	-30 ... +80
Ambient temperature, operation (flexible routing)		°C	-20 ... +70
Leakage capacitance	$C_{Y\_K\_typ}$	nF/m	48
Characteristic impedance at 20°C	Z	ohm/km	284
Operational voltage, control cores	V_{peak}	V	125
Halogens			Halogen-free acc. to VDE 0472, Part 815
Oil resistance			EN 60811-2-1 and EN 50363-10-2
Flammability			UL 758, section 40, Cable Flame Test Section 1061 acc. to UL 1581 and CSA C22.2 No. 210-05 Sec. 8.8.2 test according to EN 60332-1-2
Flexible cable tracks			
Suitable for application in flexible cable tracks			Yes
Bending cycles			5 million
Bending radius with flexible routing		mm	8 x D
Bending radius with permanent routing		mm	4 x D
Maximum acceleration [2)]	a_{max}	m/s²	3
Maximum travel velocity[2)]	v	m/s	3
Bending and torsional stress		°/m	up to ±180 (subject to correct installation)
			Last modification: 2017-06-23

1) The bulk cable is provided by a third-party manufacturer and thus cannot be ordered individually. The technical data apply to the bulk cable of the RKB0061 and RKB0062 cable types

2) Flexible cable track parameters: Maximum values only apply individually

Tab. 12-72: Technical data - bulk cable

13 Service and support

Our worldwide service network provides an optimized and efficient support. Our experts offer you advice and assistance should you have any queries. You can contact us **24/7**.

Service Germany

Our technology-oriented Competence Center in Lohr, Germany, is responsible for all your service-related queries for electric drive and controls.

Contact the **Service Hotline** and **Service Helpdesk** under:

Phone:	**+49 9352 40 5060**
Fax:	**+49 9352 18 4941**
E-mail:	service.svc@boschrexroth.de
Internet:	http://www.boschrexroth.com

Additional information on service, repair (e.g. delivery addresses) and training can be found on our internet sites.

Service worldwide

Outside Germany, please contact your local service office first. For hotline numbers, refer to the sales office addresses on the internet.

Preparing information

To be able to help you more quickly and efficiently, please have the following information ready:

- Detailed description of malfunction and circumstances
- Type plate specifications of the affected products, in particular type codes and serial numbers
- Your contact data (phone and fax number as well as your e-mail address)

Glossary

Appropriate use of a machine

Use of a machine in compliance with the information made available in the user information.

Category

Classification of the safety-related parts of a control system in respect of their resistance to faults and their subsequent behaviour in the fault condition, and which is achieved by the structural arrangement of the parts, fault detection and/or by their reliability (EN ISO 13849-1).

Configuration

"Configuration" describes a specific combination of optional modules to form a configured control section which is ideally suited for the intended application.

AND

"Configuration" is used in conjunction with the parameterization of functions.

Connection point of equipment grounding conductor

The connection point of the equipment grounding conductor is the connection point at which the equipment grounding conductor is fixed to the component. The connection point is identified with the ⏚ icon.

Control panel

The control panel is the complete unit for operation; it contains input and output elements, such as a key panel and a display.

CSos

"CSos" is the abbreviation of "CIP safety on sercos", the safe channel in sercos.

Diagnostic coverage (DC)

Measure for the effectiveness of the diagnosis, which can be determined as the relation of the failure rate of detected dangerous failures and the failure rate of the total of dangerous failures.

NOTE 1: The diagnostic coverage can apply to the entirety or to parts of the safety-related system. For example, there might be a diagnostic coverage for the sensors and/or the logic system and/or the actuators.

NOTE 2: According to IEC 61508-4:2010, term 3.8.6.

Drive controller

Device with which a motor can be operated. Umbrella term for converter or inverter.

Drive system

The drive system comprises all components from mains supply to motor shaft. It consists of the components supply unit, power section with control section incl. firmware, as well as motor and required additional components and corresponding system connections.

DYN

"DYN" is the abbreviation of the digital outputs for monitoring the wiring.

Dynamization

Optional module "Safe Motion": Dynamization is to detect static error states in the safety-relevant circuits. Dynamization takes place automatically in the background without having an effect on the safety function or the standard drive functions.

Electric drive system

An electric drive system is the entirety of hardware and software components that have an influence on the sequence of motions of the machine. The electric drive system consists of, for example, drive controllers, plug-in control units, supply modules, motors and encoders.

EMERGENCY STOP (stopping process in case of an emergency)

An emergency operation which is destined to halt a process or motion that has become dangerous.

Equipment grounding conductor

The equipment grounding conductor establishes the conductive connection from the connection point of the equipment grounding conductor of the component to the equipment grounding system.

Equipment grounding system

The equipment grounding system is the entire equipment by which the equipment grounding conductors of components are connected to the equipment grounding conductor of the mains. In the majority of cases, an earth-circuit connector belongs to the equipment grounding system.

Failure

Termination of the ability of an item to perform a required function [IEC 60050-191:1990, 04-01].

NOTE 1: After failure, the item has a fault.

NOTE 2: "Failure" is an event, as distinguished from "fault", which is a state.

NOTE 3: The concept as defined does not apply to items consisting of software only.

NOTE 4: Failures which only concern the availability of the process to be controlled are not within the field of application of this part of ISO 13849.

Fault

State of an item characterized by inability to perform a required function, excluding the inability during preventive maintenance or other planned actions, or due to lack of external resources (IEC 60050-191:1990, 05-01).

NOTE 1: A fault is often the result of a failure of the item itself, but may exist without prior failure.

NOTE 2: In this part of ISO 13849, the term "fault" means random fault.

FMEA (Failure Mode and Effects Analysis)

The FMEA is an analytical method of preventive quality assurance. It helps to identify potential failure modes, recognize and evaluate their severity, and in due time initiate appropriate measures to prevent or detect them. The systematic analysis and elimination of failure modes result in the minimization of risk, the reduction of failure costs and improved reliability.

Functional safety

Part of the overall safety relating to the EUC and the EUC control system that depends on the correct functioning of the E/E/PE safety-related systems and other risk reduction measures (IEC 61508-4:2010, 3.1.12).

EUC: Equipment, machinery, apparatus or plant used for manufacturing, process, transportation, medical or other activities (IEC 61508-4:2010, 3.2.1).

EUC control system: System that responds to input signals from the process and/or from an operator and generates output signals causing the EUC to operate in the desired manner (IEC 61508-4:2010, 3.3.3).

IndraDrive Service Tool (IDST)

"IndraDrive Service Tool" is a web-based diagnostic tool that allows the user to establish a connection to IndraDrive devices. Details on the supported hardware components, information on firmware versions, serial numbers and manufacturer codes can be displayed. With the "service" user account, additional functions, such as the replacement of drive components, are available.

Interrupting circuit

An interrupting circuit is the point of access that can be used for switching the drive or installation off. In the case of drive controllers, the interrupting circuit is used, for example, for switching off the output stage.

NOTE: Switching off in a safe way requires 2 interrupting circuits.

Key panel

The key panel is part of the control panel. For example, converters can be controlled via the keys of the key panel.

Master communication

Master communication is the specific communication between hierarchical communication levels. Through master communication, command variables (e.g., command values) are transmitted from a higher-level control unit to receivers, and actual values, for example, are transmitted back to the control unit.

Mean time to failure

[Mean time to failure ($MTTF_d$)]; expected value of the mean time to failure.

NOTE: According to IEC 62061:2005, term 3.2.34.

Mode selector

The mode selector determines the operation mode relevant for safe operation, like for example:

- Normal operation (productive operation, automatic operation etc.) and

- Special mode (manual mode, tool or workpiece change and cleaning process)

The selected type of control has to be on a higher level than all other control functions - except for the one for the emergency control device. The mode selector can be replaced by other means of selection which allow only certain groups of operators to carry out certain machine functions (e.g., access code for certain numerical control functions etc.). Each position of the mode selector may only correspond to one control mode or operation mode. (For details see Machinery Directive 2006/42/EG, annex I, chapter 1.2.5.).

MTTF

See "Mean time to failure"

Operating stop

Operating stop is the state in which the mechanical component is kept at rest and the motor is supplied with energy, i.e. it is under torque or under force.

Performance Level (PL)

Discrete level which specifies the ability of safety-related parts of a control system to carry out a safety function under predictable conditions.

PFH (Probability of dangerous Failure)

Average probability of dangerous failure within an hour (DIN EN 62061)

PL

See "Performance Level (PL)"

Protective measure

Measure intended to achieve risk reduction [EXAMPLE 1 Implemented by the designer: Inherently safe design, safeguarding and complementary protective measures, information for use. EXAMPLE 2 Implemented by the user: By organization (safe working procedures, supervision, permit-to-work systems), provision and use of additional safeguards (use of personal protective equipment; training)].

NOTE: According to ISO 12100:2011, term 3.19.

Required performance level

[Required performance level (PL_r)]; performance level (PL) applied to achieve the required risk minimization for each safety function.

Residual risk

Residual risk is the risk remaining after protective measures have been taken [according to ISO 12100:2011, 3.13].

Risk

Combination of the probability of occurrence of harm and the severity of that harm (ISO 12100:2011, 3.12).

Risk analysis

The risk analysis is the combination of the specification of the limits of the machine, hazard identification and risk estimation (ISO 12100:2011, 3.15).

Risk assessment

Overall process comprising a risk analysis and a risk evaluation (ISO 12100:2011, 3.17).

Risk evaluation

Judgement, on the basis of risk analysis, of whether the risk reduction objectives have been achieved (ISO 12100:2011, 3.16).

Safe Motion

See "SMO"

Safe Torque Off

See "STO"

Safety Integrity Level (SIL)

Discrete level (one out of a possible four) specifying the safety integrity values of the safety functions assigned to the E/E/PE safety-related systems, where safety integrity level 4 has the highest level of safety integrity and safety integrity level 1 has the lowest (IEC 61508-4:2010, 3.5.8).

SBC

"SBC" is the abbreviation of the safety function "Safe brake control".

SBT

"SBT" is the abbreviation of the safety function "Safe brake check".

SCA

"SCA" is the abbreviation of the safety function "Safe CAM".

SCM

"SCM" is the abbreviation of the "SMO configuration mode" state.

SDI

"SDI" is the abbreviation of the safety function "Safe direction".

SDL
"SDL" is the abbreviation of the safety function "Safe door locking".

SLE
"SLE" is the abbreviation of the safety function "Safely-limited end position".

SLI
"SLI" is the abbreviation of the safety function "Safely-limited increment".

SLP
"SLP" is the abbreviation of the safety function "Safely-limited position".

SLS
"SLS" is the abbreviation of the safety function "Safely-limited speed".

SLS-LT
"SLS-LT" is the abbreviation of the safety function "Safely-monitored transient oscillation".

SMD
"SMD" is the abbreviation of the transition function "Safely-monitored deceleration".

SMES
"SMES" is the abbreviation of the special mode "EMERGENCY STOP".

SMM
"SMM" is the abbreviation of the special mode "Safe motion"

SMO
"SMO" is the abbreviation of "Safe motion". The integrated safety technology "Safe motion" provides the user with universally parameterizable safe motion monitoring or standstill monitoring.

SMP
"SMP" is the abbreviation of the safety function "Safely-monitored position"

SMS
"SMS" is the abbreviation of the safety function "Safe maximum speed"

SMST
"SMST" is the abbreviation of the special mode "Safe standstill"

SOM
"SOM" is the abbreviation of the state "SMO operating mode"

SOS
"SOS" is the abbreviation of the safety function "Safe operating stop"

SPM
"SPM" is the abbreviation of the state "SMO parameterization mode"

SS1
"SS1" is the abbreviation of the transition function "Safe stop 1"

SS2
"SS2" is the abbreviation of the transition function "Safe stop 2"

STO
"STO" is the abbreviation of the safety function "Safe torque off"

Stop categories according to EN 60204-1
- Category 0: Stopping process by immediately switching off power supply to the drives.

- Category 1: Controlled stopping process; power supply to the drives is maintained in order to achieve stopping process. Power is only cut off when standstill has been reached.

- Category 2: Controlled stopping process; power supply to the drives is maintained.

SZA
"SZA" is the abbreviation of the safety function "Safety zone acknowledge"

SZE
"SZE" is the abbreviation of the safety function "Safe zone error"

TUNID
"TUNID" is the abbreviation of "Target Unique Identifier". The TUNID (also called "Target UNID") is used to unequivocally identify an axis for Safety bus communication.

Verification display
The parameter verification is carried out in IndraWorks via the bottom sections of the Safe Motion dialogs ("Verification display").

All parameter values of the dialog are displayed which were changed but have not yet been verified. For this purpose, the corresponding parameter content is read from the drive and displayed. In the main section of the dialog, the entered value of the parameter is still displayed. Changed and unverified parameter settings are marked with a yellow "!" in the dialog (see the example of parameter verification for assigning the SMO axis identifier: fig. 9-6 "Parameter verification" on page 304).

Parameter values that were written have to be verified by visual control and confirmation (**Apply** button). This, too, applies when the parameter is written again with the same value, because safety technology cannot distinguish whether the same value is actually to be written, or whether the user had entered a different value that was altered during transmission.

TIP: If more parameters need to be verified than can be displayed, the Apply button is grayed out. The button only becomes active again when the user has compared all parameter values by using the scrollbar.

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Notes

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