ACOPOSmulti SafeMOTION

User's manual

Version: **3.00 (2015-01-21)**
Model no.: **MAACPMSAFEMC-ENG**

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Chapter 1 • General information

1 Manual history

Information:

This user's manual is only valid together with the ACOPOSmulti user's manual (MAACPM-ENG) and the Integrated Safety user's manual (MASAFETY-ENG)!

Information:

B&R keeps user's manuals as current as possible.
From a safety standpoint, however, the current version from the B&R website must be used (www.br-automation.com).

<table>
<tr><th>Version</th><th>Date</th><th>Comment</th></tr>
<tr><td>3.00</td><td>2015-01-21</td><td>Start of revision history publication
Merged user's manuals ACOPOSmulti SafeMC EnDat 2.2 V2.4 and ACOPOSmulti with SafeMC SinCos V1.1: ACOPOSmulti SafeMOTION
The same model number (MAACPMSAFEMC) applies to ACOPOSmulti SafeMOTION.
<table>
<tr><th>Version</th><th>Date</th><th>Comment</th></tr>
<tr><td>1.00</td><td>2010-03-26</td><td>Start of revision history publication</td></tr>
<tr><td>2.2</td><td>2012-03-19</td><td>Updated manual for Safety Release 1.4.</td></tr>
<tr><td>2.3</td><td>2012-09-24</td><td>"General information" chapter: Added disclaimer.
Chapter "System characteristics": Added "Detection of errors within the module".
Chapter "Safety technology / Integrated safety technology in the ACOPOSmulti with SafeMC / The safe power transmission system": Updated "Encoder options and danger notice".
Chapter "Safety technology / Safety characteristics": Added danger warning for measuring instruments.</td></tr>
<tr><td>2.4</td><td>2014-02-17</td><td>Chapter "General information / Protection against touching electrical parts": Updated danger warning.
Chapter "ACOPOSmulti with SafeMC": Added information about motor and encoder cables sorted by model number and danger warning about safe motor holding brake (X4A/X4B connectors).
Chapter "ACOPOSmulti with SafeMC / Overview": Added additional PE connection for 8BVE expansion modules.
Chapter "Safety technology / The safe power transmission system": Added information about motor cables.
Chapter "Safety technology / Principle - Implementing safety functions": Changed danger warning.
Chapter "Safety technology / Safe motor holding brake output": Added danger warning about safe motor holding brake output.
Chapter "Safety technology / Encoder mounting with proof of fatigue strength": Changed title (previously: Fault exclusion).
Chapter "Safety technology / Encoder mounting without proof of fatigue strength – Safe lag error monitoring": Shared content with ACOPOSmulti with SafeMC SinCos user's manual (previously: Safe monitoring without fault exclusion).
Chapter "Safety technology / Safety-related characteristic values of integrated safety functions": Updated description of Safe Operating Stop (SOS).
Chapter "Safety technology / Integrated safety functions": Added SafePosition, SafeSpeed.
Chapter "Safety technology / Parameters in the I/O configuration of the SafeMC module": Removed group "General, Parameters".
Chapter "Safety technology / Programming the safety application": Added SBT with reference to ACOPOSmulti SafeMC SinCos, shared content.
Chapter "Safety technology / Programming the safety application / SafeMC Help Tool": Updated Safe Brake Test (SBT).
Chapter "Safety technology / Application in SafeDESIGNER": Added reference to ACOPOSmulti SafeMC SinCos, shared content.
Chapter "Safety technology / ACOPOSmulti parameter IDs": Shared content with ACOPOSmulti SafeMC SinCos, update.
Chapter "Safety technology / SafeMC library": Optimized and restructured description, added SBT (shared content with ACOPOSmulti SafeMC SinCos).
Chapter "Safety technology / Replacing a safe encoder/motor": Shared content with ACOPOSmulti with SafeMC SinCos user's manual.
Chapter "PLCopen safety / SF_SafeMC_BR_V2": "Integrated safety functions" section identical to "Integrated safety functions" section in "Safety technology" chapter.
Chapter "PLCopen safety / Encoder mounting with proof of fatigue strength": Shared content with ACOPOSmulti with SafeMC SinCos user's manual (previously: Fault exclusion).</td></tr>
</table>
Table 2: Manual history - ACOPOSmulti SafeMC EnDat 2.2</td></tr>
</table>

Table 1: Manual history

<table>
<tr><th>Version</th><th>Date</th><th>Comment</th></tr>
<tr><td></td><td></td><td>
<table>
<tr><th>Version</th><th>Date</th><th>Comment</th></tr>
<tr><td></td><td></td><td>Chapter "PLCopen safety / Encoder mounting without proof of fatigue strength – Safe lag error monitoring": Shared content with ACOPOSmulti with SafeMC SinCos user's manual (previously: Safe monitoring without fault exclusion).
Chapter "Standards and certifications" Removed EN 954-1, change ...in accordance with IFA (previously BGIA)... 2/2012, Additional environmental limit values in accordance with EN 61800-2: Removed footnote.</td></tr>
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Table 2: Manual history - ACOPOSmulti SafeMC EnDat 2.2

<table>
<tr><th>Version</th><th>Date</th><th>Comment</th></tr>
<tr><td>1.0</td><td>September 2013</td><td>Start of revision history publication</td></tr>
<tr><td>1.1</td><td>February 2014</td><td>Chapter "Safety technology / Integrated safety functions / Safe Position, Safe Speed: Changed danger warnings, changed information, added example.
Chapter "Safety technology / Programming the safety application / SafeMC Help Tool": Updated Safe Brake Test (SBT).
Chapter "Standards and certifications" change ...in accordance with IFA (previously BGIA)... 2/2012</td></tr>
<tr><td></td><td>March 2014</td><td>Chapter "Safety technology / Safety requirements for SinCos measuring instruments:
... Requirements from the "Error list for movement and position sensors in accordance with EN 61800-5-2:2007", Table D.16
... Performance level (PL) of the encoder with diagnosis of encoder evaluation
... Safety integrity level (SIL) of the encoder with diagnosis of encoder evaluation
"Excerpt" removed, replaced with "in accordance with..."; error list table: Added footnote regarding linear encoders.</td></tr>
</table>

Table 3: Manual history - ACOPOSmulti SafeMC SinCos
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</table>

Table 1: Manual history

1.1 Publications

Model number	Medium	Contents
MAACPMSAFEMC-ENG	Electronic	Complete
MAACPM-ENG	Electronic	Complete
MASAFETY-ENG	Electronic	Complete

Table 4: Publications

1.2 Release information

<table>
<tr><th>Manual version</th><th>Valid for</th></tr>
<tr><td>V3.00</td><td>SafeMOTION Safety Release 1.9
<table>
<tr><th>Manual version</th><th>Valid for</th></tr>
<tr><td>V1.00</td><td>Safety Release 1.3</td></tr>
<tr><td>V2.2
V2.3
V2.4</td><td>Safety Release 1.3 and Safety Release 1.4</td></tr>
</table>

Table 6: ACOPOSmulti SafeMC EnDat 2.2 - Release information

<table>
<tr><th>Manual version</th><th>Valid for</th></tr>
<tr><td>V1.0</td><td>Safety Release 1.4 to Safety Release 1.7 - ACOPOSmulti with SafeMC SinCos</td></tr>
</table>

Table 7: ACOPOSmulti with SafeMC SinCos - Release information
</td></tr>
</table>

Table 5: Release information

2 Safety guidelines

2.1 Organization of safety notices

Safety notices in this manual are organized as follows:

Safety notice	Description
Danger!	Disregarding these safety guidelines and notices can be life-threatening.
Warning!	Disregarding these safety guidelines and notices can result in severe injury or substantial damage to equipment.
Caution!	Disregarding these safety guidelines and notices can result in injury or damage to equipment.
Information:	This information is important for preventing errors.

Table 8: Description of the safety notices used in this documentation

2.2 General information

B&R drive systems and servo motors have been designed, developed and manufactured for conventional use in industrial environments.

They were not designed, developed and manufactured for any use involving serious risks or hazards that could lead to death, injury, serious physical damage or loss of any kind without the implementation of exceptionally stringent safety precautions.

In particular, such risks and hazards include the use of these devices to monitor nuclear reactions in nuclear power plants, their use in flight control or flight safety systems as well as in the control of mass transportation systems, medical life support systems or weapons systems.

Servo drives, inverter modules and frequency inverters from B&R are not dual-use goods in accordance with EU regulation 428/2009 | 3A225.

Danger!

Drive systems and servo motors can have exposed parts with voltages applied (e.g. terminals) or hot surfaces. Additional hazards include moving machine parts. The removal of required covers, inappropriate use of the devices or their improper installation or operation can result in severe personal injury or damage to property.

All tasks such as the transport, installation, commissioning and servicing of devices are only permitted to be carried out by qualified personnel. Qualified personnel are those familiar with the transport, mounting, installation, commissioning and operation of devices who also have the appropriate qualifications (e.g. IEC 60364). National accident prevention regulations must be observed.

The safety notices, connection descriptions (type plate and documentation) and limit values listed in the technical data are to be read carefully before installation and commissioning and must be observed.

Danger!

The improper handling of drive systems and servo motors can cause severe personal injury or damage to property!

2.3 Qualified personnel

Use of safety-related products is restricted to the following persons:

- Qualified personnel who are familiar with relevant safety concepts for automation technology as well as applicable standards and regulations
- Qualified personnel who plan, develop, install and commission safety equipment in machines and systems

Qualified personnel in the context of this manual's safety guidelines are those who, because of their training, experience and instruction combined with their knowledge of relevant standards, regulations, accident prevention guidelines and operating conditions, are qualified to carry out essential tasks and recognize and avoid potentially dangerous situations.

In this regard, sufficient language skills are also required in order to be able to properly understand this manual.

2.4 Intended use

Servo drives are components designed to be installed in electrical systems or machines. They are not permitted to be used unless the machine meets directive 2006/42/EC (machinery directive) as well as directive 2004/108/EC (EMC directive).

Drive systems are only permitted to be operated directly on grounded, three-phase industrial mains (TN, TT power mains). When used in residential areas, shops or small businesses, additional filter measures must be implemented by the user.

> **Danger!**
>
> **Drive systems are not permitted to be operated directly on IT and TN-S mains with a grounded phase conductor and protective ground conductor!**

Technical data as well as connection and environmental specifications can be found on the type plate and in this user's manual. Specifications regarding connection and environmental conditions must be observed!

> **Danger!**
>
> **Electronic devices are never completely failsafe. If the drive systems fails, the user is responsible for making sure that the motor is brought to a secure state.**

2.5 Disclaimer

It is the user's responsibility to clarify guidelines for the use of safety-related B&R components with the respective authorities and to ensure these guidelines are met.

B&R will not assume warranty or liability for damages that occur due to:

- Improper use
- Non-observance of standards and guidelines
- Unauthorized modifications to devices, connections and settings
- Operation of unauthorized or unsuitable devices or device groups
- Failure to follow the safety notices covered in this manual

2.6 Protection against electrostatic discharge

Electrical components that can be damaged by electrostatic discharge (ESD) must be handled accordingly.

2.6.1 Packaging

Electrical components with a housing do not require any special ESD packaging, but they must still be handled properly (see section 2.6.2 "Guidelines for proper ESD handling" on page 16).

Electrical components without a housing are protected by ESD-suitable packaging.

2.6.2 Guidelines for proper ESD handling

Electrical components with a housing

- Do not touch the connector contacts on connected cables.
- Do not touch the contact tips on circuit boards.

Electrical components without a housing

The following applies in addition to the points listed under "Electrical components with a housing":

- Any persons handling electrical components or devices with installed electrical components must be grounded.
- Components are only permitted to be touched on their narrow sides or front plate.
- Components should always be stored in a suitable medium (ESD packaging, conductive foam, etc.). Metallic surfaces are not suitable storage surfaces!
- Components should not be subjected to electrostatic discharge (e.g. through the use of charged plastics).
- Ensure a minimum distance of 10 cm from monitors and TV sets.
- Measuring instruments and equipment must be grounded.

- Probes on potential-free measuring instruments must be discharged on sufficiently grounded surfaces before taking measurements.

Individual components

- ESD protective measures for individual components are thoroughly integrated at B&R (conductive floors, footwear, arm bands, etc.).
- These increased ESD protective measures for individual components are not necessary for customers handling B&R products.

2.7 Transport and storage

During transport and storage, devices must be protected against undue stress (mechanical loads, temperature, moisture, corrosive atmospheres, etc.).

Drive systems contain components sensitive to electrostatic charges that can be damaged by inappropriate handling. It is therefore necessary to provide the required protective measures against electrostatic discharge when installing or removing these drive systems.

2.8 Handling and installation

> **Warning!**
>
> **B&R drive systems and servo motors can be heavy.**
>
> **During handling and installation of heavy B&R drive systems or servo motors, there is therefore the danger of personal injury or damage to equipment (through shearing, impacts, cutting or crushing). Suitable protective equipment (e.g. safety glasses, protective gloves, safety shoes, etc.) must be used whenever necessary!**

Installation must be performed according to this documentation using suitable equipment and tools.

Devices are only permitted to be installed by qualified personnel without voltage applied. Before installation, voltage to the control cabinet must be switched off and prevented from being switched on again.

General safety guidelines and national accident prevention regulations (e.g. VBG 4) for working with high voltage systems must be observed.

Electrical installation must be carried out according to applicable guidelines (e.g. line cross sections, fuses, protective ground connections, see also 5 "Dimensioning" on page 141).

2.9 Operation

2.9.1 Protection against touching electrical parts

> **Danger!**
>
> **To operate drive systems, it is necessary for certain parts to carry dangerous voltage levels over 42 VDC. Touching one of these parts can result in a life-threatening electric shock. This could lead to death, severe injury or damage to equipment.**

Before turning on a drive system, it is important to ensure that the housing is properly connected to ground (PE rail). Ground connections must be established even when testing or operating the drive system for a short time!

Before turning the device on, all parts that carry voltage must be securely covered. During operation, all covers and control cabinet doors must remain closed.

> **Danger!**
>
> **If an application uses the safety functions integrated in the drive system, then the safety functions must be fully validated before being turned on for the first time. Failure to do so could lead to death, severe injury or damage to equipment.**

Control and power connections can still carry voltage even if the motor is not turning. Touching these connections when the device is switched on is prohibited.

Before performing any work on drive systems, they must first be disconnected from the power mains and prevented from being switched on again.

> ## Danger!
>
> **Dangerously high voltage**
>
> **Before performing service work, disconnect the power supply and wait 5 minutes to ensure that the capacitors have discharged. Observe regulations!**
> **This delay time of 5 minutes begins as soon as all of the synchronous motors connected to the drive system that has been disconnected from the supply have come to a standstill. If the synchronous motors are not stationary when the drive system is disconnected from the supply, then the delay time must be extended accordingly.**

ACOPOSmulti modules are labeled with the following warning:

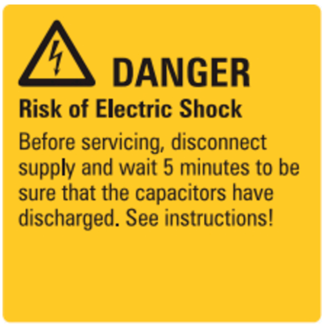


Figure 1: Warning sticker on the ACOPOSmulti module

The connections for drive system signal voltages ranging from 5 to 30 V are safely isolated circuits. The signal voltage connections and interfaces are therefore only permitted to be connected to devices or electrical components that have sufficient isolation in accordance with IEC 60364-4-41 or EN 61800-5-1 and that correspond to SELV / PELV or class DVC A safety extra-low voltage in accordance with EN 61800-5-1.

Never remove the electrical connections from the drive system with voltage applied. In some cases, electric arcs may occur that can cause personal injury and/or damage to contacts.

2.9.2 Protection against hazardous movements

> ## Danger!
>
> **Improper control of motors can result in unintended hazardous movements! Such incorrect behavior can have various causes:**
>
> - **Incorrect installation or mishandling of components**
> - **Improper or incomplete wiring**
> - **Defective devices (drive system, motor, position encoder, cables, brake)**
> - **Incorrect control (e.g. caused by software error)**

Some of the errors listed above can be detected and prevented by the drive system's internal monitoring. Nevertheless, it is still possible for the motor shaft to move any time the device is switched on! For this reason, higher-level safety precautions need to be put in place to ensure that personnel and machines are protected.

The moving parts on machines must be shielded in such a way as to prevent unintentional access by personnel. This type of protection can be achieved by using stable mechanical protective equipment such as protective covers, protective fences, protective gates or photoelectric sensors.

Removing, bypassing or circumventing these protective measures and entering the area where movement takes place is prohibited.

A sufficient number of emergency stop switches must be installed in direct proximity to the machine and be easily accessible at all times. This emergency stop equipment must be checked before the machine is commissioned.

On free running motors, the shaft key (if present) must be removed or measures taken to prevent its ejection. The holding brake built into motors cannot prevent hoisting equipment from dropping hanging loads.

2.10 Functional safety data and specifications

Specifications for individual safety functions are listed in the section 3 "Safety-related characteristic values of integrated safety functions " on page 190.

Specifications are calculated based on a proof test interval of maximum 20 years. Since a proof test cannot be carried out for B&R drive systems, the proof test interval is the same as the system's mission time.

In accordance with the EN ISO 13849, EN 62061 and IEC 61508 standards, the safety functions described in the section 4 "Safety technology" on page 166 cannot be used beyond the specified mission time.

Danger!

Operating ACOPOSmulti SafeMOTION inverter modules beyond the specified mission time is not permitted!

The user must ensure that all ACOPOSmulti SafeMOTION inverter modules are replaced by new ACOPOSmulti SafeMOTION inverter modules or removed from operation before their mission time expires.

3 Environmentally friendly disposal

All B&R drive systems and servo motors are designed to inflict as little harm as possible on the environment.

3.1 Separation of materials

It is necessary to separate different materials so the device can undergo an environmentally friendly recycling process.

Component	Disposal
Drive systems, servo motors, cables	Electronic recycling
Cardboard box / Paper packaging	Paper/Cardboard recycling

Table 9: Environmentally friendly separation of materials

Disposal must comply with applicable legal regulations.

Chapter 2 • ACOPOSmulti SafeMOTION

1 Configuration of an ACOPOSmulti drive system

The ACOPOSmulti drive system consists of a mounting plate, various modules (power supply, auxiliary supply, inverter, expansion and capacitor modules), plug-in modules as well as a line filter and – only in combination with 8BVP active power supply modules – a regeneration choke.

There are 10 steps necessary to configure the ACOPOSmulti:

1. Determine the cooling method.
2. Define or verify the supply voltage range and mains type.
3. Select the ACOPOSmulti inverter modules according to the application requirements.
4. Select the ACOPOSmulti plug-in modules for the motor encoder and external axis encoder according to the application requirements.
5. Determine if it should be possible to extend the ACOPOSmulti drive system:
   If so, determine the number of optional slots on the mounting plate for other ACOPOSmulti modules
6. Select ACOPOSmulti power supply modules according to the application requirements (active/passive power supply module) based on the total power of the ACOPOSmulti inverter modules needed (derating information must be taken into consideration if the supply voltage <3x 400 VAC)
7. Check the maximum chargeable DC bus capacitance.
8. Select the ACOPOSmulti auxiliary supply module based on the total power required for the 24 VDC supply of the selected ACOPOSmulti module, ACOPOSmulti plug-in modules as well as the peripheral supply (e.g. PLC, actuators, motor holding brakes, sensors)

   > **Danger!**
   >
   > **ACOPOSmulti auxiliary supply modules (8B0C0320Hx00.00A-1) must not be used in combination with ACOPOSmulti SafeMOTION inverter modules!**

9. Determine the total number of slots by adding the widths of all selected ACOPOSmulti modules (including optional slots).
10. Select the ACOPOSmulti mounting plate according to the total number of slots required and specified cooling method.

2 Status indicators

Status indicators are located on the black cover of each module.

2.1 8BVI SafeMOTION inverter modules

2.1.1 Single-axis modules

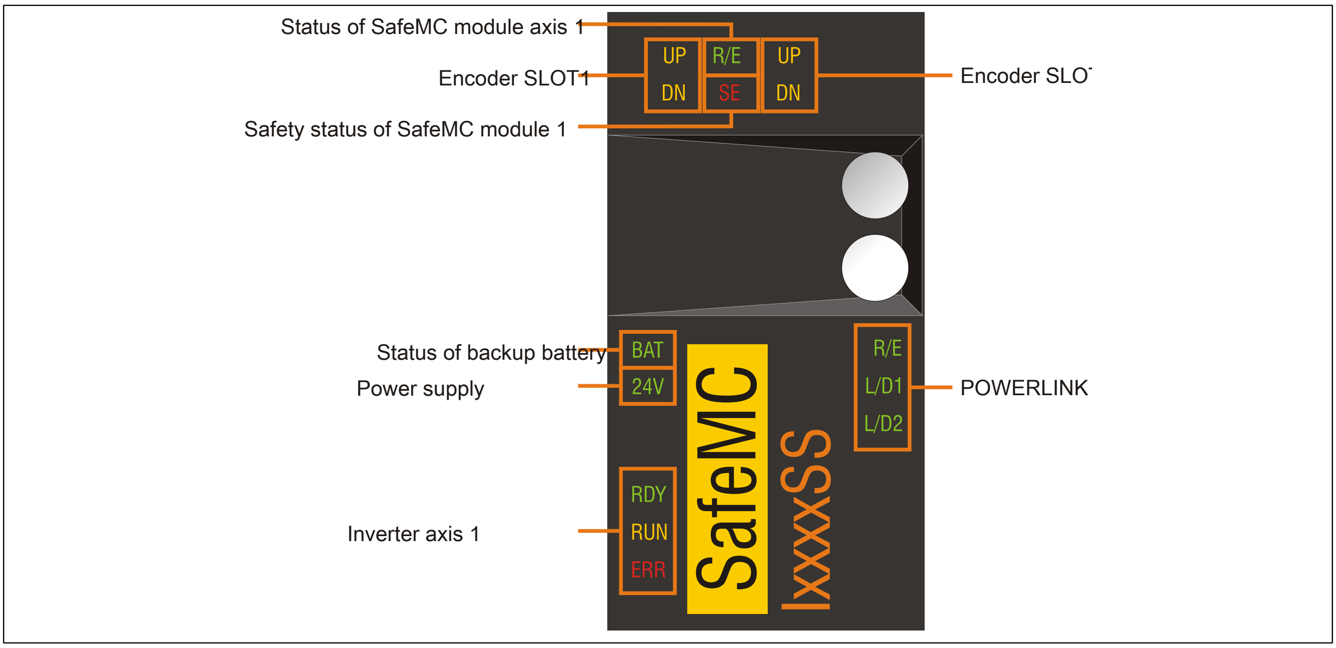


Figure 2: 8BVI SafeMOTION inverter modules (single-axis modules) - Status indicator groups

2.1.1.1 LED status indicators

Status indicator group	Labeling	Color	Function	Description
POWERLINK	R/E	Green/Red	Ready/Error	see "POWERLINK - LED status indicators" on page 23
	L/D1	Green	Link/Data activity on port 1	
	L/D2		Link/Data activity on port 2	
Inverter axis 1	RDY	Green	Ready	see "RDY, RUN, ERR (8BVI, 8BVP, 8B0P) - LED status indicators" on page 23
	RUN	Orange	Run	
	ERR	Red	Error	
Status of backup battery	BAT	Green/Red	Ready/Error	see "Backup battery - LED status indicators (ACOPOSmulti SafeMOTION EnDat 2.2)" on page 23
Power supply	24 V	Green	24 V OK	The 24 V module supply voltage is within the tolerance range.
Encoder SLOT1	UP	Orange	Encoder direction of rotation +	Indicates that the position of the connected encoder is changing in the positive direction. The faster the encoder position changes, the brighter the LED is lit.
	DN		Encoder direction of rotation -	Indicates that the position of the connected encoder is changing in the negative direction. The faster the encoder position changes, the brighter the LED is lit.
Encoder SLOT2	UP	Orange	Encoder direction of rotation +	see Encoder SLOT1
	DN		Encoder direction of rotation -	
Status of SafeMOTION module axis 1	R/E	Green/Red	Ready/Error	see "SafeMOTION module - LED status indicators" on page 24
Safety status of SafeMOTION module 1	SE	Red	Safe/Error	

Table 10: 8BVI SafeMOTION inverter modules (single-axis modules) - LED status indicators

2.1.2 Dual-axis modules

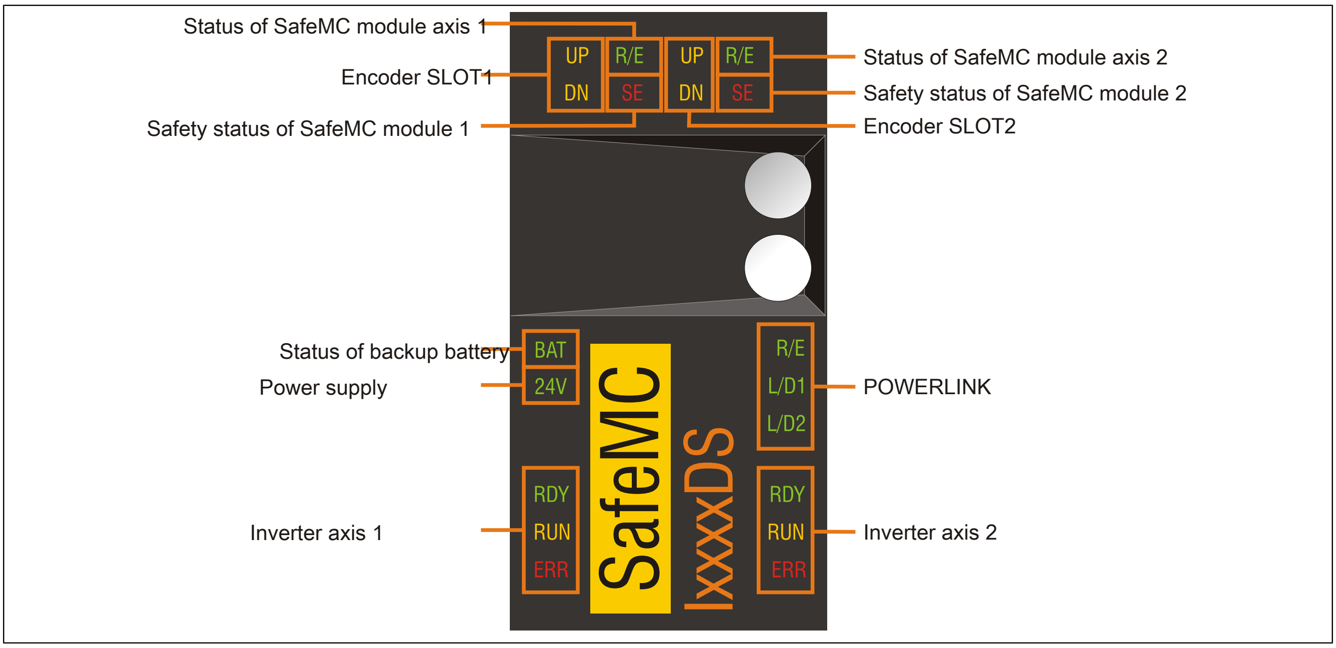


Figure 3: 8BVI SafeMOTION inverter modules (two-axis modules) - Status indicator groups

2.1.2.1 LED status indicators

Status indicator group	Labeling	Color	Function	Description
POWERLINK	R/E	Green/Red	Ready/Error	see "POWERLINK - LED status indicators" on page 23
	L/D1	Green	Link/Data activity on port 1	
	L/D2		Link/Data activity on port 2	
Inverter axis 1	RDY	Green	Ready	see "RDY, RUN, ERR (8BVI, 8BVP, 8B0P) - LED status indicators" on page 23
	RUN	Orange	Run	
	ERR	Red	Error	
Inverter axis 2	RDY	Green	Ready	See inverter axis 1
	RUN	Orange	Run	
	ERR	Red	Error	
Status of backup battery	BAT	Green/Red	Ready/Error	see "Backup battery - LED status indicators (ACOPOSmulti SafeMOTION EnDat 2.2)" on page 23
Power supply	24 V	Green	24 V OK	The 24 V module supply voltage is within the tolerance range.
Encoder SLOT1	UP	Orange	Encoder direction of rotation +	Indicates that the position of the connected encoder is changing in the positive direction. The faster the encoder position changes, the brighter the LED is lit.
	DN		Encoder direction of rotation -	Indicates that the position of the connected encoder is changing in the negative direction. The faster the encoder position changes, the brighter the LED is lit.
Encoder SLOT2	UP	Orange	Encoder direction of rotation +	see Encoder SLOT1
	DN		Encoder direction of rotation -	
Status of SafeMOTION module axis 1	R/E	Green/Red	Ready/Error	see "SafeMOTION module - LED status indicators" on page 24
Safety status of SafeMOTION module 1	SE	Red	Safe/Error	
Status of SafeMOTION module axis 2	R/E	Green/Red	Ready/Error	
Safety status of SafeMOTION module 2	SE	Red	Safe/Error	

Table 11: 8BVI SafeMOTION inverter modules (two-axis modules) - LED status indicators

2.1.3 RDY, RUN, ERR (8BVI, 8BVP, 8B0P) - LED status indicators

Labeling	Color	Function	Description	
RDY	Green	Ready	Green (lit)	The module is operational and the power stage can be enabled (operating system present and booted, no permanent or temporary errors).
			Green (blinking) [1]	The module is not ready for operation. **Examples:** • No signal on one or both enable inputs • DC bus voltage outside the tolerance range • Overtemperature on the motor (temperature sensor) • Motor feedback not connected or defective • Motor temperature sensor not connected or defective • Overtemperature on the module (IGBT junction, heat sink, etc.) • Disturbance on network
RUN	Orange	Run	Orange (lit)	The module's power stage is enabled.
ERR	Red	Error	Red (lit) [1]	There is a permanent error on the module. **Examples:** • Permanent overcurrent • Invalid data in EPROM

Table 12: RDY, RUN, ERR (8BVI, 8BVP, 8B0P) - LED status indicators

1) Firmware V2.130 and higher.

2.1.4 POWERLINK - LED status indicators

Labeling	Color	Function	Description	
R/E	Green/Red	Ready/Error	LED not lit	The module is not receiving power or initialization of the network interface has failed.
			Red (lit)	The POWERLINK station number of the module is 0.
			Red/Green, blinking	The client is in an error state (drops out of cyclic operation).
			Green (blinking) (single)	The client detects a valid POWERLINK frame on the network.
			Green (blinking) (2x)	Cyclic operation on the network is taking place, but the client itself is not yet a participant.
			Green (blinking) (3x)	Cyclic operation of the client is in preparation.
			Green (lit)	The client is participating in cyclic operation.
			Green (flickering)	The client is not participating in cyclic operation and also does not detect any other stations on the network participating in cyclic operation.
L/D1	Green	Link/Data activity on port 1	Green (lit)	A physical connection has been established to another station on the network.
			Green (blinking)	Activity on port 1
L/D2	Green	Link/Data activity on port 2	Green (lit)	A physical connection has been established to another station on the network.
			Green (blinking)	Activity on port 2

Table 13: POWERLINK - LED status indicators

2.1.5 Backup battery - LED status indicators (ACOPOSmulti SafeMOTION EnDat 2.2)

Labeling	Color	Function	Description	
BAT	Green/Red	Ready/Error	LED not lit	**Possible causes:** • The voltage of the installed backup battery is within the tolerance range, but an EnDat encoder with backup battery is not connected. • A battery-backed EnDat encoder is connected and registering "Battery OK", but the module's firmware version does not support EnDat encoders with battery backup.
			Green (lit)	A battery-backed EnDat encoder is connected and registering "Battery OK" (voltage of the installed backup battery is within the tolerance range).
			Red (lit)	A battery-backed EnDat encoder is connected and registering "Battery not OK". **Possible causes:** • Voltage of the installed backup battery outside of tolerance range • No backup battery installed in module

Table 14: Backup battery - LED status indicators

2.1.6 SafeMOTION module - LED status indicators

There are 3 additional LEDs for each safe axis behind the front cover of an ACOPOSmulti SafeMOTION inverter module:

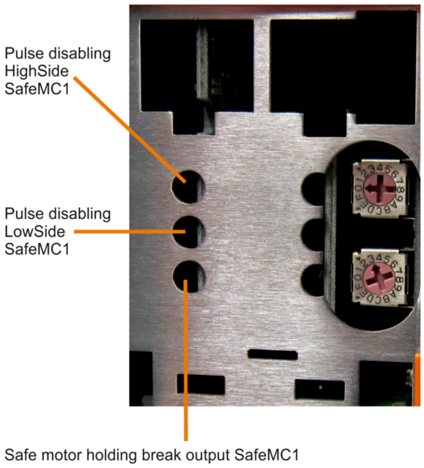


Figure 4: Single-axis modules

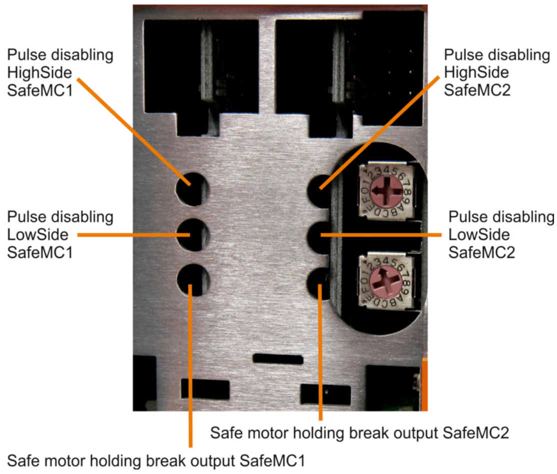


Figure 5: Dual-axis modules

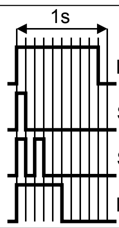
LED	Color		Description
R/E	Green	Red	
	Off	Off	Module not supplied with current, no communication
	Single flash		Unlink mode
	Double flash		Updating firmware
	Blinking		PREOPERATIONAL mode
	On		RUN mode
	On	Single flash, inverse	Safety-related firmware invalid
		Triple flash, inverse	Updating safety-related firmware
		On	Communication error
	Off	On	Errors
Status LED Pulse disabling output, high-side	Red		Warning/Error on the channel During the boot phase, the channel LEDs are always lit constantly red.
	Orange		24 V on the output
	Off		0 V on the output
Status LED Pulse disabling output, low-side	Red		Warning/Error on the channel During the boot phase, the channel LEDs are always lit constantly red.
	Orange		24 V on the output
	Off		0 V on the output
Status LED Motor holding brake output	Red		Warning/Error on the channel During the boot phase, the channel LEDs are always lit constantly red.
	Orange		24 V on the output
	Off		0 V on the output
SE	Red	Off	RUN mode
			Boot phase or defective processor Safety preoperational state Safe communication channel not OK Boot phase, Firmware error
		On	Non-acknowledgeable error state, FAIL SAFE state
	The two "SE" indicators are two separate LEDs that show the states of safety processor 1 and safety processor 2. This is only distinguishable when the front cover is open, however.		

Table 15: SafeMOTION module - LED status indicators

Danger!

Constantly lit "SE" LEDs indicate a non-acknowledgeable FAIL SAFE state. The cause of this could be a defective module or faulty configuration.
Check the entries in the logbook! If you are able to rule out a faulty configuration, then the module is defective and must be replaced immediately.

It is your responsibility to ensure that all necessary repair measures or corrections to the configuration are initiated after an error occurs since subsequent errors can result in dangerous situations!

2.1.7 Status changes when booting the operating system loader

The following timing is used for the LED status indicators:

Block size: 50 ms
Repeats after: 3,000 ms

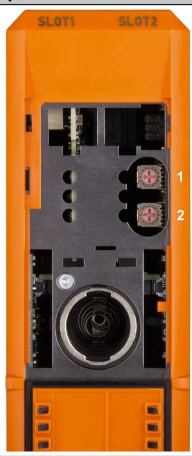
Status	LED	Indicator
1. Boot procedure for base hardware active	RDY	
	RUN	
	ERR	
2. Network configuration active	RDY	
	RUN	
	ERR	
3. Waiting for network telegram	RDY	
	RUN	
	ERR	
4. Network communication active	RDY	
	RUN	
	ERR	
5. ACOPOS operating system being transferred/burned [1]	RDY	
	RUN	
	ERR	

Table 16: Status changes when booting the operating system loader

1) Firmware V2.140 and higher.

2.1.8 Setting the POWERLINK station number

The POWERLINK station number can be set using the two coded hexadecimal rotary switches located behind the black cover.

<table>
<tr><th colspan="2">Figure</th><th rowspan="2">Coded rotary switches</th><th rowspan="2">POWERLINK station number</th></tr>
<tr><th>Cover closed</th><th>Cover open</th></tr>
<tr><td rowspan="3">
</td><td rowspan="3">
</td><td>1</td><td>Position 16</td></tr>
<tr><td>2</td><td>Position 1</td></tr>
<tr><td colspan="2">The POWERLINK station number change takes effect the next time the ACOPOSmulti drive system is switched on.

Information:

Station numbers in the range from 0x01 to 0xFD are allowed.

Recommendation: For compatibility reasons, avoid station numbers between 0xF0 and 0xFD since these are intended for future system expansions.

Station numbers 0x00, 0xFE and 0xFF are reserved and therefore not allowed to be set.</td></tr>
</table>

Table 17: Setting the POWERLINK station number

3 Data sheets

3.1 Module overview

Safe single-width inverter modules (single-axis modules)

Product ID	Short description	on page
8BVI0014HCSA.000-1	ACOPOSmulti SafeMOTION SinCos inverter module, 1.9 A, HV, cold plate or feed-through mounting	27
8BVI0014HCSS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 1.9 A, HV, cold plate or feed-through mounting	27
8BVI0014HWSA.000-1	ACOPOSmulti SafeMOTION SinCos inverter module, 1.9 A, HV, wall mounting	27
8BVI0014HWSS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 1.9 A, HV, wall mounting	27
8BVI0028HCSA.000-1	ACOPOSmulti SafeMOTION SinCos inverter module, 3.8 A, HV, cold plate or feed-through mounting	33
8BVI0028HCSS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 3.8 A, HV, cold plate or feed-through mounting	33
8BVI0028HWSA.000-1	ACOPOSmulti SafeMOTION SinCos inverter module, 3.8 A, HV, wall mounting	33
8BVI0028HWSS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 3.8 A, HV, wall mounting	33
8BVI0055HCSA.000-1	ACOPOSmulti SafeMOTION SinCos inverter module, 7.6 A, HV, cold plate or feed-through mounting	39
8BVI0055HCSS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 7.6 A, HV, cold plate or feed-through mounting	39
8BVI0055HWSA.000-1	ACOPOSmulti SafeMOTION SinCos inverter module, 7.6 A, HV, wall mounting	39
8BVI0055HWSS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 7.6 A, HV, wall mounting	39
8BVI0110HCSA.000-1	ACOPOSmulti SafeMOTION SinCos inverter module, 15.1 A, HV, cold plate or feed-through mounting	45
8BVI0110HCSS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 15.1 A, HV, cold plate or feed-through mounting	45
8BVI0110HWSA.000-1	ACOPOSmulti SafeMOTION SinCos inverter module, 15.1 A, HV, wall mounting	45
8BVI0110HWSS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 15.1 A, HV, wall mounting	45

Safe double-width inverter modules (single-axis modules)

Product ID	Short description	on page
8BVI0220HCSA.000-1	ACOPOSmulti SafeMOTION SinCos inverter module, 22 A, HV, cold plate or feed-through mounting	56
8BVI0220HCSS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 22 A, HV, cold plate or feed-through mounting	56
8BVI0220HWSA.000-1	ACOPOSmulti SafeMOTION SinCos inverter module, 22 A, HV, wall mounting	56
8BVI0220HWSS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 22 A, HV, wall mounting	56
8BVI0330HCSA.000-1	ACOPOSmulti SafeMOTION SinCos inverter module, 33 A, HV, cold plate or feed-through mounting	62
8BVI0330HCSS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 33 A, HV, cold plate or feed-through mounting	62
8BVI0330HWSA.000-1	ACOPOSmulti SafeMOTION SinCos inverter module, 33 A, HV, wall mounting	62
8BVI0330HWSS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 33 A, HV, wall mounting	62
8BVI0440HCSA.000-1	ACOPOSmulti SafeMOTION SinCos inverter module, 44 A, HV, cold plate or feed-through mounting	68
8BVI0440HCSS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 44 A, HV, cold plate or feed-through mounting	68
8BVI0440HWSA.000-1	ACOPOSmulti SafeMOTION SinCos inverter module, 44 A, HV, wall mounting	68
8BVI0440HWSS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 44 A, HV, wall mounting	68

Safe 4x width inverter modules (single-axis modules)

Product ID	Short description	on page
8BVI0660HCSA.000-1	ACOPOSmulti SafeMOTION SinCos inverter module, 66 A, HV, cold plate or feed-through mounting	111
8BVI0660HCSS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 66 A, HV, cold plate or feed-through mounting	111
8BVI0660HWSA.000-1	ACOPOSmulti SafeMOTION SinCos inverter module, 66 A, HV, wall mounting	111
8BVI0660HWSS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 66 A, HV, wall mounting	111
8BVI0880HCSA.004-1	ACOPOSmulti SafeMOTION SinCos inverter module, 88 A, HV, cold plate or feed-through mounting	117
8BVI0880HCSS.004-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 88 A, HV, cold plate or feed-through mounting	117
8BVI0880HWSA.004-1	ACOPOSmulti SafeMOTION SinCos inverter module, 88 A, HV, wall mounting	117
8BVI0880HWSS.004-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 88 A, HV, wall mounting	117

Safe 8x width inverter modules (single-axis modules)

Product ID	Short description	on page
8BVI1650HCSS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 165 A, HV, cold plate or feed-through mounting	130

Safe single-width inverter modules (dual-axis modules)

Product ID	Short description	on page
8BVI0014HCDS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 1.9 A, HV, cold plate or feed-through mounting, 2 axes	78
8BVI0014HWDS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 1.9 A, HV, wall mounting, 2 axes	78
8BVI0028HCDS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 3.8 A, HV, cold plate or feed-through mounting, 2 axes	83
8BVI0028HWDS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 3.8 A, HV, wall mounting, 2 axes	83
8BVI0055HCDS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 7.6 A, HV, cold plate or feed-through mounting, 2 axes	88
8BVI0055HWDS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 7.6 A, HV, wall mounting, 2 axes	88

Safe double-width inverter modules (dual-axis modules)

Product ID	Short description	on page
8BVI0110HCDS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 15.1 A, HV, cold plate or feed-through mounting, 2 axes	97
8BVI0110HWDS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 15.1 A, HV, wall mounting, 2 axes	97
8BVI0220HCDS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 22 A, HV, cold plate or feed-through mounting, 2 axes	102
8BVI0220HWDS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 22 A, HV, wall mounting, 2 axes	102

3.2 Safe single-width inverter modules (single-axis modules)

3.2.1 8BVI0014HCSS.000-1, 8BVI0014HWSS.000-1, 8BVI0014HCSA.000-1, 8BVI0014HWSA.000-1

3.2.1.1 General information

- Clearly structured, straightforward implementation via network-based safety technology
- Modular expandability through virtual wiring
- Immediate triggering of safety function due to short cycle times
- Easy implementation with transparent control and status information, even in the standard application
- Compact design

3.2.1.2 Order data

Model number	Short description	Figure
	Cold plate or feed-through mounting	
8BVI0014HCSS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 1.9 A, HV, cold plate or feed-through mounting	
8BVI0014HCSA.000-1	ACOPOSmulti SafeMOTION SinCos inverter module, 1.9 A, HV, cold plate or feed-through mounting	
	Wall mounting	
8BVI0014HWSS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 1.9 A, HV, wall mounting	
8BVI0014HWSA.000-1	ACOPOSmulti SafeMOTION SinCos inverter module, 1.9 A, HV, wall mounting	
	Required accessories	
	Terminal block sets	
8BZVI0055SS.000-1A	Screw clamp set for ACOPOSmulti 8BVI00xxHxSS and 8BVI00xxHxSA modules: 1x 8TB3104.204G-11, 1x 8TB2104.203L-00, 1x 8TB2108.2010-00	
	Optional accessories	
	Accessory sets	
8BXB000.0000-00	ACPmulti accessory set for encoder buffering consisting of: 1 lithium battery AA 3.6 V; 1 protective cap for battery holder	
	Fan modules	
8BXF001.0000-00	ACOPOSmulti fan module, replacement fan for ACOPOSmulti modules (8BVP / 8B0C / 8BVI / 8BVE / 8B0K)	
	POWERLINK cables	
X20CA0E61.00020	POWERLINK connection cable, RJ45 to RJ45, 0.2 m	
X20CA0E61.00025	POWERLINK connection cable, RJ45 to RJ45, 0.25 m	
X20CA0E61.00030	POWERLINK connection cable, RJ45 to RJ45, 0.3 m	
X20CA0E61.00035	POWERLINK connection cable, RJ45 to RJ45, 0.35 m	
X20CA0E61.00050	POWERLINK connection cable, RJ45 to RJ45, 0.5 m	
X20CA0E61.00100	POWERLINK connection cable, RJ45 to RJ45, 1 m	
	Plug-in modules	
8BAC0120.000-1	ACOPOSmulti plug-in module, EnDat 2.1 interface	
8BAC0120.001-2	ACOPOSmulti plug-in module, EnDat 2.2 interface	
8BAC0121.000-1	ACOPOSmulti plug-in module, HIPERFACE interface	
8BAC0122.000-1	ACOPOSmulti plug-in module, resolver interface 10 kHz	
8BAC0123.000-1	ACOPOSmulti plug-in module, incremental encoder and SSI absolute encoder interface for RS422 signals	
8BAC0123.001-1	ACOPOSmulti plug-in module, incremental encoder interface for 5 V single-ended and 5 V differential signals	
8BAC0123.002-1	ACOPOSmulti plug-in module, incremental encoder interface for 24 V single-ended and 24 V differential signals	
8BAC0124.000-1	ACOPOSmulti plug-in module, SinCos interface	
8BAC0125.000-1	ACOPOSmulti plug-in module, SinCos EnDat 2.1/SSI interface	
8BAC0130.000-1	ACOPOSmulti plug-in module, 2 digital outputs, 50 mA, max. 62,5 kHz, 4 digital outputs, 500 mA, max. 1,25 kHz, 2 digital inputs 24 VDC	
8BAC0130.001-1	ACOPOSmulti plug-in module, 2 digital outputs, 50 mA, max. 62.5 kHz, 4 digital outputs, 500 mA, max. 1.25 kHz	
8BAC0132.000-1	ACOPOSmulti input module, 4 analog inputs ±10 V	
8BAC0133.000-1	ACOPOSmulti plug-in module, 3 RS422 outputs for ABR encoder emulation, 1 Mhz	
	Shield component sets	
8SCS000.0000-00	ACOPOSmulti shielding components set: 1x shielding plate 1fold type 0; 1x hose clamp, W 9 mm, D 12-22 mm	
8SCS002.0000-00	ACOPOSmulti shield component set: 1x clamping plate; 2x clamps D 4-13.5 mm; 4x screws	
8SCS009.0000-00	ACOPOSmulti shield component set: 1x ACOPOSmulti holding plate SK8-14; 1x shield terminal SK14	
	Terminal blocks	

Table 18: 8BVI0014HCSS.000-1, 8BVI0014HCSA.000-1, 8BVI0014HWSS.000-1, 8BVI0014HWSA.000-1 - Order data

Model number	Short description	Figure
8TB2104.203L-00	Screw clamp 4-pin, single row, spacing: 5.08 mm, label 3: T- T + B- B+, L keying: 1010	
8TB2108.2010-00	Screw clamp 8-pin, single row, spacing: 5.08 mm, label 1: numbered serially	
8TB3104.204G-11	Screw clamp 4-pin, single row, spacing: 7.62 mm, label 4: PE W V U, G coding: 0110	

Table 18: 8BVI0014HCSS.000-1, 8BVI0014HCSA.000-1, 8BVI0014HWSS.000-1, 8BVI0014HWSA.000-1 - Order data

Information:

Only 8BCM motor cables from B&R are permitted to be connected to the motor connectors.

ACOPOSmulti SafeMOTION EnDat 2.2

Information:

Only 8BCF EnDat 2.2 cables from B&R or 8BCH hybrid motor cables from B&R are permitted to be connected to the encoder interfaces.

ACOPOSmulti SafeMOTION SinCos

Information:

Only 8BCS encoder cables from B&R are permitted to be connected to the encoder interfaces on B&R standard motors.

For details, see 1.2 "Safe power transmission system " on page 167.

3.2.1.3 Technical data

Product ID	8BVI0014HCSS.000-1	8BVI0014HWSS.000-1	8BVI0014HCSA.000-1	8BVI0014HWSA.000-1
General information				
B&R ID code	0xAA0C	0xAA0E	0xE0B0	0xE0B1
Cooling and mounting method	Cold plate or feed-through mounting	Wall mounting	Cold plate or feed-through mounting	Wall mounting
Slots for plug-in modules	2 [1]			
Certification				
CE	Yes			
cULus	Yes			
KC	Yes		-	
FSC	Yes			
DC bus connection				
Voltage				
Nominal	750 VDC			
Continuous power consumption [2]	1.46 kW			
Power loss depending on the switching frequency [3]				
Switching frequency 5 kHz	[0.6 * I_M^2 + 1.3 * I_M + 60] W			
Switching frequency 10 kHz	[0.97 * I_M^2 + 0.5 * I_M + 110] W			
Switching frequency 20 kHz	[1.7 * I_M^2 - 0.7 * I_M + 225] W			
DC bus capacitance	165 µF			
Design	ACOPOSmulti backplane			
24 VDC supply				
Input voltage	25 VDC ±1.6%			
Input capacitance	23.5 µF			
Max. power consumption	18 W + P_{SMC1} + P_{SLOT2} + $P_{24\ V\ Out}$ + $P_{HoldingBrake}$ + $P_{Fan8B0M...}$ [4]		25 W + P_{SMC1} + P_{SLOT2} + $P_{24\ V\ Out}$ + $P_{HoldingBrake}$ + $P_{Fan8B0M...}$ [5]	
Design	ACOPOSmulti backplane			
24 VDC output				
Quantity	2			
Output voltage				
DC bus voltage (U_{DC}): 260 to 315 VDC	25 VDC * (U_{DC}/315)			
DC bus voltage (U_{DC}): 315 to 800 VDC	24 VDC ±6%			
Protection	250 mA (slow-blow) electronic, automatic reset			
Motor connection [6]				
Quantity	1			
Continuous power per motor connection [2]	1.4 kW			
Continuous current per motor connection [2]	1.9 A_{eff}			

Table 19: 8BVI0014HCSS.000-1, 8BVI0014HWSS.000-1, 8BVI0014HCSA.000-1, 8BVI0014HWSA.000-1 - Technical data

Product ID	8BVI0014HCSS.000-1	8BVI0014HWSS.000-1	8BVI0014HCSA.000-1	8BVI0014HWSA.000-1
Reduction of continuous current depending on the switching frequency [7]				
Switching frequency 5 kHz	-	No reduction [8]	-	No reduction [8]
Switching frequency 10 kHz	-	No reduction	-	No reduction
Switching frequency 20 kHz	-	0.11 A/K (from 33°C) [9]	-	0.11 A/K (from 33°C) [9]
Reduction of continuous current depending on the switching frequency and mounting method [10]				
Switching frequency 5 kHz				
Cold plate mounting [11]	No reduction [8]	-	No reduction [8]	-
Feed-through mounting	No reduction [8]	-	No reduction [8]	-
Switching frequency 10 kHz				
Cold plate mounting [11]	No reduction	-	No reduction	-
Feed-through mounting	No reduction	-	No reduction	-
Switching frequency 20 kHz				
Cold plate mounting [11]	0.13 A/K (from 46°C)	-	0.13 A/K (from 46°C)	-
Feed-through mounting	0.1 A/K (from 41°C)	-	0.1 A/K (from 41°C)	-
Reduction of continuous current depending on the installation elevation				
Starting at 500 m above sea level	0.19 A_{eff} per 1000 m			
Peak current	4.7 A_{eff}			
Nominal switching frequency	5 kHz			
Possible switching frequencies [12]	5/10/20 kHz			
Electrical stress of the connected motor in accordance with IEC TS 60034-25 [13]	Limit value curve A			
Protective measures				
Overload protection	Yes			
Short circuit and ground fault protection	Yes			
Max. output frequency	598 Hz [14]			
Design				
U, V, W, PE	Male connector			
Shield connection	Yes			
Terminal connection cross section				
Flexible and fine wire lines				
With wire end sleeves	0.25 to 4 mm²			
Approbation data				
UL/C-UL-US	30 to 10			
CSA	28 to 10			
Terminal cable cross section dimension of shield connection	12 to 22 mm			
Max. motor line length depending on the switching frequency				
Switching frequency 5 kHz	25 m			
Switching frequency 10 kHz	25 m			
Switching frequency 20 kHz	10 m			
Motor holding brake connection				
Quantity	1			
Output voltage [15]	24 VDC +5.8% / -0% [16]			
Continuous current	1.1 A			
Max. internal resistance	0.5 Ω			
Extinction potential	Approx. 30 V			
Max. extinction energy per switching operation	1.5 Ws			
Max. switching frequency	0.5 Hz			
Protective measures				
Overload and short circuit protection	Yes			
Open line monitoring	Yes			
Undervoltage monitoring	Yes			
Response threshold for open line monitoring	Approx. 0.25 A			
Response threshold for undervoltage monitoring	24 VDC -2% / -4%			
Encoder interfaces [17]				
Quantity	1			
Type	EnDat 2.2 [18]		SinCos	
Connections	9-pin female DSUB connector		15-pin female DSUB connector	
Status indicators	UP/DN LEDs			
Electrical isolation				
Encoder - ACOPOSmulti	No			
Encoder monitoring	Yes			
Max. encoder cable length	100 m Depends on the cross section of the encoder's supply wires [19]		50 m [20]	

Table 19: 8BVI0014HCSS.000-1, 8BVI0014HWSS.000-1, 8BVI0014HCSA.000-1, 8BVI0014HWSA.000-1 - Technical data

Product ID	8BVI0014HCSS.000-1	8BVI0014HWSS.000-1	8BVI0014HCSA.000-1	8BVI0014HWSA.000-1
Encoder supply				
Output voltage	Typ. 12.5 V		5 V ±5% [21]	
Load capability	350 mA		300 mA [22]	
Sense lines	-		2, compensation of max. 2 x 0.7 V	
Protective measures				
Short circuit protection	Yes			
Overload protection	Yes			
Synchronous serial interface				
Signal transmission	RS485			
Data transfer rate	6.25 Mbit/s		781.25 kbit/s	
Sine/Cosine inputs				
Signal transmission	-		Differential signals, symmetrical	
Differential voltage				
In motion	-		0.5 to 1.35 V [23]	
At standstill	-		0.8 to 1.35 V [24]	
Differential voltage deviation per signal period	-		±10% [25]	
Common-mode voltage	-		Max. ±7 V	
Terminating resistors	-		120 Ω	
Max. input frequency	-		200 kHz	
Signal frequency (-5 dB)	-		<300 kHz	
Signal frequency (-3 dB)	-		DC up to 200 kHz	
ADC resolution	-		12-bit	
Reference input				
Signal transmission	-		Differential signal, symmetrical	
Differential voltage for low	-		≤ -0.2 V	
Differential voltage for high	-		≥ 0.2 V	
Common-mode voltage	-		Max. -5 V to +9 V	
Terminating resistors	-		120 Ω	
Position				
Resolution @ 1 V_{SS} [26]	-		Number of encoder lines * 5700	
Precision [27]	-		---	
Noise [27]	-		---	
Max. power consumption per encoder interface	P_{SMC}[W] = 19 V * $I_{Encoder}$[A] [28]		P_{SMC}[W] = 25 V * (0.376 A + 0.35 * $I_{Encoder}$[A]) [28]	
Trigger inputs				
Quantity	2			
Wiring	Sink			
Electrical isolation				
Input - Inverter module	Yes			
Input - Input	Yes			
Input voltage				
Nominal	24 VDC			
Maximum	30 VDC			
Switching threshold				
Low	<5 V			
High	>15 V			
Input current at nominal voltage	Approx. 10 mA			
Switching delay				
Rising edge	52 µs ±0.5 µs (digitally filtered)			
Falling edge	53 µs ±0.5 µs (digitally filtered)			
Modulation compared to ground potential	Max. ±38 V			
Electrical characteristics				
Discharge capacitance	0.14 µF			
Operating conditions				
Permitted mounting orientations				
Hanging vertically	Yes			
Lying horizontally	Yes			
Standing horizontally	No			
Installation at elevations above sea level				
Nominal	0 to 500 m			
Maximum [29]	4000 m			
Degree of pollution in accordance with EN 60664-1	2 (non-conductive pollution)			
Overvoltage category in accordance with IEC 60364-4-443:1999	III			
EN 60529 protection	IP20 [30]			
Environmental conditions				
Temperature				
Operation				
Nominal	5 to 40°C			
Maximum [31]	55°C			
Storage	-25 to 55°C			
Transport	-25 to 70°C			

Table 19: 8BVI0014HCSS.000-1, 8BVI0014HWSS.000-1, 8BVI0014HCSA.000-1, 8BVI0014HWSA.000-1 - Technical data

Product ID	8BVI0014HCSS.000-1	8BVI0014HWSS.000-1	8BVI0014HCSA.000-1	8BVI0014HWSA.000-1
Relative humidity				
Operation	5 to 85%			
Storage	5 to 95%			
Transport	Max. 95% at 40°C			
Mechanical characteristics				
Dimensions [32]				
Width	53 mm			
Height	317 mm			
Depth				
Wall mounting	-	263 mm	-	263 mm
Cold plate	212 mm	-	212 mm	-
Feed-through mounting	209 mm	-	209 mm	-
Weight	Approx. 2.1 kg	Approx. 2.6 kg	Approx. 2.1 kg	Approx. 2.6 kg
Module width	1			

Table 19: 8BVI0014HCSS.000-1, 8BVI0014HWSS.000-1, 8BVI0014HCSA.000-1, 8BVI0014HWSA.000-1 - Technical data

1) SLOT 2 is not occupied. SLOT 1 of the ACOPOSmulti module is occupied by the SafeMOTION module.
2) Valid in the following conditions: 750 VDC DC bus voltage, 5 kHz switching frequency, 40°C ambient temperature, installation elevation <500 m above sea level, no derating due to cooling type.
3) I_M... Current on the motor connection [A].
4) P_{SMC1} ... Max. power consumption P_{SMC} [W] of the SafeMOTION module in SLOT1 (see the "Encoder interfaces" section).
P_{SLOT2} ... Max. power consumption P_{8BAC} [W] of the plug-in module in SLOT2 (see the technical data for the respective plug-in module).
$P_{24\ V\ Out}$... Power [W] that is output to the connections X2/+24 V Out 1 and X2/+24 V Out 2 on the module (max. 10 W).
$P_{Fan8B0M...}$... Portion of the power [W] that is used by the fan modules in the mounting plate or the 8B0M0040HFF0.000-1 fan module (see the technical data for the respective 8B0M... mounting plate / 8B0M0040HFF0.000-1 fan module).
5) P_{SMC1} ... Max. power consumption P_{SMC} [W] of the SafeMOTION module in SLOT1 (see the "Encoder interfaces" section).
P_{SLOT2} ... Max. power consumption P_{8BAC} [W] of the plug-in module in SLOT2 (see the technical data for the respective plug-in module).
$P_{24\ V\ Out}$ ... Power [W] that is output to the connections X2/+24 V Out 1 and X2/+24 V Out 2 on the module (max. 10 W).
$P_{Fan8B0M...}$ ... Portion of the power [W] that is used by the fan modules in the mounting plate or the 8B0M0040HFF0.000-1 fan module (see the technical data for the respective 8B0M... mounting plate / 8B0M0040HFF0.000-1 fan module).
6) Only 8BCM motor cables from B&R are permitted to be connected to the motor connectors.
7) Valid in the following conditions: 750 VDC DC bus voltage. The temperature specifications refer to the ambient temperature.
8) Value for the nominal switching frequency.
9) The module cannot supply the full continuous current at this switching frequency. This unusual value for the ambient temperature, at which derating of the continuous current must be taken into account, ensures that the derating of the continuous current can be determined in the same manner as at other switching frequencies.
10) Valid in the following conditions: 750 VDC DC bus voltage, minimum permissible coolant flow volume (3 l/min).
11) The temperature specifications refer to the return temperature of the cold plate mounting plate.
12) B&R recommends operating the module at its nominal switching frequency. Operating the module at a higher switching frequency for application-specific reasons reduces the continuous current and increases the CPU load.
13) If necessary, the stress of the motor isolation system can be reduced by an additional externally wired dU/dt choke. For example, the RWK 305 three-phase du/dt choke from Schaffner (www.schaffner.com) can be used. Important: Even when using a dU/dt choke, it is necessary to ensure that an EMC-compatible, low inductance shield connection is used!
14) The module's electrical output frequency (SCTRL_SPEED_ACT * MOTOR_POLEPAIRS) is monitored to protect against dual use in accordance with EC regulation 428/2009 | 3A225. If the electrical output frequency of the module exceeds the limit value of 598 Hz uninterrupted for more than 0.5 s, then the current movement is aborted and error 6060 is output (Power element: Limit speed exceeded).
15) During project development, it is necessary to check if the minimum voltage can be maintained on the holding brake with the specified wiring. The operating voltage range of the holding brake can be found in the user's manual for the respective motor.
16) The specified value is only valid under the following conditions:
- The 24 VDC supply for the module is provided by an 8B0C auxiliary supply module installed on the same mounting plate.
If the 24 VDC supply for the module is applied to the mounting plate using an 8BVE expansion module, then the output voltage is reduced because of voltage drops on the expansion cable. In this case, undervoltage monitoring must be disabled.
17) Only 8BCF EnDat 2.2 cables from B&R are permitted to be connected to the encoder interfaces.
18) An EnDat 2.2 functional safety encoder is required when using ACOPOSmulti SafeMOTION inverter modules! With standard EnDat 2.2 encoders, only the STO, SBC and SS1 functions are monitored with respect to timing!
19) The maximum encoder cable length l_{max} can be calculated as follows (the maximum permissible encoder cable length of 100 m must not be exceeded):

$l_{max} = 7.9 / I_G * A * 1/(2*\rho)$

I_G ... Max. current consumption of the encoder [A].
A ... Cross section of the supply wire [mm²].
ρ ... Specific resistance [Ω mm²/m] (e.g. for copper: ρ = 0.0178).
20) The maximum permitted cable length is 50 m.
21) During the power-on procedure for the encoder supply voltage (2 seconds), the monitoring limit for the supply voltage is increased from 5.25 V to 6 V. In this phase, overvoltages up to 6 V are not detected.
A short-term overvoltage of maximum 6 V should not damage the encoder electronics in any way.
An undervoltage on the encoder supply will result in a sine or cosine signal outside the specification.
22) An actual reserve of 12 mA exists for the terminating resistor.
23) The sine-cosine output signals from the measuring instrument are checked by the evaluation circuit using pointer length monitoring.
The pointer length $z = 2\sqrt{(Sin - nSin)^2 + (Cos - nCos)^2}$ is monitored according to the specified limits.
24) The sine-cosine output signals from the measuring instrument are checked by the evaluation circuit using pointer length monitoring.
The pointer length $z = 2\sqrt{(Sin - nSin)^2 + (Cos - nCos)^2}$ is also monitored according to the specified limits from the time the evaluation circuit is switched on until a signal period has passed.
25) The sine-cosine output signals from the measuring instrument are checked by the evaluation circuit using pointer length monitoring.
The pointer length $z = 2\sqrt{(Sin - nSin)^2 + (Cos - nCos)^2}$ is only permitted to vary by maximum ±10% per signal period.
26) This value does not correspond to the encoder resolution that must be configured in Automation Studio (16384 * number of encoder lines).
27) Limited by the encoder in practice.
28) $I_{Encoder}$ ... Max. power consumption of the connected encoder [A].

29) Continuous operation at elevations ranging from 500 m to 4000 m above sea level is possible (taking the specified continuous current reductions into consideration).

30) This value only applies in its delivered state (SLOT2 of the module is sealed by a slot cover / shield plate). If SLOT2 on the module is not sealed, then the level of protection is reduced to IP10. It is important to note that a 8SCS005.0000-00 shield set (slot cover / shield plate) or plug-in module must always be inserted!

31) Continuous operation at ambient temperatures ranging from 40°C to max. 55°C is possible (taking the specified continuous current reductions into consideration), but this will result in a shorter service life.

32) These dimensions refer to the actual device dimensions including the respective mounting plate. Make sure to leave additional space above and below the devices for mounting, connections and air circulation.

3.2.1.4 Wiring

For details, see 3.2.5 "Wiring: Safe single-width inverter modules (single-axis modules)" on page 51.

For general information, see 6 "Wiring" on page 142.

3.2.2 8BVI0028HCSS.000-1, 8BVI0028HWSS.000-1, 8BVI0028HCSA.000-1, 8BVI0028HWSA.000-1

3.2.2.1 General information

- Clearly structured, straightforward implementation via network-based safety technology
- Modular expandability through virtual wiring
- Immediate triggering of safety function due to short cycle times
- Easy implementation with transparent control and status information, even in the standard application
- Compact design

3.2.2.2 Order data

Model number	Short description	Figure
	Cold plate or feed-through mounting	
8BVI0028HCSS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 3.8 A, HV, cold plate or feed-through mounting	
8BVI0028HCSA.000-1	ACOPOSmulti SafeMOTION SinCos inverter module, 3.8 A, HV, cold plate or feed-through mounting	
	Wall mounting	
8BVI0028HWSS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 3.8 A, HV, wall mounting	
8BVI0028HWSA.000-1	ACOPOSmulti SafeMOTION SinCos inverter module, 3.8 A, HV, wall mounting	
	Required accessories	
	Terminal block sets	
8BZVI0055SS.000-1A	Screw clamp set for ACOPOSmulti 8BVI00xxHxSS and 8BVI00xxHxSA modules: 1x 8TB3104.204G-11, 1x 8TB2104.203L-00, 1x 8TB2108.2010-00	
	Optional accessories	
	Accessory sets	
8BXB000.0000-00	ACPmulti accessory set for encoder buffering consisting of: 1 lithium battery AA 3.6 V; 1 protective cap for battery holder	
	Fan modules	
8BXF001.0000-00	ACOPOSmulti fan module, replacement fan for ACOPOSmulti modules (8BVP / 8B0C / 8BVI / 8BVE / 8B0K)	
	POWERLINK cables	
X20CA0E61.00020	POWERLINK connection cable, RJ45 to RJ45, 0.2 m	
X20CA0E61.00025	POWERLINK connection cable, RJ45 to RJ45, 0.25 m	
X20CA0E61.00030	POWERLINK connection cable, RJ45 to RJ45, 0.3 m	
X20CA0E61.00035	POWERLINK connection cable, RJ45 to RJ45, 0.35 m	
X20CA0E61.00050	POWERLINK connection cable, RJ45 to RJ45, 0.5 m	
X20CA0E61.00100	POWERLINK connection cable, RJ45 to RJ45, 1 m	
	Plug-in modules	
8BAC0120.000-1	ACOPOSmulti plug-in module, EnDat 2.1 interface	
8BAC0120.001-2	ACOPOSmulti plug-in module, EnDat 2.2 interface	
8BAC0121.000-1	ACOPOSmulti plug-in module, HIPERFACE interface	
8BAC0122.000-1	ACOPOSmulti plug-in module, resolver interface 10 kHz	
8BAC0123.000-1	ACOPOSmulti plug-in module, incremental encoder and SSI absolute encoder interface for RS422 signals	
8BAC0123.001-1	ACOPOSmulti plug-in module, incremental encoder interface for 5 V single-ended and 5 V differential signals	
8BAC0123.002-1	ACOPOSmulti plug-in module, incremental encoder interface for 24 V single-ended and 24 V differential signals	
8BAC0124.000-1	ACOPOSmulti plug-in module, SinCos interface	
8BAC0125.000-1	ACOPOSmulti plug-in module, SinCos EnDat 2.1/SSI interface	
8BAC0130.000-1	ACOPOSmulti plug-in module, 2 digital outputs, 50 mA, max. 62,5 kHz, 4 digital outputs, 500 mA, max. 1,25 kHz, 2 digital inputs 24 VDC	
8BAC0130.001-1	ACOPOSmulti plug-in module, 2 digital outputs, 50 mA, max. 62.5 kHz, 4 digital outputs, 500 mA, max. 1.25 kHz	
8BAC0132.000-1	ACOPOSmulti input module, 4 analog inputs ±10 V	
8BAC0133.000-1	ACOPOSmulti plug-in module, 3 RS422 outputs for ABR encoder emulation, 1 Mhz	
	Shield component sets	
8SCS000.0000-00	ACOPOSmulti shielding components set: 1x shielding plate 1fold type 0; 1x hose clamp, W 9 mm, D 12-22 mm	
8SCS002.0000-00	ACOPOSmulti shield component set: 1x clamping plate; 2x clamps D 4-13.5 mm; 4x screws	
8SCS009.0000-00	ACOPOSmulti shield component set: 1x ACOPOSmulti holding plate SK8-14; 1x shield terminal SK14	
	Terminal blocks	
8TB2104.203L-00	Screw clamp 4-pin, single row, spacing: 5.08 mm, label 3: T- T + B- B+, L keying: 1010	

Table 20: 8BVI0028HCSS.000-1, 8BVI0028HCSA.000-1, 8BVI0028HWSS.000-1, 8BVI0028HWSA.000-1 - Order data

Model number	Short description	Figure
8TB2108.2010-00	Screw clamp 8-pin, single row, spacing: 5.08 mm, label 1: numbered serially	
8TB3104.204G-11	Screw clamp 4-pin, single row, spacing: 7.62 mm, label 4: PE W V U, G coding: 0110	

Table 20: 8BVI0028HCSS.000-1, 8BVI0028HCSA.000-1, 8BVI0028HWSS.000-1, 8BVI0028HWSA.000-1 - Order data

Information:

Only 8BCM motor cables from B&R are permitted to be connected to the motor connectors.

ACOPOSmulti SafeMOTION EnDat 2.2

Information:

Only 8BCF EnDat 2.2 cables from B&R or 8BCH hybrid motor cables from B&R are permitted to be connected to the encoder interfaces.

ACOPOSmulti SafeMOTION SinCos

Information:

Only 8BCS encoder cables from B&R are permitted to be connected to the encoder interfaces on B&R standard motors.

For details, see 1.2 "Safe power transmission system " on page 167.

3.2.2.3 Technical data

Product ID	8BVI0028HCSS.000-1	8BVI0028HWSS.000-1	8BVI0028HCSA.000-1	8BVI0028HWSA.000-1
General information				
B&R ID code	0xAA10	0xAA12	0xCD74	0xE0B2
Cooling and mounting method	Cold plate or feed-through mounting	Wall mounting	Cold plate or feed-through mounting	Wall mounting
Slots for plug-in modules	2 [1]			
Certification				
CE	Yes			
cULus	Yes			
KC	Yes		-	
FSC	Yes			
DC bus connection				
Voltage				
Nominal	750 VDC			
Continuous power consumption [2]	2.87 kW			
Power loss depending on the switching frequency [3]				
Switching frequency 5 kHz	$[0.6 * I_M^2 + 1.3 * I_M + 60]$ W			
Switching frequency 10 kHz	$[0.97 * I_M^2 + 0.5 * I_M + 110]$ W			
Switching frequency 20 kHz	$[1.7 * I_M^2 - 0.7 * I_M + 225]$ W			
DC bus capacitance	165 µF			
Design	ACOPOSmulti backplane			
24 VDC supply				
Input voltage	25 VDC ±1.6%			
Input capacitance	23.5 µF			
Max. power consumption	18 W + P_{SMC1} + P_{SLOT2} + $P_{24\ V\ Out}$ + $P_{HoldingBrake}$ + $P_{Fan8B0M...}$ [4]		25 W + P_{SMC1} + P_{SLOT2} + $P_{24\ V\ Out}$ + $P_{HoldingBrake}$ + $P_{Fan8B0M...}$ [5]	
Design	ACOPOSmulti backplane			
24 VDC output				
Quantity	2			
Output voltage				
DC bus voltage (U_{DC}): 260 to 315 VDC	25 VDC * (U_{DC}/315)			
DC bus voltage (U_{DC}): 315 to 800 VDC	24 VDC ±6%			
Protection	250 mA (slow-blow) electronic, automatic reset			
Motor connection [6]				
Quantity	1			
Continuous power per motor connection [2]	2.8 kW			
Continuous current per motor connection [2]	3.8 A_{eff}			

Table 21: 8BVI0028HCSS.000-1, 8BVI0028HWSS.000-1, 8BVI0028HCSA.000-1, 8BVI0028HWSA.000-1 - Technical data

Product ID	8BVI0028HCSS.000-1	8BVI0028HWSS.000-1	8BVI0028HCSA.000-1	8BVI0028HWSA.000-1
Reduction of continuous current depending on the switching frequency [7]				
Switching frequency 5 kHz	-	No reduction [8]	-	No reduction [8]
Switching frequency 10 kHz	-	No reduction	-	No reduction
Switching frequency 20 kHz	-	0.12 A/K (from 33°C) [9]	-	0.12 A/K (from 33°C) [9]
Reduction of continuous current depending on the switching frequency and mounting method [10]				
Switching frequency 5 kHz				
Cold plate mounting [11]	No reduction [8]	-	No reduction [8]	-
Feed-through mounting	No reduction [8]	-	No reduction [8]	-
Switching frequency 10 kHz				
Cold plate mounting [11]	0.6 A/K (from 58°C)	-	0.6 A/K (from 58°C)	-
Feed-through mounting	No reduction	-	No reduction	-
Switching frequency 20 kHz				
Cold plate mounting [11]	0.1 A/K (from 34°C) [12]	-	0.1 A/K (from 34°C) [12]	-
Feed-through mounting	0.09 A/K (from 18°C) [9]	-	0.1 A/K (from 18°C) [9]	-
Reduction of continuous current depending on the installation elevation				
Starting at 500 m above sea level	0.38 A_{eff} per 1000 m			
Peak current	9.5 A_{eff}			
Nominal switching frequency	5 kHz			
Possible switching frequencies [13]	5/10/20 kHz			
Electrical stress of the connected motor in accordance with IEC TS 60034-25 [14]	Limit value curve A			
Protective measures				
Overload protection	Yes			
Short circuit and ground fault protection	Yes			
Max. output frequency	598 Hz [15]			
Design				
U, V, W, PE	Male connector			
Shield connection	Yes			
Terminal connection cross section				
Flexible and fine wire lines				
With wire end sleeves	0.25 to 4 mm²			
Approbation data				
UL/C-UL-US	30 to 10			
CSA	28 to 10			
Terminal cable cross section dimension of shield connection	12 to 22 mm			
Max. motor line length depending on the switching frequency				
Switching frequency 5 kHz	25 m			
Switching frequency 10 kHz	25 m			
Switching frequency 20 kHz	10 m			
Motor holding brake connection				
Quantity	1			
Output voltage [16]	24 VDC +5.8% / -0% [17]			
Continuous current	1.1 A			
Max. internal resistance	0.5 Ω			
Extinction potential	Approx. 30 V			
Max. extinction energy per switching operation	1.5 Ws			
Max. switching frequency	0.5 Hz			
Protective measures				
Overload and short circuit protection	Yes			
Open line monitoring	Yes			
Undervoltage monitoring	Yes			
Response threshold for open line monitoring	Approx. 0.25 A			
Response threshold for undervoltage monitoring	24 VDC -2% / -4%			
Encoder interfaces [18]				
Quantity	1			
Type	EnDat 2.2 [19]		SinCos	
Connections	9-pin female DSUB connector		15-pin female DSUB connector	
Status indicators	UP/DN LEDs			
Electrical isolation				
Encoder - ACOPOSmulti	No			
Encoder monitoring	Yes			
Max. encoder cable length	100 m Depends on the cross section of the encoder's supply wires [20]		50 m [21]	

Table 21: 8BVI0028HCSS.000-1, 8BVI0028HWSS.000-1, 8BVI0028HCSA.000-1, 8BVI0028HWSA.000-1 - Technical data

Product ID	8BVI0028HCSS.000-1	8BVI0028HWSS.000-1	8BVI0028HCSA.000-1	8BVI0028HWSA.000-1
Encoder supply				
Output voltage	Typ. 12.5 V		5 V ±5% [22]	
Load capability	350 mA		300 mA [23]	
Sense lines	-		2, compensation of max. 2 x 0.7 V	
Protective measures				
Short circuit protection	Yes			
Overload protection	Yes			
Synchronous serial interface				
Signal transmission	RS485			
Data transfer rate	6.25 Mbit/s		781.25 kbit/s	
Sine/Cosine inputs				
Signal transmission	-		Differential signals, symmetrical	
Differential voltage				
In motion	-		0.5 to 1.35 V [24]	
At standstill	-		0.8 to 1.35 V [25]	
Differential voltage deviation per signal period	-		±10% [26]	
Common-mode voltage	-		Max. ±7 V	
Terminating resistors	-		120 Ω	
Max. input frequency	-		200 kHz	
Signal frequency (-5 dB)	-		<300 kHz	
Signal frequency (-3 dB)	-		DC up to 200 kHz	
ADC resolution	-		12-bit	
Reference input				
Signal transmission	-		Differential signal, symmetrical	
Differential voltage for low	-		≤ -0.2 V	
Differential voltage for high	-		≥ 0.2 V	
Common-mode voltage	-		Max. -5 V to +9 V	
Terminating resistors	-		120 Ω	
Position				
Resolution @ 1 V_{SS} [27]	-		Number of encoder lines * 5700	
Precision [28]	-		---	
Noise [28]	-		---	
Max. power consumption per encoder interface	P_{SMC}[W] = 19 V * $I_{Encoder}$[A] [29]		P_{SMC}[W] = 25 V * (0.376 A + 0.35 * $I_{Encoder}$[A]) [29]	
Trigger inputs				
Quantity	2			
Wiring	Sink			
Electrical isolation				
Input - Inverter module	Yes			
Input - Input	Yes			
Input voltage				
Nominal	24 VDC			
Maximum	30 VDC			
Switching threshold				
Low	<5 V			
High	>15 V			
Input current at nominal voltage	Approx. 10 mA			
Switching delay				
Rising edge	52 µs ±0.5 µs (digitally filtered)			
Falling edge	53 µs ±0.5 µs (digitally filtered)			
Modulation compared to ground potential	Max. ±38 V			
Electrical characteristics				
Discharge capacitance	0.14 µF			
Operating conditions				
Permitted mounting orientations				
Hanging vertically	Yes			
Lying horizontally	Yes			
Standing horizontally	No			
Installation at elevations above sea level				
Nominal	0 to 500 m			
Maximum [30]	4000 m			
Degree of pollution in accordance with EN 60664-1	2 (non-conductive pollution)			
Overvoltage category in accordance with IEC 60364-4-443:1999	III			
EN 60529 protection	IP20 [31]			
Environmental conditions				
Temperature				
Operation				
Nominal	5 to 40°C			
Maximum [32]	55°C			
Storage	-25 to 55°C			
Transport	-25 to 70°C			

Table 21: 8BVI0028HCSS.000-1, 8BVI0028HWSS.000-1, 8BVI0028HCSA.000-1, 8BVI0028HWSA.000-1 - Technical data

Product ID	8BVI0028HCSS.000-1	8BVI0028HWSS.000-1	8BVI0028HCSA.000-1	8BVI0028HWSA.000-1
Relative humidity				
Operation	5 to 85%			
Storage	5 to 95%			
Transport	Max. 95% at 40°C			
Mechanical characteristics				
Dimensions 33)				
Width	53 mm			
Height	317 mm			
Depth				
Wall mounting	-	263 mm	-	263 mm
Cold plate	212 mm	-	212 mm	-
Feed-through mounting	209 mm	-	209 mm	-
Weight	Approx. 2.1 kg	Approx. 2.6 kg	Approx. 2.1 kg	Approx. 2.6 kg
Module width	1			

Table 21: 8BVI0028HCSS.000-1, 8BVI0028HWSS.000-1, 8BVI0028HCSA.000-1, 8BVI0028HWSA.000-1 - Technical data

1) SLOT 2 is not occupied. SLOT 1 of the ACOPOSmulti module is occupied by the SafeMOTION module.
2) Valid in the following conditions: 750 VDC DC bus voltage, 5 kHz switching frequency, 40°C ambient temperature, installation elevation <500 m above sea level, no derating due to cooling type.
3) I_M... Current on the motor connection [A].
4) P_{SMC1} ... Max. power consumption P_{SMC} [W] of the SafeMOTION module in SLOT1 (see the "Encoder interfaces" section).
P_{SLOT2} ... Max. power consumption P_{8BAC} [W] of the plug-in module in SLOT2 (see the technical data for the respective plug-in module).
$P_{24\,V\,Out}$... Power [W] that is output to the connections X2/+24 V Out 1 and X2/+24 V Out 2 on the module (max. 10 W).
$P_{Fan8B0M...}$... Portion of the power [W] that is used by the fan modules in the mounting plate or the 8B0M0040HFF0.000-1 fan module (see the technical data for the respective 8B0M... mounting plate / 8B0M0040HFF0.000-1 fan module).
5) P_{SMC1} ... Max. power consumption P_{SMC} [W] of the SafeMOTION module in SLOT1 (see the "Encoder interfaces" section).
P_{SLOT2} ... Max. power consumption P_{8BAC} [W] of the plug-in module in SLOT2 (see the technical data for the respective plug-in module).
$P_{24\,V\,Out}$ ... Power [W] that is output to the connections X2/+24 V Out 1 and X2/+24 V Out 2 on the module (max. 10 W).
$P_{Fan8B0M...}$ ... Portion of the power [W] that is used by the fan modules in the mounting plate or the 8B0M0040HFF0.000-1 fan module (see the technical data for the respective 8B0M... mounting plate / 8B0M0040HFF0.000-1 fan module).
6) Only 8BCM motor cables from B&R are permitted to be connected to the motor connectors.
7) Valid in the following conditions: 750 VDC DC bus voltage. The temperature specifications refer to the ambient temperature.
8) Value for the nominal switching frequency.
9) The module cannot supply the full continuous current at this switching frequency. This unusual value for the ambient temperature, at which derating of the continuous current must be taken into account, ensures that the derating of the continuous current can be determined in the same manner as at other switching frequencies.
10) Valid in the following conditions: 750 VDC DC bus voltage, minimum permissible coolant flow volume (3 l/min).
11) The temperature specifications refer to the return temperature of the cold plate mounting plate.
12) The module cannot supply the full continuous current at this switching frequency. This unusual value for the return temperature, at which derating of the continuous current must be taken into account, ensures that the derating of the continuous current can be determined in the same manner as at other switching frequencies.
Caution! Condensation can occur at low flow temperatures and return temperatures.
13) B&R recommends operating the module at its nominal switching frequency. Operating the module at a higher switching frequency for application-specific reasons reduces the continuous current and increases the CPU load.
14) If necessary, the stress of the motor isolation system can be reduced by an additional externally wired dU/dt choke. For example, the RWK 305 three-phase du/dt choke from Schaffner (www.schaffner.com) can be used. Important: Even when using a dU/dt choke, it is necessary to ensure that an EMC-compatible, low inductance shield connection is used!
15) The module's electrical output frequency (SCTRL_SPEED_ACT * MOTOR_POLEPAIRS) is monitored to protect against dual use in accordance with EC regulation 428/2009 | 3A225. If the electrical output frequency of the module exceeds the limit value of 598 Hz uninterrupted for more than 0.5 s, then the current movement is aborted and error 6060 is output (Power element: Limit speed exceeded).
16) During project development, it is necessary to check if the minimum voltage can be maintained on the holding brake with the specified wiring. The operating voltage range of the holding brake can be found in the user's manual for the respective motor.
17) The specified value is only valid under the following conditions:
- The 24 VDC supply for the module is provided by an 8B0C auxiliary supply module installed on the same mounting plate.
If the 24 VDC supply for the module is applied to the mounting plate using an 8BVE expansion module, then the output voltage is reduced because of voltage drops on the expansion cable. In this case, undervoltage monitoring must be disabled.
18) Only 8BCF EnDat 2.2 cables from B&R are permitted to be connected to the encoder interfaces.
19) An EnDat 2.2 functional safety encoder is required when using ACOPOSmulti SafeMOTION inverter modules! With standard EnDat 2.2 encoders, only the STO, SBC and SS1 functions are monitored with respect to timing!
20) The maximum encoder cable length l_{max} can be calculated as follows (the maximum permissible encoder cable length of 100 m must not be exceeded):

$l_{max} = 7.9 / I_G * A * 1/(2*\rho)$

I_G ... Max. current consumption of the encoder [A].
A ... Cross section of the supply wire [mm²].
ρ ... Specific resistance [Ω mm²/m] (e.g. for copper: ρ = 0.0178).
21) The maximum permitted cable length is 50 m.
22) During the power-on procedure for the encoder supply voltage (2 seconds), the monitoring limit for the supply voltage is increased from 5.25 V to 6 V. In this phase, overvoltages up to 6 V are not detected.
A short-term overvoltage of maximum 6 V should not damage the encoder electronics in any way.
An undervoltage on the encoder supply will result in a sine or cosine signal outside the specification.
23) An actual reserve of 12 mA exists for the terminating resistor.
24) The sine-cosine output signals from the measuring instrument are checked by the evaluation circuit using pointer length monitoring.
The pointer length $z = 2\sqrt{(Sin - nSin)^2 + (Cos - nCos)^2}$ is monitored according to the specified limits.
25) The sine-cosine output signals from the measuring instrument are checked by the evaluation circuit using pointer length monitoring.
The pointer length $z = 2\sqrt{(Sin - nSin)^2 + (Cos - nCos)^2}$ is also monitored according to the specified limits from the time the evaluation circuit is switched on until a signal period has passed.
26) The sine-cosine output signals from the measuring instrument are checked by the evaluation circuit using pointer length monitoring.
The pointer length $z = 2\sqrt{(Sin - nSin)^2 + (Cos - nCos)^2}$ is only permitted to vary by maximum ±10% per signal period.

27) This value does not correspond to the encoder resolution that must be configured in Automation Studio (16384 * number of encoder lines).
28) Limited by the encoder in practice.
29) $I_{Encoder}$ ... Max. power consumption of the connected encoder [A].
30) Continuous operation at elevations ranging from 500 m to 4000 m above sea level is possible (taking the specified continuous current reductions into consideration).
31) This value only applies in its delivered state (SLOT2 of the module is sealed by a slot cover / shield plate). If SLOT2 on the module is not sealed, then the level of protection is reduced to IP10. It is important to note that a 8SCS005.0000-00 shield set (slot cover / shield plate) or plug-in module must always be inserted!
32) Continuous operation at ambient temperatures ranging from 40°C to max. 55°C is possible (taking the specified continuous current reductions into consideration), but this will result in a shorter service life.
33) These dimensions refer to the actual device dimensions including the respective mounting plate. Make sure to leave additional space above and below the devices for mounting, connections and air circulation.

3.2.2.4 Wiring

For details, see 3.2.5 "Wiring: Safe single-width inverter modules (single-axis modules)" on page 51.

For general information, see 6 "Wiring" on page 142.

3.2.3 8BVI0055HCSS.000-1, 8BVI0055HWSS.000-1, 8BVI0055HCSA.000-1, 8BVI0055HWSA.000-1

3.2.3.1 General information

- Clearly structured, straightforward implementation via network-based safety technology
- Modular expandability through virtual wiring
- Immediate triggering of safety function due to short cycle times
- Easy implementation with transparent control and status information, even in the standard application
- Compact design

3.2.3.2 Order data

Model number	Short description	Figure
	Cold plate or feed-through mounting	
8BVI0055HCSS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 7.6 A, HV, cold plate or feed-through mounting	
8BVI0055HCSA.000-1	ACOPOSmulti SafeMOTION SinCos inverter module, 7.6 A, HV, cold plate or feed-through mounting	
	Wall mounting	
8BVI0055HWSS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 7.6 A, HV, wall mounting	
8BVI0055HWSA.000-1	ACOPOSmulti SafeMOTION SinCos inverter module, 7.6 A, HV, wall mounting	
	Required accessories	
	Terminal block sets	
8BZVI0055SS.000-1A	Screw clamp set for ACOPOSmulti 8BVI00xxHxSS and 8BVI00xxHxSA modules: 1x 8TB3104.204G-11, 1x 8TB2104.203L-00, 1x 8TB2108.2010-00	
	Optional accessories	
	Accessory sets	
8BXB000.0000-00	ACPmulti accessory set for encoder buffering consisting of: 1 lithium battery AA 3.6 V; 1 protective cap for battery holder	
	Fan modules	
8BXF001.0000-00	ACOPOSmulti fan module, replacement fan for ACOPOSmulti modules (8BVP / 8B0C / 8BVI / 8BVE / 8B0K)	
	POWERLINK cables	
X20CA0E61.00020	POWERLINK connection cable, RJ45 to RJ45, 0.2 m	
X20CA0E61.00025	POWERLINK connection cable, RJ45 to RJ45, 0.25 m	
X20CA0E61.00030	POWERLINK connection cable, RJ45 to RJ45, 0.3 m	
X20CA0E61.00035	POWERLINK connection cable, RJ45 to RJ45, 0.35 m	
X20CA0E61.00050	POWERLINK connection cable, RJ45 to RJ45, 0.5 m	
X20CA0E61.00100	POWERLINK connection cable, RJ45 to RJ45, 1 m	
	Plug-in modules	
8BAC0120.000-1	ACOPOSmulti plug-in module, EnDat 2.1 interface	
8BAC0120.001-2	ACOPOSmulti plug-in module, EnDat 2.2 interface	
8BAC0121.000-1	ACOPOSmulti plug-in module, HIPERFACE interface	
8BAC0122.000-1	ACOPOSmulti plug-in module, resolver interface 10 kHz	
8BAC0123.000-1	ACOPOSmulti plug-in module, incremental encoder and SSI absolute encoder interface for RS422 signals	
8BAC0123.001-1	ACOPOSmulti plug-in module, incremental encoder interface for 5 V single-ended and 5 V differential signals	
8BAC0123.002-1	ACOPOSmulti plug-in module, incremental encoder interface for 24 V single-ended and 24 V differential signals	
8BAC0124.000-1	ACOPOSmulti plug-in module, SinCos interface	
8BAC0125.000-1	ACOPOSmulti plug-in module, SinCos EnDat 2.1/SSI interface	
8BAC0130.000-1	ACOPOSmulti plug-in module, 2 digital outputs, 50 mA, max. 62,5 kHz, 4 digital outputs, 500 mA, max. 1,25 kHz, 2 digital inputs 24 VDC	
8BAC0130.001-1	ACOPOSmulti plug-in module, 2 digital outputs, 50 mA, max. 62.5 kHz, 4 digital outputs, 500 mA, max. 1.25 kHz	
8BAC0132.000-1	ACOPOSmulti input module, 4 analog inputs ±10 V	
8BAC0133.000-1	ACOPOSmulti plug-in module, 3 RS422 outputs for ABR encoder emulation, 1 Mhz	
	Shield component sets	
8SCS000.0000-00	ACOPOSmulti shielding components set: 1x shielding plate 1fold type 0; 1x hose clamp, W 9 mm, D 12-22 mm	
8SCS002.0000-00	ACOPOSmulti shield component set: 1x clamping plate; 2x clamps D 4-13.5 mm; 4x screws	
8SCS009.0000-00	ACOPOSmulti shield component set: 1x ACOPOSmulti holding plate SK8-14; 1x shield terminal SK14	
	Terminal blocks	
8TB2104.203L-00	Screw clamp 4-pin, single row, spacing: 5.08 mm, label 3: T- T + B- B+, L keying: 1010	

Table 22: 8BVI0055HCSS.000-1, 8BVI0055HCSA.000-1, 8BVI0055HWSS.000-1, 8BVI0055HWSA.000-1 - Order data

Model number	Short description	Figure
8TB2108.2010-00	Screw clamp 8-pin, single row, spacing: 5.08 mm, label 1: numbered serially	
8TB3104.204G-11	Screw clamp 4-pin, single row, spacing: 7.62 mm, label 4: PE W V U, G coding: 0110	

Table 22: 8BVI0055HCSS.000-1, 8BVI0055HCSA.000-1, 8BVI0055HWSS.000-1, 8BVI0055HWSA.000-1 - Order data

Information:

Only 8BCM motor cables from B&R are permitted to be connected to the motor connectors.

ACOPOSmulti SafeMOTION EnDat 2.2

Information:

Only 8BCF EnDat 2.2 cables from B&R or 8BCH hybrid motor cables from B&R are permitted to be connected to the encoder interfaces.

ACOPOSmulti SafeMOTION SinCos

Information:

Only 8BCS encoder cables from B&R are permitted to be connected to the encoder interfaces on B&R standard motors.

For details, see 1.2 "Safe power transmission system " on page 167.

3.2.3.3 Technical data

Product ID	8BVI0055HCSS.000-1	8BVI0055HWSS.000-1	8BVI0055HCSA.000-1	8BVI0055HWSA.000-1
General information				
B&R ID code	0xAA14	0xAA16	0xDD6B	0xE0B3
Cooling and mounting method	Cold plate or feed-through mounting	Wall mounting	Cold plate or feed-through mounting	Wall mounting
Slots for plug-in modules	2 [1]			
Certification				
CE	Yes			
cULus	Yes			
KC	Yes		-	
FSC	Yes			
DC bus connection				
Voltage				
Nominal	750 VDC			
Continuous power consumption [2]	5.6 kW			
Power loss depending on the switching frequency [3]				
Switching frequency 5 kHz	[0.6 * I_M² + 1.3 * I_M + 60] W			
Switching frequency 10 kHz	[0.97 * I_M² + 0.5 * I_M + 110] W			
Switching frequency 20 kHz	[1.7 * I_M² - 0.7 * I_M + 225] W			
DC bus capacitance	165 µF			
Design	ACOPOSmulti backplane			
24 VDC supply				
Input voltage	25 VDC ±1.6%			
Input capacitance	23.5 µF			
Max. power consumption	18 W + P_{SMC1} + P_{SLOT2} + $P_{24\ V\ Out}$ + $P_{HoldingBrake}$ + $P_{Fan8B0M...}$ [4]		25 W + P_{SMC1} + P_{SLOT2} + $P_{24\ V\ Out}$ + $P_{HoldingBrake}$ + $P_{Fan8B0M...}$ [5]	
Design	ACOPOSmulti backplane			
24 VDC output				
Quantity	2			
Output voltage				
DC bus voltage (U_{DC}): 260 to 315 VDC	25 VDC * (U_{DC}/315)			
DC bus voltage (U_{DC}): 315 to 800 VDC	24 VDC ±6%			
Protection	250 mA (slow-blow) electronic, automatic reset			
Motor connection [6]				
Quantity	1			
Continuous power per motor connection [2]	5.5 kW			
Continuous current per motor connection [2]	7.6 A_{eff}			

Table 23: 8BVI0055HCSS.000-1, 8BVI0055HWSS.000-1, 8BVI0055HCSA.000-1, 8BVI0055HWSA.000-1 - Technical data

Product ID	8BVI0055HCSS.000-1	8BVI0055HWSS.000-1	8BVI0055HCSA.000-1	8BVI0055HWSA.000-1
Reduction of continuous current depending on the switching frequency 7)				
Switching frequency 5 kHz	-	No reduction 8)	-	No reduction 8)
Switching frequency 10 kHz	-	0.2 A/K (from 49°C)	-	0.2 A/K (from 49°C)
Switching frequency 20 kHz	-	0.13 A/K (from 4°C) 9)	-	0.13 A/K (from 4°C) 9)
Reduction of continuous current depending on the switching frequency and mounting method 10)				
Switching frequency 5 kHz				
Cold plate mounting 11)	0.65 A/K (from 57°C) 8)	-	0.65 A/K (from 57°C) 8)	-
Feed-through mounting	No reduction 8)	-	No reduction 8)	-
Switching frequency 10 kHz				
Cold plate mounting 11)	0.28 A/K (from 46°C)	-	0.28 A/K (from 46°C)	-
Feed-through mounting	0.15 A/K (from 34°C) 9)	-	0.15 A/K (from 34°C) 9)	-
Switching frequency 20 kHz				
Cold plate mounting 11)	0.14 A/K (from 5°C) 12)	-	0.14 A/K (from 5°C) 12)	-
Feed-through mounting	0.08 A/K (from -33°C) 9)	-	0.08 A/K (from -33°C) 9)	-
Reduction of continuous current depending on the installation elevation				
Starting at 500 m above sea level	0.76 A_{eff} per 1000 m			
Peak current	18.9 A_{eff}			
Nominal switching frequency	5 kHz			
Possible switching frequencies 13)	5/10/20 kHz			
Electrical stress of the connected motor in accordance with IEC TS 60034-25 14)	Limit value curve A			
Protective measures				
Overload protection	Yes			
Short circuit and ground fault protection	Yes			
Max. output frequency	598 Hz 15)			
Design				
U, V, W, PE	Male connector			
Shield connection	Yes			
Terminal connection cross section				
Flexible and fine wire lines				
With wire end sleeves	0.25 to 4 mm²			
Approbation data				
UL/C-UL-US	30 to 10			
CSA	28 to 10			
Terminal cable cross section dimension of shield connection	12 to 22 mm			
Max. motor line length depending on the switching frequency				
Switching frequency 5 kHz	25 m			
Switching frequency 10 kHz	25 m			
Switching frequency 20 kHz	10 m			
Motor holding brake connection				
Quantity	1			
Output voltage 16)	24 VDC +5.8% / -0% 17)			
Continuous current	1.1 A			
Max. internal resistance	0.5 Ω			
Extinction potential	Approx. 30 V			
Max. extinction energy per switching operation	1.5 Ws			
Max. switching frequency	0.5 Hz			
Protective measures				
Overload and short circuit protection	Yes			
Open line monitoring	Yes			
Undervoltage monitoring	Yes			
Response threshold for open line monitoring	Approx. 0.25 A			
Response threshold for undervoltage monitoring	24 VDC -2% / -4%			
Encoder interfaces 18)				
Quantity	1			
Type	EnDat 2.2 19)		SinCos	
Connections	9-pin female DSUB connector		15-pin female DSUB connector	
Status indicators	UP/DN LEDs			
Electrical isolation				
Encoder - ACOPOSmulti	No			
Encoder monitoring	Yes			
Max. encoder cable length	100 m Depends on the cross section of the encoder's supply wires 20)		50 m 21)	

Table 23: 8BVI0055HCSS.000-1, 8BVI0055HWSS.000-1, 8BVI0055HCSA.000-1, 8BVI0055HWSA.000-1 - Technical data

Product ID	8BVI0055HCSS.000-1	8BVI0055HWSS.000-1	8BVI0055HCSA.000-1	8BVI0055HWSA.000-1
Encoder supply				
Output voltage	Typ. 12.5 V		5 V ±5% [22]	
Load capability	350 mA		300 mA [23]	
Sense lines	-		2, compensation of max. 2 x 0.7 V	
Protective measures				
Short circuit protection	Yes			
Overload protection	Yes			
Synchronous serial interface				
Signal transmission	RS485			
Data transfer rate	6.25 Mbit/s		781.25 kbit/s	
Sine/Cosine inputs				
Signal transmission	-		Differential signals, symmetrical	
Differential voltage				
In motion	-		0.5 to 1.35 V [24]	
At standstill	-		0.8 to 1.35 V [25]	
Differential voltage deviation per signal period	-		±10% [26]	
Common-mode voltage	-		Max. ±7 V	
Terminating resistors	-		120 Ω	
Max. input frequency	-		200 kHz	
Signal frequency (-5 dB)	-		<300 kHz	
Signal frequency (-3 dB)	-		DC up to 200 kHz	
ADC resolution	-		12-bit	
Reference input				
Signal transmission	-		Differential signal, symmetrical	
Differential voltage for low	-		≤ -0.2 V	
Differential voltage for high	-		≥ 0.2 V	
Common-mode voltage	-		Max. -5 V to +9 V	
Terminating resistors	-		120 Ω	
Position				
Resolution @ 1 V_{SS} [27]	-		Number of encoder lines * 5700	
Precision [28]	-		---	
Noise [28]	-		---	
Max. power consumption per encoder interface	P_{SMC}[W] = 19 V * $I_{Encoder}$[A] [29]		P_{SMC}[W] = 25 V * (0.376 A + 0.35 * $I_{Encoder}$[A]) [29]	
Trigger inputs				
Quantity	2			
Wiring	Sink			
Electrical isolation				
Input - Inverter module	Yes			
Input - Input	Yes			
Input voltage				
Nominal	24 VDC			
Maximum	30 VDC			
Switching threshold				
Low	<5 V			
High	>15 V			
Input current at nominal voltage	Approx. 10 mA			
Switching delay				
Rising edge	52 µs ±0.5 µs (digitally filtered)			
Falling edge	53 µs ±0.5 µs (digitally filtered)			
Modulation compared to ground potential	Max. ±38 V			
Electrical characteristics				
Discharge capacitance	0.14 µF			
Operating conditions				
Permitted mounting orientations				
Hanging vertically	Yes			
Lying horizontally	Yes			
Standing horizontally	No			
Installation at elevations above sea level				
Nominal	0 to 500 m			
Maximum [30]	4000 m			
Degree of pollution in accordance with EN 60664-1	2 (non-conductive pollution)			
Overvoltage category in accordance with IEC 60364-4-443:1999	III			
EN 60529 protection	IP20 [31]			
Environmental conditions				
Temperature				
Operation				
Nominal	5 to 40°C			
Maximum [32]	55°C			
Storage	-25 to 55°C			
Transport	-25 to 70°C			

Table 23: 8BVI0055HCSS.000-1, 8BVI0055HWSS.000-1, 8BVI0055HCSA.000-1, 8BVI0055HWSA.000-1 - Technical data

Product ID	8BVI0055HCSS.000-1	8BVI0055HWSS.000-1	8BVI0055HCSA.000-1	8BVI0055HWSA.000-1
Relative humidity				
Operation	5 to 85%			
Storage	5 to 95%			
Transport	Max. 95% at 40°C			
Mechanical characteristics				
Dimensions [33]				
Width	53 mm			
Height	317 mm			
Depth				
Wall mounting	-	263 mm	-	263 mm
Cold plate	212 mm	-	212 mm	-
Feed-through mounting	209 mm	-	209 mm	-
Weight	Approx. 2.2 kg	Approx. 2.7 kg	Approx. 2.2 kg	Approx. 2.7 kg
Module width	1			

Table 23: 8BVI0055HCSS.000-1, 8BVI0055HWSS.000-1, 8BVI0055HCSA.000-1, 8BVI0055HWSA.000-1 - Technical data

1) SLOT 2 is not occupied. SLOT 1 of the ACOPOSmulti module is occupied by the SafeMOTION module.
2) Valid in the following conditions: 750 VDC DC bus voltage, 5 kHz switching frequency, 40°C ambient temperature, installation elevation <500 m above sea level, no derating due to cooling type.
3) I_M... Current on the motor connection [A].
4) P_{SMC1} ... Max. power consumption P_{SMC} [W] of the SafeMOTION module in SLOT1 (see the "Encoder interfaces" section).
P_{SLOT2} ... Max. power consumption P_{8BAC} [W] of the plug-in module in SLOT2 (see the technical data for the respective plug-in module).
$P_{24\ V\ Out}$... Power [W] that is output to the connections X2/+24 V Out 1 and X2/+24 V Out 2 on the module (max. 10 W).
$P_{Fan8B0M...}$... Portion of the power [W] that is used by the fan modules in the mounting plate or the 8B0M0040HFF0.000-1 fan module (see the technical data for the respective 8B0M... mounting plate / 8B0M0040HFF0.000-1 fan module).
5) P_{SMC1} ... Max. power consumption P_{SMC} [W] of the SafeMOTION module in SLOT1 (see the "Encoder interfaces" section).
P_{SLOT2} ... Max. power consumption P_{8BAC} [W] of the plug-in module in SLOT2 (see the technical data for the respective plug-in module).
$P_{24\ V\ Out}$ ... Power [W] that is output to the connections X2/+24 V Out 1 and X2/+24 V Out 2 on the module (max. 10 W).
$P_{Fan8B0M...}$ ... Portion of the power [W] that is used by the fan modules in the mounting plate or the 8B0M0040HFF0.000-1 fan module (see the technical data for the respective 8B0M... mounting plate / 8B0M0040HFF0.000-1 fan module).
6) Only 8BCM motor cables from B&R are permitted to be connected to the motor connectors.
7) Valid in the following conditions: 750 VDC DC bus voltage. The temperature specifications refer to the ambient temperature.
8) Value for the nominal switching frequency.
9) The module cannot supply the full continuous current at this switching frequency. This unusual value for the ambient temperature, at which derating of the continuous current must be taken into account, ensures that the derating of the continuous current can be determined in the same manner as at other switching frequencies.
10) Valid in the following conditions: 750 VDC DC bus voltage, minimum permissible coolant flow volume (3 l/min).
11) The temperature specifications refer to the return temperature of the cold plate mounting plate.
12) The module cannot supply the full continuous current at this switching frequency. This unusual value for the return temperature, at which derating of the continuous current must be taken into account, ensures that the derating of the continuous current can be determined in the same manner as at other switching frequencies.
Caution! Condensation can occur at low flow temperatures and return temperatures.
13) B&R recommends operating the module at its nominal switching frequency. Operating the module at a higher switching frequency for application-specific reasons reduces the continuous current and increases the CPU load.
14) If necessary, the stress of the motor isolation system can be reduced by an additional externally wired dU/dt choke. For example, the RWK 305 three-phase du/dt choke from Schaffner (www.schaffner.com) can be used. Important: Even when using a dU/dt choke, it is necessary to ensure that an EMC-compatible, low inductance shield connection is used!
15) The module's electrical output frequency (SCTRL_SPEED_ACT * MOTOR_POLEPAIRS) is monitored to protect against dual use in accordance with EC regulation 428/2009 | 3A225. If the electrical output frequency of the module exceeds the limit value of 598 Hz uninterrupted for more than 0.5 s, then the current movement is aborted and error 6060 is output (Power element: Limit speed exceeded).
16) During project development, it is necessary to check if the minimum voltage can be maintained on the holding brake with the specified wiring. The operating voltage range of the holding brake can be found in the user's manual for the respective motor.
17) The specified value is only valid under the following conditions:
- The 24 VDC supply for the module is provided by an 8B0C auxiliary supply module installed on the same mounting plate.
If the 24 VDC supply for the module is applied to the mounting plate using an 8BVE expansion module, then the output voltage is reduced because of voltage drops on the expansion cable. In this case, undervoltage monitoring must be disabled.
18) Only 8BCF EnDat 2.2 cables from B&R are permitted to be connected to the encoder interfaces.
19) An EnDat 2.2 functional safety encoder is required when using ACOPOSmulti SafeMOTION inverter modules! With standard EnDat 2.2 encoders, only the STO, SBC and SS1 functions are monitored with respect to timing!
20) The maximum encoder cable length l_{max} can be calculated as follows (the maximum permissible encoder cable length of 100 m must not be exceeded):

$l_{max} = 7.9 / I_G * A * 1/(2*\rho)$

I_G ... Max. current consumption of the encoder [A].
A ... Cross section of the supply wire [mm²].
ρ ... Specific resistance [Ω mm²/m] (e.g. for copper: ρ = 0.0178).
21) The maximum permitted cable length is 50 m.
22) During the power-on procedure for the encoder supply voltage (2 seconds), the monitoring limit for the supply voltage is increased from 5.25 V to 6 V. In this phase, overvoltages up to 6 V are not detected.
A short-term overvoltage of maximum 6 V should not damage the encoder electronics in any way.
An undervoltage on the encoder supply will result in a sine or cosine signal outside the specification.
23) An actual reserve of 12 mA exists for the terminating resistor.
24) The sine-cosine output signals from the measuring instrument are checked by the evaluation circuit using pointer length monitoring.
The pointer length z = 2 √((Sin - nSin)² + (Cos - nCos)²) is monitored according to the specified limits.
25) The sine-cosine output signals from the measuring instrument are checked by the evaluation circuit using pointer length monitoring.
The pointer length z = 2 √((Sin - nSin)² + (Cos - nCos)²) is also monitored according to the specified limits from the time the evaluation circuit is switched on until a signal period has passed.
26) The sine-cosine output signals from the measuring instrument are checked by the evaluation circuit using pointer length monitoring.
The pointer length z = 2 √((Sin - nSin)² + (Cos - nCos)²) is only permitted to vary by maximum ±10% per signal period.

27) This value does not correspond to the encoder resolution that must be configured in Automation Studio (16384 * number of encoder lines).
28) Limited by the encoder in practice.
29) $I_{Encoder}$ ... Max. power consumption of the connected encoder [A].
30) Continuous operation at elevations ranging from 500 m to 4000 m above sea level is possible (taking the specified continuous current reductions into consideration).
31) This value only applies in its delivered state (SLOT2 of the module is sealed by a slot cover / shield plate). If SLOT2 on the module is not sealed, then the level of protection is reduced to IP10. It is important to note that a 8SCS005.0000-00 shield set (slot cover / shield plate) or plug-in module must always be inserted!
32) Continuous operation at ambient temperatures ranging from 40°C to max. 55°C is possible (taking the specified continuous current reductions into consideration), but this will result in a shorter service life.
33) These dimensions refer to the actual device dimensions including the respective mounting plate. Make sure to leave additional space above and below the devices for mounting, connections and air circulation.

3.2.3.4 Wiring

For details, see 3.2.5 "Wiring: Safe single-width inverter modules (single-axis modules)" on page 51.

For general information, see 6 "Wiring" on page 142.

3.2.4 8BVI0110HCSS.000-1, 8BVI0110HWSS.000-1, 8BVI0110HCSA.000-1, 8BVI0110HWSA.000-1

3.2.4.1 General information

- Clearly structured, straightforward implementation via network-based safety technology
- Modular expandability through virtual wiring
- Immediate triggering of safety function due to short cycle times
- Easy implementation with transparent control and status information, even in the standard application
- Compact design

3.2.4.2 Order data

Model number	Short description	Figure
	Cold plate or feed-through mounting	
8BVI0110HCSS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 15.1 A, HV, cold plate or feed-through mounting	
8BVI0110HCSA.000-1	ACOPOSmulti SafeMOTION SinCos inverter module, 15.1 A, HV, cold plate or feed-through mounting	
	Wall mounting	
8BVI0110HWSS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 15.1 A, HV, wall mounting	
8BVI0110HWSA.000-1	ACOPOSmulti SafeMOTION SinCos inverter module, 15.1 A, HV, wall mounting	
	Required accessories	
	Terminal block sets	
8BZVI0110SS.000-1A	Screw clamp set for ACOPOSmulti 8BVI0110HxSS and 8BVI0110HxSA modules: 1x 8TB3104.204G-11, 1x 8TB2104.203L-00, 1x 8TB2108.2010-00	
	Optional accessories	
	Accessory sets	
8BXB000.0000-00	ACPmulti accessory set for encoder buffering consisting of: 1 lithium battery AA 3.6 V; 1 protective cap for battery holder	
	Fan modules	
8BXF001.0000-00	ACOPOSmulti fan module, replacement fan for ACOPOSmulti modules (8BVP / 8B0C / 8BVI / 8BVE / 8B0K)	
	POWERLINK cables	
X20CA0E61.00020	POWERLINK connection cable, RJ45 to RJ45, 0.2 m	
X20CA0E61.00025	POWERLINK connection cable, RJ45 to RJ45, 0.25 m	
X20CA0E61.00030	POWERLINK connection cable, RJ45 to RJ45, 0.3 m	
X20CA0E61.00035	POWERLINK connection cable, RJ45 to RJ45, 0.35 m	
X20CA0E61.00050	POWERLINK connection cable, RJ45 to RJ45, 0.5 m	
X20CA0E61.00100	POWERLINK connection cable, RJ45 to RJ45, 1 m	
	Plug-in modules	
8BAC0120.000-1	ACOPOSmulti plug-in module, EnDat 2.1 interface	
8BAC0120.001-2	ACOPOSmulti plug-in module, EnDat 2.2 interface	
8BAC0121.000-1	ACOPOSmulti plug-in module, HIPERFACE interface	
8BAC0122.000-1	ACOPOSmulti plug-in module, resolver interface 10 kHz	
8BAC0123.000-1	ACOPOSmulti plug-in module, incremental encoder and SSI absolute encoder interface for RS422 signals	
8BAC0123.001-1	ACOPOSmulti plug-in module, incremental encoder interface for 5 V single-ended and 5 V differential signals	
8BAC0123.002-1	ACOPOSmulti plug-in module, incremental encoder interface for 24 V single-ended and 24 V differential signals	
8BAC0124.000-1	ACOPOSmulti plug-in module, SinCos interface	
8BAC0125.000-1	ACOPOSmulti plug-in module, SinCos EnDat 2.1/SSI interface	
8BAC0130.000-1	ACOPOSmulti plug-in module, 2 digital outputs, 50 mA, max. 62,5 kHz, 4 digital outputs, 500 mA, max. 1,25 kHz, 2 digital inputs 24 VDC	
8BAC0130.001-1	ACOPOSmulti plug-in module, 2 digital outputs, 50 mA, max. 62.5 kHz, 4 digital outputs, 500 mA, max. 1.25 kHz	
8BAC0132.000-1	ACOPOSmulti input module, 4 analog inputs ±10 V	
8BAC0133.000-1	ACOPOSmulti plug-in module, 3 RS422 outputs for ABR encoder emulation, 1 Mhz	
	Shield component sets	
8SCS000.0000-00	ACOPOSmulti shielding components set: 1x shielding plate 1fold type 0; 1x hose clamp, W 9 mm, D 12-22 mm	
8SCS002.0000-00	ACOPOSmulti shield component set: 1x clamping plate; 2x clamps D 4-13.5 mm; 4x screws	
8SCS009.0000-00	ACOPOSmulti shield component set: 1x ACOPOSmulti holding plate SK8-14; 1x shield terminal SK14	
	Terminal blocks	
8TB2104.203L-00	Screw clamp 4-pin, single row, spacing: 5.08 mm, label 3: T- T + B- B+, L keying: 1010	

Table 24: 8BVI0110HCSS.000-1, 8BVI0110HCSA.000-1, 8BVI0110HWSS.000-1, 8BVI0110HWSA.000-1 - Order data

Model number	Short description	Figure
8TB2108.2010-00	Screw clamp 8-pin, single row, spacing: 5.08 mm, label 1: numbered serially	
8TB3104.204G-11	Screw clamp 4-pin, single row, spacing: 7.62 mm, label 4: PE W V U, G coding: 0110	

Table 24: 8BVI0110HCSS.000-1, 8BVI0110HCSA.000-1, 8BVI0110HWSS.000-1, 8BVI0110HWSA.000-1 - Order data

Information:

Only 8BCM motor cables from B&R are permitted to be connected to the motor connectors.

ACOPOSmulti SafeMOTION EnDat 2.2

Information:

Only 8BCF EnDat 2.2 cables from B&R or 8BCH hybrid motor cables from B&R are permitted to be connected to the encoder interfaces.

ACOPOSmulti SafeMOTION SinCos

Information:

Only 8BCS encoder cables from B&R are permitted to be connected to the encoder interfaces on B&R standard motors.

For details, see 1.2 "Safe power transmission system " on page 167.

3.2.4.3 Technical data

Product ID	8BVI0110HCSS.000-1	8BVI0110HWSS.000-1	8BVI0110HCSA.000-1	8BVI0110HWSA.000-1
General information				
B&R ID code	0xAA18	0xAA1A	0xDD1F	0xE0BC
Cooling and mounting method	Cold plate or feed-through mounting	Wall mounting	Cold plate or feed-through mounting	Wall mounting
Slots for plug-in modules	2 [1]			
Certification				
CE	Yes			
cULus	Yes			
KC	Yes		-	
FSC	Yes			
DC bus connection				
Voltage				
Nominal	750 VDC			
Continuous power consumption [2]	11.2 kW			
Power loss depending on the switching frequency [3]				
Switching frequency 5 kHz	$[0.16 * I_M^2 + 5.6 * I_M + 55]$ W			
Switching frequency 10 kHz	$[0.49 * I_M^2 + 4.7 * I_M + 95]$ W			
Switching frequency 20 kHz	$[0.87 * I_M^2 + 10 * I_M + 200]$ W			
DC bus capacitance	330 µF			
Design	ACOPOSmulti backplane			
24 VDC supply				
Input voltage	25 VDC ±1.6%			
Input capacitance	23.5 µF			
Max. power consumption	18 W + P_{SMC1} + P_{SLOT2} + $P_{24\ V\ Out}$ + $P_{HoldingBrake}$ + $P_{Fan8B0M...}$ [4]		25 W + P_{SMC1} + P_{SLOT2} + $P_{24\ V\ Out}$ + $P_{HoldingBrake}$ + $P_{Fan8B0M...}$ [5]	
Design	ACOPOSmulti backplane			
24 VDC output				
Quantity	2			
Output voltage				
DC bus voltage (U_{DC}): 260 to 315 VDC	25 VDC * (U_{DC}/315)			
DC bus voltage (U_{DC}): 315 to 800 VDC	24 VDC ±6%			
Protection	250 mA (slow-blow) electronic, automatic reset			
Motor connection [6]				
Quantity	1			
Continuous power per motor connection [2]	11 kW			
Continuous current per motor connection [2]	15.1 A_{eff}			

Table 25: 8BVI0110HCSS.000-1, 8BVI0110HWSS.000-1, 8BVI0110HCSA.000-1, 8BVI0110HWSA.000-1 - Technical data

Product ID	8BVI0110HCSS.000-1	8BVI0110HWSS.000-1	8BVI0110HCSA.000-1	8BVI0110HWSA.000-1
Reduction of continuous current depending on the switching frequency [7]				
Switching frequency 5 kHz	-	No reduction [8]	-	No reduction [8]
Switching frequency 10 kHz	-	0.26 A/K (from 33°C) [9]	-	0.26 A/K (from 33°C) [9]
Switching frequency 20 kHz	-	0.15 A/K (from -28°C) [9]	-	0.15 A/K (from -28°C) [9]
Reduction of continuous current depending on the switching frequency and mounting method [10]				
Switching frequency 5 kHz				
Cold plate mounting [11]	0.73 A/K (from 55°C) [8]	-	0.73 A/K (from 55°C) [8]	-
Feed-through mounting	0.29 A/K (from 49°C) [8]	-	0.29 A/K (from 49°C) [8]	-
Switching frequency 10 kHz				
Cold plate mounting [11]	0.32 A/K (from 35°C) [12]	-	0.32 A/K (from 35°C) [12]	-
Feed-through mounting	0.17 A/K (from 11°C) [13]	-	0.17 A/K (from 11°C) [13]	-
Switching frequency 20 kHz				
Cold plate mounting [11]	0.18 A/K (from -13°C) [12]	-	0.18 A/K (from -13°C) [12]	-
Feed-through mounting	0.11 A/K (from -73°C) [13]	-	0.11 A/K (from -73°C) [13]	-
Reduction of continuous current depending on the installation elevation				
Starting at 500 m above sea level	1.51 A_{eff} per 1000 m			
Peak current	37.7 A_{eff}			
Nominal switching frequency	5 kHz			
Possible switching frequencies [14]	5/10/20 kHz			
Electrical stress of the connected motor in accordance with IEC TS 60034-25 [15]	Limit value curve A			
Protective measures				
Overload protection	Yes			
Short circuit and ground fault protection	Yes			
Max. output frequency	598 Hz [16]			
Design				
U, V, W, PE	Male connector			
Shield connection	Yes			
Terminal connection cross section				
Flexible and fine wire lines				
With wire end sleeves	0.25 to 4 mm²			
Approbation data				
UL/C-UL-US	30 to 10			
CSA	28 to 10			
Terminal cable cross section dimension of shield connection	12 to 22 mm			
Max. motor line length depending on the switching frequency				
Switching frequency 5 kHz	25 m			
Switching frequency 10 kHz	25 m			
Switching frequency 20 kHz	10 m			
Motor holding brake connection				
Quantity	1			
Output voltage [17]	24 VDC +5.8% / -0% [18]			
Continuous current	2.1 A			
Max. internal resistance	0.3 Ω			
Extinction potential	Approx. 30 V			
Max. extinction energy per switching operation	3 Ws			
Max. switching frequency	0.5 Hz			
Protective measures				
Overload and short circuit protection	Yes			
Open line monitoring	Yes			
Undervoltage monitoring	Yes			
Response threshold for open line monitoring	Approx. 0.5 A			
Response threshold for undervoltage monitoring	24 VDC -2% / -4%			
Encoder interfaces [19]				
Quantity	1			
Type	EnDat 2.2 [20]		SinCos	
Connections	9-pin female DSUB connector		15-pin female DSUB connector	
Status indicators	UP/DN LEDs			
Electrical isolation				
Encoder - ACOPOSmulti	No			
Encoder monitoring	Yes			
Max. encoder cable length	100 m Depends on the cross section of the encoder's supply wires [21]		50 m [22]	

Table 25: 8BVI0110HCSS.000-1, 8BVI0110HWSS.000-1, 8BVI0110HCSA.000-1, 8BVI0110HWSA.000-1 - Technical data

Product ID	8BVI0110HCSS.000-1	8BVI0110HWSS.000-1	8BVI0110HCSA.000-1	8BVI0110HWSA.000-1
Encoder supply				
Output voltage	Typ. 12.5 V		5 V ±5% [23]	
Load capability	350 mA		300 mA [24]	
Sense lines	-		2, compensation of max. 2 x 0.7 V	
Protective measures				
Short circuit protection	Yes			
Overload protection	Yes			
Synchronous serial interface				
Signal transmission	RS485			
Data transfer rate	6.25 Mbit/s		781.25 kbit/s	
Sine/Cosine inputs				
Signal transmission	-		Differential signals, symmetrical	
Differential voltage				
In motion	-		0.5 to 1.35 V [25]	
At standstill	-		0.8 to 1.35 V [26]	
Differential voltage deviation per signal period	-		±10% [27]	
Common-mode voltage	-		Max. ±7 V	
Terminating resistors	-		120 Ω	
Max. input frequency	-		200 kHz	
Signal frequency (-5 dB)	-		<300 kHz	
Signal frequency (-3 dB)	-		DC up to 200 kHz	
ADC resolution	-		12-bit	
Reference input				
Signal transmission	-		Differential signal, symmetrical	
Differential voltage for low	-		≤ -0.2 V	
Differential voltage for high	-		≥ 0.2 V	
Common-mode voltage	-		Max. -5 V to +9 V	
Terminating resistors	-		120 Ω	
Position				
Resolution @ 1 V_{SS} [28]	-		Number of encoder lines * 5700	
Precision [29]	-		---	
Noise [29]	-		---	
Max. power consumption per encoder interface	P_{SMC}[W] = 19 V * $I_{Encoder}$[A] [30]		P_{SMC}[W] = 25 V * (0.376 A + 0.35 * $I_{Encoder}$[A]) [30]	
Trigger inputs				
Quantity	2			
Wiring	Sink			
Electrical isolation				
Input - Inverter module	Yes			
Input - Input	Yes			
Input voltage				
Nominal	24 VDC			
Maximum	30 VDC			
Switching threshold				
Low	<5 V			
High	>15 V			
Input current at nominal voltage	Approx. 10 mA			
Switching delay				
Rising edge	52 µs ±0.5 µs (digitally filtered)			
Falling edge	53 µs ±0.5 µs (digitally filtered)			
Modulation compared to ground potential	Max. ±38 V			
Electrical characteristics				
Discharge capacitance	0.14 µF			
Operating conditions				
Permitted mounting orientations				
Hanging vertically	Yes			
Lying horizontally	Yes			
Standing horizontally	No			
Installation at elevations above sea level				
Nominal	0 to 500 m			
Maximum [31]	4000 m			
Degree of pollution in accordance with EN 60664-1	2 (non-conductive pollution)			
Overvoltage category in accordance with IEC 60364-4-443:1999	III			
EN 60529 protection	IP20 [32]			
Environmental conditions				
Temperature				
Operation				
Nominal	5 to 40°C			
Maximum [33]	55°C			
Storage	-25 to 55°C			
Transport	-25 to 70°C			

Table 25: 8BVI0110HCSS.000-1, 8BVI0110HWSS.000-1, 8BVI0110HCSA.000-1, 8BVI0110HWSA.000-1 - Technical data

Product ID	8BVI0110HCSS.000-1	8BVI0110HWSS.000-1	8BVI0110HCSA.000-1	8BVI0110HWSA.000-1
Relative humidity				
Operation	5 to 85%			
Storage	5 to 95%			
Transport	Max. 95% at 40°C			
Mechanical characteristics				
Dimensions 34)				
Width	53 mm			
Height	317 mm			
Depth				
Wall mounting	-	263 mm	-	263 mm
Cold plate	212 mm	-	212 mm	-
Feed-through mounting	209 mm	-	209 mm	-
Weight	Approx. 2.4 kg	Approx. 2.9 kg	Approx. 2.4 kg	Approx. 2.9 kg
Module width	1			

Table 25: 8BVI0110HCSS.000-1, 8BVI0110HWSS.000-1, 8BVI0110HCSA.000-1, 8BVI0110HWSA.000-1 - Technical data

1) SLOT 2 is not occupied. SLOT 1 of the ACOPOSmulti module is occupied by the SafeMOTION module.
2) Valid in the following conditions: 750 VDC DC bus voltage, 5 kHz switching frequency, 40°C ambient temperature, installation elevation <500 m above sea level, no derating due to cooling type.
3) I_M... Current on the motor connection [A].
4) P_{SMC1} ... Max. power consumption P_{SMC} [W] of the SafeMOTION module in SLOT1 (see the "Encoder interfaces" section).
P_{SLOT2} ... Max. power consumption P_{8BAC} [W] of the plug-in module in SLOT2 (see the technical data for the respective plug-in module).
$P_{24\,V\,Out}$... Power [W] that is output to the connections X2/+24 V Out 1 and X2/+24 V Out 2 on the module (max. 10 W).
$P_{Fan8B0M...}$... Portion of the power [W] that is used by the fan modules in the mounting plate or the 8B0M0040HFF0.000-1 fan module (see the technical data for the respective 8B0M... mounting plate / 8B0M0040HFF0.000-1 fan module).
5) P_{SMC1} ... Max. power consumption P_{SMC} [W] of the SafeMOTION module in SLOT1 (see the "Encoder interfaces" section).
P_{SLOT2} ... Max. power consumption P_{8BAC} [W] of the plug-in module in SLOT2 (see the technical data for the respective plug-in module).
$P_{24\,V\,Out}$ ... Power [W] that is output to the connections X2/+24 V Out 1 and X2/+24 V Out 2 on the module (max. 10 W).
$P_{Fan8B0M...}$ ... Portion of the power [W] that is used by the fan modules in the mounting plate or the 8B0M0040HFF0.000-1 fan module (see the technical data for the respective 8B0M... mounting plate / 8B0M0040HFF0.000-1 fan module).
6) Only 8BCM motor cables from B&R are permitted to be connected to the motor connectors.
7) Valid in the following conditions: 750 VDC DC bus voltage. The temperature specifications refer to the ambient temperature.
8) Value for the nominal switching frequency.
9) The module cannot supply the full continuous current at this switching frequency. This unusual value for the ambient temperature, at which derating of the continuous current must be taken into account, ensures that the derating of the continuous current can be determined in the same manner as at other switching frequencies.
10) Valid in the following conditions: 750 VDC DC bus voltage, minimum permissible coolant flow volume (3 l/min).
11) The temperature specifications refer to the return temperature of the cold plate mounting plate.
12) The module cannot supply the full continuous current at this switching frequency. This unusual value for the return temperature, at which derating of the continuous current must be taken into account, ensures that the derating of the continuous current can be determined in the same manner as at other switching frequencies.
Caution! Condensation can occur at low flow temperatures and return temperatures.
13) The module cannot supply the full continuous current at this switching frequency. This unusual value for the return temperature, at which derating of the continuous current must be taken into account, ensures that the derating of the continuous current can be determined in the same manner as at other switching frequencies.
14) B&R recommends operating the module at its nominal switching frequency. Operating the module at a higher switching frequency for application-specific reasons reduces the continuous current and increases the CPU load.
15) If necessary, the stress of the motor isolation system can be reduced by an additional externally wired dU/dt choke. For example, the RWK 305 three-phase du/dt choke from Schaffner (www.schaffner.com) can be used. Important: Even when using a dU/dt choke, it is necessary to ensure that an EMC-compatible, low inductance shield connection is used!
16) The module's electrical output frequency (SCTRL_SPEED_ACT * MOTOR_POLEPAIRS) is monitored to protect against dual use in accordance with EC regulation 428/2009 | 3A225. If the electrical output frequency of the module exceeds the limit value of 598 Hz uninterrupted for more than 0.5 s, then the current movement is aborted and error 6060 is output (Power element: Limit speed exceeded).
17) During project development, it is necessary to check if the minimum voltage can be maintained on the holding brake with the specified wiring. The operating voltage range of the holding brake can be found in the user's manual for the respective motor.
18) The specified value is only valid under the following conditions:
- The 24 VDC supply for the module is provided by an 8B0C auxiliary supply module installed on the same mounting plate.
If the 24 VDC supply for the module is applied to the mounting plate using an 8BVE expansion module, then the output voltage is reduced because of voltage drops on the expansion cable. In this case, undervoltage monitoring must be disabled.
19) Only 8BCF EnDat 2.2 cables from B&R are permitted to be connected to the encoder interfaces.
20) An EnDat 2.2 functional safety encoder is required when using ACOPOSmulti SafeMOTION inverter modules! With standard EnDat 2.2 encoders, only the STO, SBC and SS1 functions are monitored with respect to timing!
21) The maximum encoder cable length l_{max} can be calculated as follows (the maximum permissible encoder cable length of 100 m must not be exceeded):

$l_{max} = 7.9 / I_G * A * 1/(2*\rho)$

I_G ... Max. current consumption of the encoder [A].
A ... Cross section of the supply wire [mm²].
ρ ... Specific resistance [Ω mm²/m] (e.g. for copper: ρ = 0.0178).
22) The maximum permitted cable length is 50 m.
23) During the power-on procedure for the encoder supply voltage (2 seconds), the monitoring limit for the supply voltage is increased from 5.25 V to 6 V. In this phase, overvoltages up to 6 V are not detected.
A short-term overvoltage of maximum 6 V should not damage the encoder electronics in any way.
An undervoltage on the encoder supply will result in a sine or cosine signal outside the specification.
24) An actual reserve of 12 mA exists for the terminating resistor.
25) The sine-cosine output signals from the measuring instrument are checked by the evaluation circuit using pointer length monitoring.
The pointer length $z = 2\sqrt{(Sin - nSin)^2 + (Cos - nCos)^2}$ is monitored according to the specified limits.

26) The sine-cosine output signals from the measuring instrument are checked by the evaluation circuit using pointer length monitoring.
The pointer length $z = 2\sqrt{(Sin - nSin)^2 + (Cos - nCos)^2}$ is also monitored according to the specified limits from the time the evaluation circuit is switched on until a signal period has passed.
27) The sine-cosine output signals from the measuring instrument are checked by the evaluation circuit using pointer length monitoring.
The pointer length $z = 2\sqrt{(Sin - nSin)^2 + (Cos - nCos)^2}$ is only permitted to vary by maximum ±10% per signal period.
28) This value does not correspond to the encoder resolution that must be configured in Automation Studio (16384 * number of encoder lines).
29) Limited by the encoder in practice.
30) $I_{Encoder}$ ... Max. power consumption of the connected encoder [A].
31) Continuous operation at elevations ranging from 500 m to 4000 m above sea level is possible (taking the specified continuous current reductions into consideration).
32) This value only applies in its delivered state (SLOT2 of the module is sealed by a slot cover / shield plate). If SLOT2 on the module is not sealed, then the level of protection is reduced to IP10. It is important to note that a 8SCS005.0000-00 shield set (slot cover / shield plate) or plug-in module must always be inserted!
33) Continuous operation at ambient temperatures ranging from 40°C to max. 55°C is possible (taking the specified continuous current reductions into consideration), but this will result in a shorter service life.
34) These dimensions refer to the actual device dimensions including the respective mounting plate. Make sure to leave additional space above and below the devices for mounting, connections and air circulation.

3.2.4.4 Wiring

For details, see 3.2.5 "Wiring: Safe single-width inverter modules (single-axis modules)" on page 51.

For general information, see 6 "Wiring" on page 142.

3.2.5 Wiring: Safe single-width inverter modules (single-axis modules)

3.2.5.1 ACOPOSmulti SafeMOTION EnDat 2.2 - Pinout overview

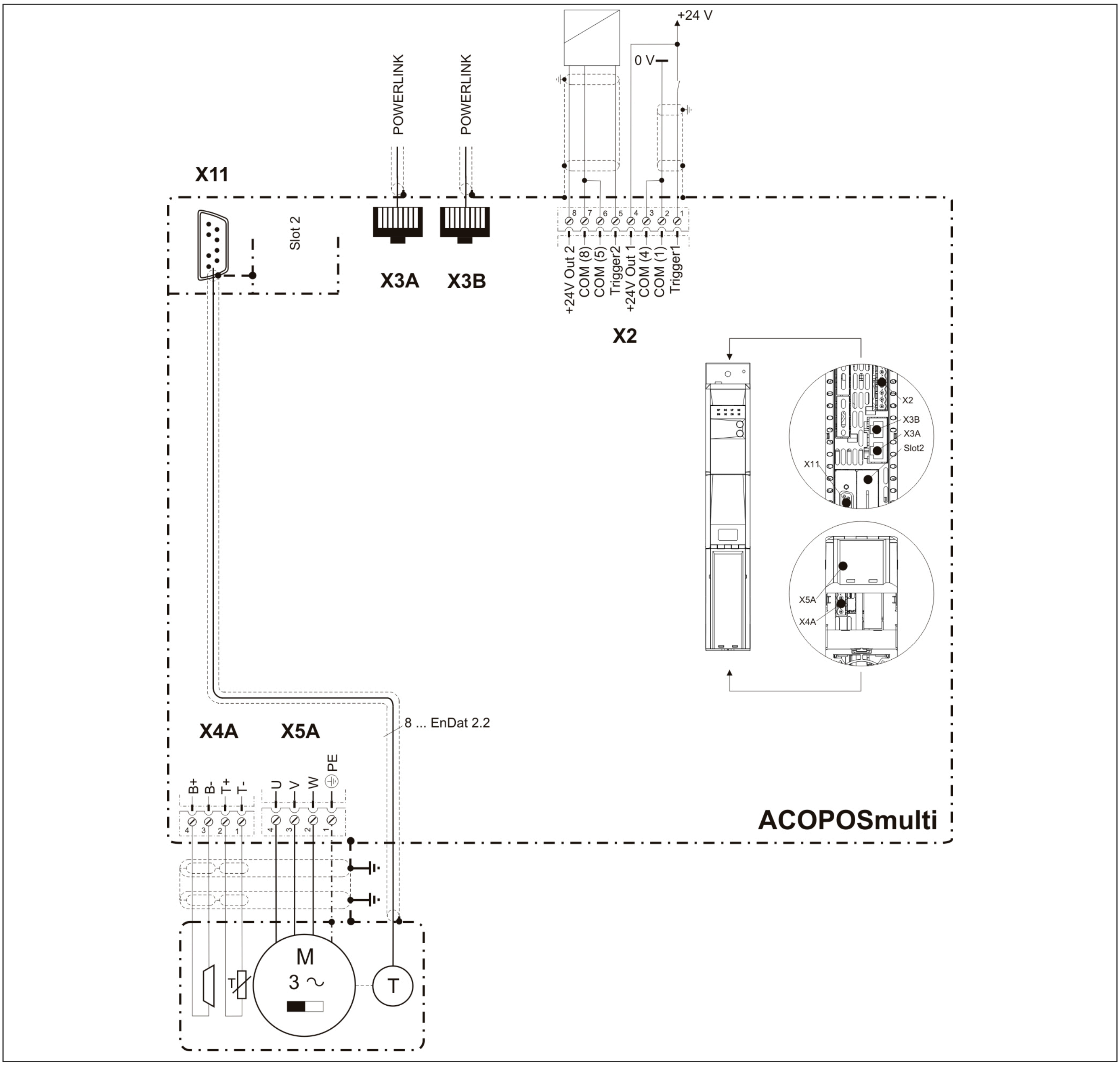


Figure 6: Pinout overview

3.2.5.2 ACOPOSmulti SafeMOTION SinCos - Pinout overview

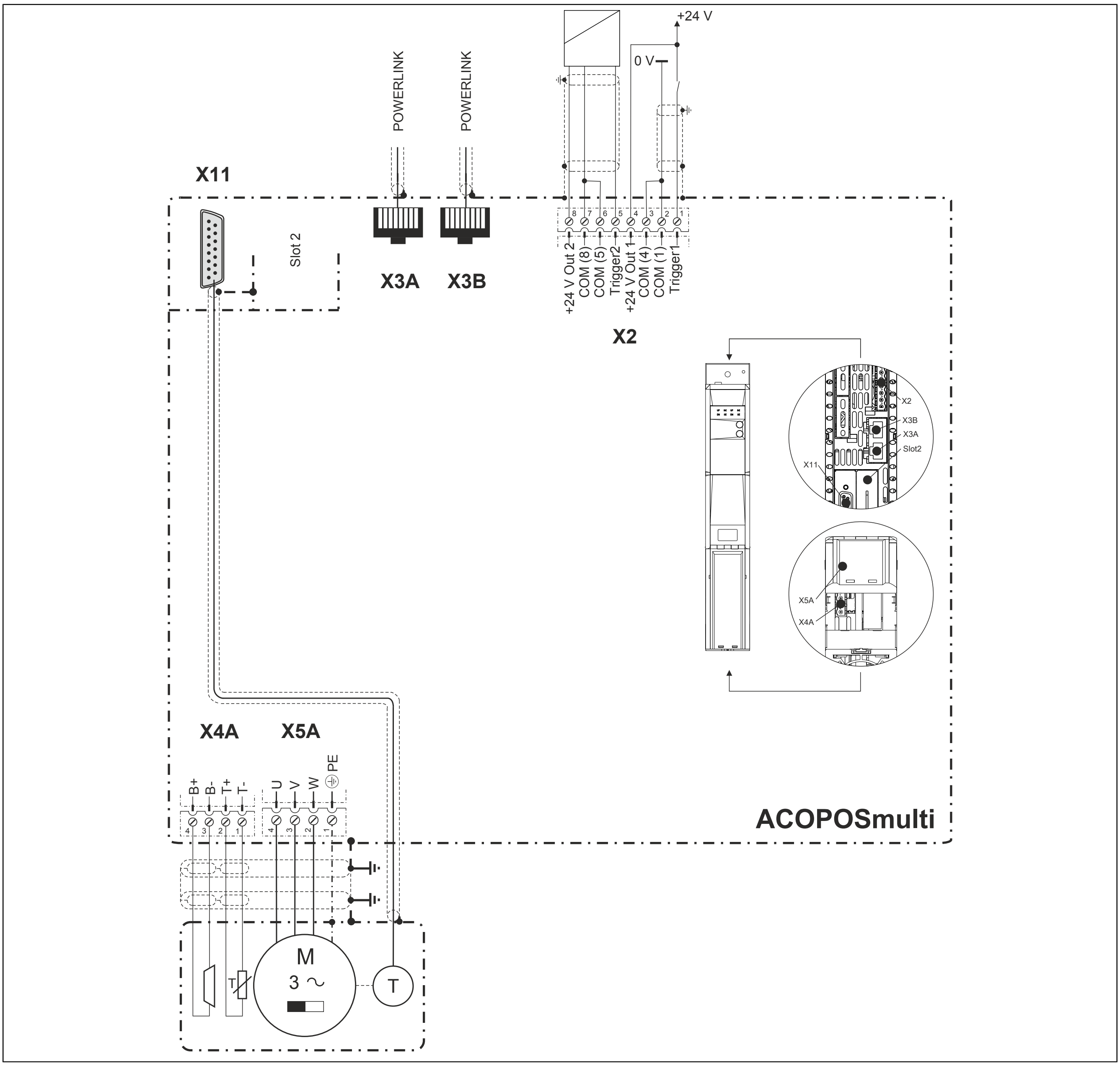


Figure 7: Pinout overview

3.2.5.3 X2 connector - Pinout

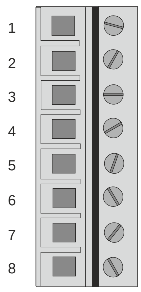
X2	Pin	Name	Function
	1	Trigger 1	Trigger 1
	2	COM (1)	Trigger 1 0 V
	3	COM (2)	+24 V output 1 0 V
	4	+24 V Out 1	+24 V output 1
	5	Trigger 2	Trigger 2
	6	COM (5)	Trigger 2 0 V
	7	COM (8)	+24 V output 2 0 V
	8	+24 V Out 2	+24 V output 2

Table 26: X2 connector - Pinout

3.2.5.4 X3A, X3B connectors - Pinout

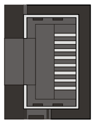
X3A, X3B	Pin	Name	Function
	1	RXD	Receive signal
	2	RXD\	Receive signal inverted
	3	TXD	Transmit signal
	4	Shield	Shield
	5	Shield	Shield
	6	TXD\	Transmit signal inverted
	7	Shield	Shield
	8	Shield	Shield

Table 27: X3A, X3B connectors - Pinout

3.2.5.5 X4A connector - Pinout

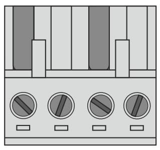
X4A	Name	Function
	T-	Axis 1: Temperature sensor -
	T+	Axis 1: Temperature sensor +
	B- [1)]	Axis 1: Brake -
	B+ [1)]	Axis 1: Brake +

Table 28: X4A connector - Pinout

1) Wiring is not permitted to exceed a total length of 3 m.

Danger!

The FUNCTIONAL FAIL SAFE state is activated if the SBC output B+ is shorted to 24 V (i.e. safe pulse disabling is activated). The brake always remains on/released, however, due to the short circuit to 24 V! This can lead to dangerous situations because the motor holding brake cannot brake or prevent the spin-out movement (or the unrestrained lowering in the case of hanging loads)!
Appropriate wiring measures must be implemented to ensure that the SBC output B+ is not shorted to 24 V!

Danger!

The SBC output

- **is not permitted to be wired to multiple modules!**
- **is not permitted to be wired as an open emitter!**
- **is not permitted to be wired as an open collector!**

Danger!

Only an output voltage of ≤5 V can be ensured for the safe motor holding brake output when shut off. When selecting a motor holding brake, the user must ensure that the required braking torque is reached at a voltage of 5 V.

Information:

The transistors of the SBC output stage are tested cyclically. When the output channels are active, this test emits low pulses on the output with a maximum length of 600 µs.

This must be taken into consideration when choosing the motor holding brake!

Danger!

The connections for the motor temperature sensors and the motor holding brake are safely isolated circuits. These connections are therefore only permitted to be connected to devices or components that have sufficient isolation in accordance with IEC 60364-4-41 or EN 61800-5-1.

Caution!

If B+ and B- are swapped when connecting the permanent magnet holding brakes, then the brakes cannot be opened! ACOPOSmulti inverter modules cannot determine if a holding brake is connected with reverse polarity!

Warning!

Temperature sensors are only permitted to be connected to the X4A/T+ and X4A/T- connectors on an ACOPOSmulti module under the following conditions:

- **There is no ACOPOSmulti plug-in module in SLOT1 on the ACOPOSmulti module with a temperature sensor connected to T+ and T-**

Otherwise, the temperature monitoring functions on the ACOPOSmulti module may become ineffective, which in extreme cases can cause the hardware (e.g. motors) connected to the ACOPOSmulti module to be destroyed!

3.2.5.6 X5A connector - Pinout

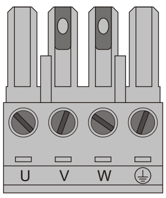
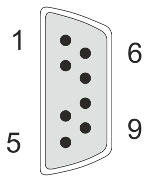
X5A	Name	Function
	⏚	Axis 1: Protective ground conductor
	W	Axis 1: Motor connection W
	V	Axis 1: Motor connection V
	U	Axis 1: Motor connection U

Table 29: X5A connector - Pinout

Information:

Only 8BCM motor cables from B&R are permitted to be connected to the motor connectors.

3.2.5.7 SafeMOTION EnDat 2.2 module - Pinout

Figure	X11 (X12)	Pin	Name	Function
		1	U+	Encoder supply +12.5 V
		2	---	---
		3	---	---
		4	D	Data input
		5	T	Clock output
		6	COM (1)	Encoder supply 0 V
		7	---	---
		8	D\	Data input inverted
		9	T\	Clock output inverted

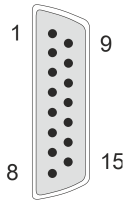
Information:

Only 8BCF EnDat 2.2 cables from B&R or 8BCH hybrid motor cables from B&R are permitted to be connected to the encoder interfaces.

Information:

SafeMOTION modules cannot be replaced! SafeMOTION modules and the corresponding inverter module form a single unit. In the event of an error, the entire inverter module must be replaced.

3.2.5.8 SafeMOTION SinCos module - Pinout

Figure	X11 (X12)	Pin	Name	Function
		1	A	Channel A/Sin
		2	COM	Ground
		3	B	Channel B/COS
		4	+5 V	Encoder supply +
		5	D	Data
		6	---	---
		7	R\	Reference pulse inverted/nREF
		8	T	Clock
		9	A\	Channel A inverted/nSIN
		10	Sense COM	Sense ground
		11	B\	Channel B inverted/nCOS
		12	Sense +5V	Sense input +5 V
		13	D\	Data inverted
		14	R	Reference pulse/REF
		15	T\	Clock cycle inverted

Information:

SafeMOTION modules cannot be replaced! SafeMOTION modules and the corresponding inverter module form a single unit. In the event of an error, the entire inverter module must be replaced.

3.3 Safe double-width inverter modules (single-axis modules)

3.3.1 8BVI0220HCSS.000-1, 8BVI0220HWSS.000-1, 8BVI0220HCSA.000-1, 8BVI0220HWSA.000-1

3.3.1.1 General information

- Clearly structured, straightforward implementation via network-based safety technology
- Modular expandability through virtual wiring
- Immediate triggering of safety function due to short cycle times
- Easy implementation with transparent control and status information, even in the standard application
- Compact design

3.3.1.2 Order data

Model number	Short description	Figure
	Cold plate or feed-through mounting	
8BVI0220HCSS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 22 A, HV, cold plate or feed-through mounting	
8BVI0220HCSA.000-1	ACOPOSmulti SafeMOTION SinCos inverter module, 22 A, HV, cold plate or feed-through mounting	
	Wall mounting	
8BVI0220HWSS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 22 A, HV, wall mounting	
8BVI0220HWSA.000-1	ACOPOSmulti SafeMOTION SinCos inverter module, 22 A, HV, wall mounting	
	Required accessories	
	Terminal block sets	
8BZVI0220SS.000-1A	Screw clamp terminal block set for ACOPOSmulti modules 8BVI0220HxSS: 1x 8TB2108.2010-00, 1x 8TB2104.203L-00, 1x 8TB4104.204G-00	
	Optional accessories	
	Accessory sets	
8BXB000.0000-00	ACPmulti accessory set for encoder buffering consisting of: 1 lithium battery AA 3.6 V; 1 protective cap for battery holder	
	Fan modules	
8BXF001.0000-00	ACOPOSmulti fan module, replacement fan for ACOPOSmulti modules (8BVP / 8B0C / 8BVI / 8BVE / 8B0K)	
	POWERLINK cables	
X20CA0E61.00020	POWERLINK connection cable, RJ45 to RJ45, 0.2 m	
X20CA0E61.00025	POWERLINK connection cable, RJ45 to RJ45, 0.25 m	
X20CA0E61.00030	POWERLINK connection cable, RJ45 to RJ45, 0.3 m	
X20CA0E61.00035	POWERLINK connection cable, RJ45 to RJ45, 0.35 m	
X20CA0E61.00050	POWERLINK connection cable, RJ45 to RJ45, 0.5 m	
X20CA0E61.00100	POWERLINK connection cable, RJ45 to RJ45, 1 m	
	Plug-in modules	
8BAC0120.000-1	ACOPOSmulti plug-in module, EnDat 2.1 interface	
8BAC0120.001-2	ACOPOSmulti plug-in module, EnDat 2.2 interface	
8BAC0121.000-1	ACOPOSmulti plug-in module, HIPERFACE interface	
8BAC0122.000-1	ACOPOSmulti plug-in module, resolver interface 10 kHz	
8BAC0123.000-1	ACOPOSmulti plug-in module, incremental encoder and SSI absolute encoder interface for RS422 signals	
8BAC0123.001-1	ACOPOSmulti plug-in module, incremental encoder interface for 5 V single-ended and 5 V differential signals	
8BAC0123.002-1	ACOPOSmulti plug-in module, incremental encoder interface for 24 V single-ended and 24 V differential signals	
8BAC0124.000-1	ACOPOSmulti plug-in module, SinCos interface	
8BAC0125.000-1	ACOPOSmulti plug-in module, SinCos EnDat 2.1/SSI interface	
8BAC0130.000-1	ACOPOSmulti plug-in module, 2 digital outputs, 50 mA, max. 62,5 kHz, 4 digital outputs, 500 mA, max. 1,25 kHz, 2 digital inputs 24 VDC	
8BAC0130.001-1	ACOPOSmulti plug-in module, 2 digital outputs, 50 mA, max. 62.5 kHz, 4 digital outputs, 500 mA, max. 1.25 kHz	
8BAC0132.000-1	ACOPOSmulti input module, 4 analog inputs ±10 V	
8BAC0133.000-1	ACOPOSmulti plug-in module, 3 RS422 outputs for ABR encoder emulation, 1 Mhz	
	Shield component sets	
8SCS000.0000-00	ACOPOSmulti shielding components set: 1x shielding plate 1fold type 0; 1x hose clamp, W 9 mm, D 12-22 mm	
8SCS002.0000-00	ACOPOSmulti shield component set: 1x clamping plate; 2x clamps D 4-13.5 mm; 4x screws	
8SCS009.0000-00	ACOPOSmulti shield component set: 1x ACOPOSmulti holding plate SK8-14; 1x shield terminal SK14	

Table 30: 8BVI0220HCSS.000-1, 8BVI0220HCSA.000-1, 8BVI0220HWSS.000-1, 8BVI0220HWSA.000-1 - Order data

Model number	Short description	Figure
8SCS010.0000-00	ACOPOSmulti shield component set: 1x ACOPOSmulti holding plate SK14-20; 1x shield terminal SK20	
	Terminal blocks	
8TB2104.203L-00	Screw clamp 4-pin, single row, spacing: 5.08 mm, label 3: T- T + B- B+, L keying: 1010	
8TB2108.2010-00	Screw clamp 8-pin, single row, spacing: 5.08 mm, label 1: numbered serially	
8TB4104.204G-00	Screw clamp terminal block 4-pin, single-row, pitch: 10.16mm, labeling 4: PE W V U, coding G: 0110	

Table 30: 8BVI0220HCSS.000-1, 8BVI0220HCSA.000-1, 8BVI0220HWSS.000-1, 8BVI0220HWSA.000-1 - Order data

Information:

Only 8BCM motor cables from B&R are permitted to be connected to the motor connectors.

ACOPOSmulti SafeMOTION EnDat 2.2

Information:

Only 8BCF EnDat 2.2 cables from B&R or 8BCH hybrid motor cables from B&R are permitted to be connected to the encoder interfaces.

ACOPOSmulti SafeMOTION SinCos

Information:

Only 8BCS encoder cables from B&R are permitted to be connected to the encoder interfaces on B&R standard motors.

For details, see 1.2 "Safe power transmission system " on page 167.

3.3.1.3 Technical data

Product ID	8BVI0220HCSS.000-1	8BVI0220HWSS.000-1	8BVI0220HCSA.000-1	8BVI0220HWSA.000-1
General information				
B&R ID code	0xAA1C	0xAA1E	0xE0B4	0xE0B5
Cooling and mounting method	Cold plate or feed-through mounting	Wall mounting	Cold plate or feed-through mounting	Wall mounting
Slots for plug-in modules	2 [1)			
Certification				
CE	Yes			
cULus	Yes			
KC	Yes		-	
FSC	Yes			
DC bus connection				
Voltage				
Nominal	750 VDC			
Continuous power consumption [2)	16.2 kW			
Power loss depending on the switching frequency [3)				
Switching frequency 5 kHz	$[0.13 * I_M^2 + 5.5 * I_M + 40]$ W			
Switching frequency 10 kHz	$[0.43 * I_M^2 + 3.7 * I_M + 110]$ W			
Switching frequency 20 kHz	$[1.4 * I_M^2 + 1.97 * I_M + 230]$ W			
DC bus capacitance	495 µF			
Design	ACOPOSmulti backplane			
24 VDC supply				
Input voltage	25 VDC ±1.6%			
Input capacitance	32.9 µF			
Max. power consumption	26 W + P_{SMC1} + P_{SLOT2} + $P_{24\ V\ Out}$ + $P_{HoldingBrake}$ + 2 * $P_{Fan8B0M...}$ [4)		25 W + P_{SMC1} + P_{SLOT2} + $P_{24\ V\ Out}$ + $P_{HoldingBrake}$ + $P_{Fan8B0M...}$ [5)	
Design	ACOPOSmulti backplane			
24 VDC output				
Quantity	2			
Output voltage				
DC bus voltage (U_{DC}): 260 to 315 VDC	25 VDC * (U_{DC}/315)			
DC bus voltage (U_{DC}): 315 to 800 VDC	24 VDC ±6%			
Protection	250 mA (slow-blow) electronic, automatic reset			
Motor connection [6)				
Quantity	1			

Table 31: 8BVI0220HCSS.000-1, 8BVI0220HWSS.000-1, 8BVI0220HCSA.000-1, 8BVI0220HWSA.000-1 - Technical data

Product ID	8BVI0220HCSS.000-1	8BVI0220HWSS.000-1	8BVI0220HCSA.000-1	8BVI0220HWSA.000-1
Continuous power per motor connection [2]	16 kW			
Continuous current per motor connection [2]	22 A_{eff}			
Reduction of continuous current depending on the switching frequency [7]				
Switching frequency 5 kHz	-	No reduction [8]	-	No reduction [8]
Switching frequency 10 kHz	-	0.4 A/K (from 31°C) [9]	-	0.4 A/K (from 31°C) [9]
Switching frequency 20 kHz	-	0.31 A/K (from -16°C) [9]	-	0.31 A/K (from -16°C) [9]
Reduction of continuous current depending on the switching frequency and mounting method [10]				
Switching frequency 5 kHz				
Cold plate mounting [11]	No reduction [8]	-	No reduction [8]	-
Feed-through mounting	No reduction [8]	-	No reduction [8]	-
Switching frequency 10 kHz				
Cold plate mounting [11]	0.36 A/K (from 5°C) [12]	-	0.36 A/K (from 5°C) [12]	-
Feed-through mounting	0.39 A/K (from 26°C) [9]	-	0.39 A/K (from 26°C) [9]	-
Switching frequency 20 kHz				
Cold plate mounting [11]	0.5 A/K (from 49°C)	-	0.5 A/K (from 49°C)	-
Feed-through mounting	0.15 A/K (from -59°C) [9]	-	0.15 A/K (from -59°C) [9]	-
Reduction of continuous current depending on the installation elevation				
Starting at 500 m above sea level	2.2 A_{eff} per 1000 m			
Peak current	55 A_{eff}			
Nominal switching frequency	5 kHz			
Possible switching frequencies [13]	5/10/20 kHz			
Electrical stress of the connected motor in accordance with IEC TS 60034-25 [14]	Limit value curve A			
Protective measures				
Overload protection	Yes			
Short circuit and ground fault protection	Yes			
Max. output frequency	598 Hz [15]			
Design				
U, V, W, PE	Male connector			
Shield connection	Yes			
Terminal connection cross section				
Flexible and fine wire lines				
With wire end sleeves	0.5 to 6 mm²		0.5 to 16 mm²	
Approbation data				
UL/C-UL-US	20 to 8			
CSA	20 to 8			
Terminal cable cross section dimension of shield connection	12 to 22 mm			
Max. motor line length depending on the switching frequency				
Switching frequency 5 kHz	25 m			
Switching frequency 10 kHz	25 m			
Switching frequency 20 kHz	25 m			
Motor holding brake connection				
Quantity	1			
Output voltage [16]	24 VDC +5.8% / -0.5% [17]			
Continuous current	4.2 A			
Max. internal resistance	0.15 Ω			
Extinction potential	Approx. 30 V			
Max. extinction energy per switching operation	3 Ws			
Max. switching frequency	0.5 Hz			
Protective measures				
Overload and short circuit protection	Yes			
Open line monitoring	Yes			
Undervoltage monitoring	Yes			
Response threshold for open line monitoring	Approx. 0.5 A			
Response threshold for undervoltage monitoring	24 VDC -2% / -4%			
Encoder interfaces [18]				
Quantity	1			
Type	EnDat 2.2 [19]		SinCos	
Connections	9-pin female DSUB connector		15-pin female DSUB connector	
Status indicators	UP/DN LEDs			
Electrical isolation				
Encoder - ACOPOSmulti	No			

Table 31: 8BVI0220HCSS.000-1, 8BVI0220HWSS.000-1, 8BVI0220HCSA.000-1, 8BVI0220HWSA.000-1 - Technical data

Product ID	8BVI0220HCSS.000-1	8BVI0220HWSS.000-1	8BVI0220HCSA.000-1	8BVI0220HWSA.000-1
Encoder monitoring	Yes			
Max. encoder cable length	100 m Depends on the cross section of the encoder's supply wires [20]		50 m [21]	
Encoder supply				
Output voltage	Typ. 12.5 V		5 V ±5% [22]	
Load capability	350 mA		300 mA [23]	
Sense lines	-		2, compensation of max. 2 x 0.7 V	
Protective measures				
Short circuit protection	Yes			
Overload protection	Yes			
Synchronous serial interface				
Signal transmission	RS485			
Data transfer rate	6.25 Mbit/s		781.25 kbit/s	
Sine/Cosine inputs				
Signal transmission	-		Differential signals, symmetrical	
Differential voltage				
In motion	-		0.5 to 1.35 V [24]	
At standstill	-		0.8 to 1.35 V [25]	
Differential voltage deviation per signal period	-		±10% [26]	
Common-mode voltage	-		Max. ±7 V	
Terminating resistors	-		120 Ω	
Max. input frequency	-		200 kHz	
Signal frequency (-5 dB)	-		<300 kHz	
Signal frequency (-3 dB)	-		DC up to 200 kHz	
ADC resolution	-		12-bit	
Reference input				
Signal transmission	-		Differential signal, symmetrical	
Differential voltage for low	-		≤ -0.2 V	
Differential voltage for high	-		≥ 0.2 V	
Common-mode voltage	-		Max. -5 V to +9 V	
Terminating resistors	-		120 Ω	
Position				
Resolution @ 1 V_{SS} [27]	-		Number of encoder lines * 5700	
Precision [28]	-		---	
Noise [28]	-		---	
Max. power consumption per encoder interface	P_{SMC}[W] = 19 V * $I_{Encoder}$[A] [29]		P_{SMC}[W] = 25 V * (0.376 A + 0.35 * $I_{Encoder}$[A]) [29]	
Trigger inputs				
Quantity	2			
Wiring	Sink			
Electrical isolation				
Input - Inverter module	Yes			
Input - Input	Yes			
Input voltage				
Nominal	24 VDC			
Maximum	30 VDC			
Switching threshold				
Low	<5 V			
High	>15 V			
Input current at nominal voltage	Approx. 10 mA			
Switching delay				
Rising edge	52 µs ±0.5 µs (digitally filtered)			
Falling edge	53 µs ±0.5 µs (digitally filtered)			
Modulation compared to ground potential	Max. ±38 V			
Electrical characteristics				
Discharge capacitance	0.22 µF			
Operating conditions				
Permitted mounting orientations				
Hanging vertically	Yes			
Lying horizontally	Yes			
Standing horizontally	No			
Installation at elevations above sea level				
Nominal	0 to 500 m			
Maximum [30]	4000 m			
Degree of pollution in accordance with EN 60664-1	2 (non-conductive pollution)			
Overvoltage category in accordance with IEC 60364-4-443:1999	III			
EN 60529 protection	IP20 [31]			

Table 31: 8BVI0220HCSS.000-1, 8BVI0220HWSS.000-1, 8BVI0220HCSA.000-1, 8BVI0220HWSA.000-1 - Technical data

Product ID	8BVI0220HCSS.000-1	8BVI0220HWSS.000-1	8BVI0220HCSA.000-1	8BVI0220HWSA.000-1
Environmental conditions				
Temperature				
Operation				
Nominal	5 to 40°C			
Maximum [32]	55°C			
Storage	-25 to 55°C			
Transport	-25 to 70°C			
Relative humidity				
Operation	5 to 85%			
Storage	5 to 95%			
Transport	Max. 95% at 40°C			
Mechanical characteristics				
Dimensions [33]				
Width	106.5 mm			
Height	317 mm			
Depth				
Wall mounting	-	263 mm	-	263 mm
Cold plate	212 mm	-	212 mm	-
Feed-through mounting	209 mm	-	209 mm	-
Weight	Approx. 3.9 kg	Approx. 5.2 kg	Approx. 3.9 kg	Approx. 5.2 kg
Module width	2			

Table 31: 8BVI0220HCSS.000-1, 8BVI0220HWSS.000-1, 8BVI0220HCSA.000-1, 8BVI0220HWSA.000-1 - Technical data

1) SLOT 2 is not occupied. SLOT 1 of the ACOPOSmulti module is occupied by the SafeMOTION module.
2) Valid in the following conditions: 750 VDC DC bus voltage, 5 kHz switching frequency, 40°C ambient temperature, installation elevation <500 m above sea level, no derating due to cooling type.
3) I_M... Current on the motor connection [A].
4) P_{SMC1} ... Max. power consumption P_{SMC} [W] of the SafeMOTION module in SLOT1 (see the "Encoder interfaces" section).
P_{SLOT2} ... Max. power consumption P_{8BAC} [W] of the plug-in module in SLOT2 (see the technical data for the respective plug-in module).
$P_{24\ V\ Out}$... Power [W] that is output to the connections X2/+24 V Out 1 and X2/+24 V Out 2 on the module (max. 10 W).
$P_{Fan8B0M...}$... Portion of the power [W] that is used by the fan modules in the mounting plate or the 8B0M0040HFF0.000-1 fan module (see the technical data for the respective 8B0M... mounting plate / 8B0M0040HFF0.000-1 fan module).
5) P_{SMC1} ... Max. power consumption P_{SMC} [W] of the SafeMOTION module in SLOT1 (see the "Encoder interfaces" section).
P_{SLOT2} ... Max. power consumption P_{8BAC} [W] of the plug-in module in SLOT2 (see the technical data for the respective plug-in module).
$P_{24\ V\ Out}$ ... Power [W] that is output to the connections X2/+24 V Out 1 and X2/+24 V Out 2 on the module (max. 10 W).
$P_{Fan8B0M...}$ ... Portion of the power [W] that is used by the fan modules in the mounting plate or the 8B0M0040HFF0.000-1 fan module (see the technical data for the respective 8B0M... mounting plate / 8B0M0040HFF0.000-1 fan module).
6) Only 8BCM motor cables from B&R are permitted to be connected to the motor connectors.
7) Valid in the following conditions: 750 VDC DC bus voltage. The temperature specifications refer to the ambient temperature.
8) Value for the nominal switching frequency.
9) The module cannot supply the full continuous current at this switching frequency. This unusual value for the ambient temperature, at which derating of the continuous current must be taken into account, ensures that the derating of the continuous current can be determined in the same manner as at other switching frequencies.
10) Valid in the following conditions: 750 VDC DC bus voltage, minimum permissible coolant flow volume (3 l/min).
11) The temperature specifications refer to the return temperature of the cold plate mounting plate.
12) The module cannot supply the full continuous current at this switching frequency. This unusual value for the return temperature, at which derating of the continuous current must be taken into account, ensures that the derating of the continuous current can be determined in the same manner as at other switching frequencies.
Caution! Condensation can occur at low flow temperatures and return temperatures.
13) B&R recommends operating the module at its nominal switching frequency. Operating the module at a higher switching frequency for application-specific reasons reduces the continuous current and increases the CPU load.
14) If necessary, the stress of the motor isolation system can be reduced by an additional externally wired dU/dt choke. For example, the RWK 305 three-phase du/dt choke from Schaffner (www.schaffner.com) can be used. Important: Even when using a dU/dt choke, it is necessary to ensure that an EMC-compatible, low inductance shield connection is used!
15) The module's electrical output frequency (SCTRL_SPEED_ACT * MOTOR_POLEPAIRS) is monitored to protect against dual use in accordance with EC regulation 428/2009 | 3A225. If the electrical output frequency of the module exceeds the limit value of 598 Hz uninterrupted for more than 0.5 s, then the current movement is aborted and error 6060 is output (Power element: Limit speed exceeded).
16) During project development, it is necessary to check if the minimum voltage can be maintained on the holding brake with the specified wiring. The operating voltage range of the holding brake can be found in the user's manual for the respective motor.
17) The specified value is only valid under the following conditions:
- The 24 VDC supply for the module is provided by an 8B0C auxiliary supply module installed on the same mounting plate.
If the 24 VDC supply for the module is applied to the mounting plate using an 8BVE expansion module, then the output voltage is reduced because of voltage drops on the expansion cable. In this case, undervoltage monitoring must be disabled.
18) Only 8BCF EnDat 2.2 cables from B&R are permitted to be connected to the encoder interfaces.
19) An EnDat 2.2 functional safety encoder is required when using ACOPOSmulti SafeMOTION inverter modules! With standard EnDat 2.2 encoders, only the STO, SBC and SS1 functions are monitored with respect to timing!
20) The maximum encoder cable length l_{max} can be calculated as follows (the maximum permissible encoder cable length of 100 m must not be exceeded):

$$l_{max} = 7.9 / I_G * A * 1/(2*\rho)$$

I_G ... Max. current consumption of the encoder [A].
A ... Cross section of the supply wire [mm²].
ρ ... Specific resistance [Ω mm²/m] (e.g. for copper: ρ = 0.0178).
21) The maximum permitted cable length is 50 m.
22) During the power-on procedure for the encoder supply voltage (2 seconds), the monitoring limit for the supply voltage is increased from 5.25 V to 6 V. In this phase, overvoltages up to 6 V are not detected.
A short-term overvoltage of maximum 6 V should not damage the encoder electronics in any way.
An undervoltage on the encoder supply will result in a sine or cosine signal outside the specification.
23) An actual reserve of 12 mA exists for the terminating resistor.

24) The sine-cosine output signals from the measuring instrument are checked by the evaluation circuit using pointer length monitoring.
The pointer length $z = 2\sqrt{(\mathrm{Sin} - \mathrm{nSin})^2 + (\mathrm{Cos} - \mathrm{nCos})^2}$ is monitored according to the specified limits.
25) The sine-cosine output signals from the measuring instrument are checked by the evaluation circuit using pointer length monitoring.
The pointer length $z = 2\sqrt{(\mathrm{Sin} - \mathrm{nSin})^2 + (\mathrm{Cos} - \mathrm{nCos})^2}$ is also monitored according to the specified limits from the time the evaluation circuit is switched on until a signal period has passed.
26) The sine-cosine output signals from the measuring instrument are checked by the evaluation circuit using pointer length monitoring.
The pointer length $z = 2\sqrt{(\mathrm{Sin} - \mathrm{nSin})^2 + (\mathrm{Cos} - \mathrm{nCos})^2}$ is only permitted to vary by maximum ±10% per signal period.
27) This value does not correspond to the encoder resolution that must be configured in Automation Studio (16384 * number of encoder lines).
28) Limited by the encoder in practice.
29) $I_{Encoder}$ ... Max. power consumption of the connected encoder [A].
30) Continuous operation at elevations ranging from 500 m to 4000 m above sea level is possible (taking the specified continuous current reductions into consideration).
31) This value only applies in its delivered state (SLOT2 of the module is sealed by a slot cover / shield plate). If SLOT2 on the module is not sealed, then the level of protection is reduced to IP10. It is important to note that a 8SCS005.0000-00 shield set (slot cover / shield plate) or plug-in module must always be inserted!
32) Continuous operation at ambient temperatures ranging from 40°C to max. 55°C is possible (taking the specified continuous current reductions into consideration), but this will result in a shorter service life.
33) These dimensions refer to the actual device dimensions including the respective mounting plate. Make sure to leave additional space above and below the devices for mounting, connections and air circulation.

3.3.1.4 Wiring

For details, see 3.3.4 "Wiring: Safe double-width inverter modules (single-axis modules)" on page 73.

For general information, see 6 "Wiring" on page 142.

3.3.2 8BVI0330HCSS.000-1, 8BVI0330HWSS.000-1, 8BVI0330HCSA.000-1, 8BVI0330HWSA.000-1

3.3.2.1 General information

- Clearly structured, straightforward implementation via network-based safety technology
- Modular expandability through virtual wiring
- Immediate triggering of safety function due to short cycle times
- Easy implementation with transparent control and status information, even in the standard application
- Compact design

3.3.2.2 Order data

Model number	Short description	Figure
	Cold plate or feed-through mounting	
8BVI0330HCSS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 33 A, HV, cold plate or feed-through mounting	
8BVI0330HCSA.000-1	ACOPOSmulti SafeMOTION SinCos inverter module, 33 A, HV, cold plate or feed-through mounting	
	Wall mounting	
8BVI0330HWSS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 33 A, HV, wall mounting	
8BVI0330HWSA.000-1	ACOPOSmulti SafeMOTION SinCos inverter module, 33 A, HV, wall mounting	
	Required accessories	
	Terminal block sets	
8BZVI0440SS.000-1A	Screw clamp set for ACOPOSmulti 8BVI0440HxSS and 8BVI0440HxSA modules: 1x 8TB2108.2010-00, 1x 8TB2104.203L-00, 1x 8TB4104.204G-10	
	Optional accessories	
	Accessory sets	
8BXB000.0000-00	ACPmulti accessory set for encoder buffering consisting of: 1 lithium battery AA 3.6 V; 1 protective cap for battery holder	
	Fan modules	
8BXF001.0000-00	ACOPOSmulti fan module, replacement fan for ACOPOSmulti modules (8BVP / 8B0C / 8BVI / 8BVE / 8B0K)	
	POWERLINK cables	
X20CA0E61.00020	POWERLINK connection cable, RJ45 to RJ45, 0.2 m	
X20CA0E61.00025	POWERLINK connection cable, RJ45 to RJ45, 0.25 m	
X20CA0E61.00030	POWERLINK connection cable, RJ45 to RJ45, 0.3 m	
X20CA0E61.00035	POWERLINK connection cable, RJ45 to RJ45, 0.35 m	
X20CA0E61.00050	POWERLINK connection cable, RJ45 to RJ45, 0.5 m	
X20CA0E61.00100	POWERLINK connection cable, RJ45 to RJ45, 1 m	
	Plug-in modules	
8BAC0120.000-1	ACOPOSmulti plug-in module, EnDat 2.1 interface	
8BAC0120.001-2	ACOPOSmulti plug-in module, EnDat 2.2 interface	
8BAC0121.000-1	ACOPOSmulti plug-in module, HIPERFACE interface	
8BAC0122.000-1	ACOPOSmulti plug-in module, resolver interface 10 kHz	
8BAC0123.000-1	ACOPOSmulti plug-in module, incremental encoder and SSI absolute encoder interface for RS422 signals	
8BAC0123.001-1	ACOPOSmulti plug-in module, incremental encoder interface for 5 V single-ended and 5 V differential signals	
8BAC0123.002-1	ACOPOSmulti plug-in module, incremental encoder interface for 24 V single-ended and 24 V differential signals	
8BAC0124.000-1	ACOPOSmulti plug-in module, SinCos interface	
8BAC0125.000-1	ACOPOSmulti plug-in module, SinCos EnDat 2.1/SSI interface	
8BAC0130.000-1	ACOPOSmulti plug-in module, 2 digital outputs, 50 mA, max. 62,5 kHz, 4 digital outputs, 500 mA, max. 1,25 kHz, 2 digital inputs 24 VDC	
8BAC0130.001-1	ACOPOSmulti plug-in module, 2 digital outputs, 50 mA, max. 62.5 kHz, 4 digital outputs, 500 mA, max. 1.25 kHz	
8BAC0132.000-1	ACOPOSmulti input module, 4 analog inputs ±10 V	
8BAC0133.000-1	ACOPOSmulti plug-in module, 3 RS422 outputs for ABR encoder emulation, 1 Mhz	
	Shield component sets	
8SCS002.0000-00	ACOPOSmulti shield component set: 1x clamping plate; 2x clamps D 4-13.5 mm; 4x screws	
8SCS007.0000-00	ACOPOSmulti shield component set: 1x shield mounting plate 2x 45°; 4x screws	
8SCS008.0000-00	ACOPOSmulti shield component set: 1x shield plate 2x type 0; 1x hose clamp, B 9 mm, D 23-35 mm	
8SCS010.0000-00	ACOPOSmulti shield component set: 1x ACOPOSmulti holding plate SK14-20; 1x shield terminal SK20	
	Terminal blocks	

Table 32: 8BVI0330HCSS.000-1, 8BVI0330HCSA.000-1, 8BVI0330HWSS.000-1, 8BVI0330HWSA.000-1 - Order data

Model number	Short description	Figure
8TB2104.203L-00	Screw clamp 4-pin, single row, spacing: 5.08 mm, label 3: T- T + B- B+, L keying: 1010	
8TB2108.2010-00	Screw clamp 8-pin, single row, spacing: 5.08 mm, label 1: numbered serially	
8TB4104.204G-10	Screw clamp 4-pin, single row, spacing: 10.16 mm, label 4: PE W V U, G keying: 0110	

Table 32: 8BVI0330HCSS.000-1, 8BVI0330HCSA.000-1, 8BVI0330HWSS.000-1, 8BVI0330HWSA.000-1 - Order data

Information:

Only 8BCM motor cables from B&R are permitted to be connected to the motor connectors.

ACOPOSmulti SafeMOTION EnDat 2.2

Information:

Only 8BCF EnDat 2.2 cables from B&R or 8BCH hybrid motor cables from B&R are permitted to be connected to the encoder interfaces.

ACOPOSmulti SafeMOTION SinCos

Information:

Only 8BCS encoder cables from B&R are permitted to be connected to the encoder interfaces on B&R standard motors.

For details, see 1.2 "Safe power transmission system " on page 167.

3.3.2.3 Technical data

Product ID	8BVI0330HCSS.000-1	8BVI0330HWSS.000-1	8BVI0330HCSA.000-1	8BVI0330HWSA.000-1
General information				
B&R ID code	0xADC3	0xADC4	0xE0B6	0xE0B7
Cooling and mounting method	Cold plate or feed-through mounting	Wall mounting	Cold plate or feed-through mounting	Wall mounting
Slots for plug-in modules	2 [1]			
Certification				
CE	Yes			
cULus	Yes			
KC	Yes		-	
FSC	Yes			
DC bus connection				
Voltage				
Nominal	750 VDC			
Continuous power consumption [2]	24.4 kW			
Power loss depending on the switching frequency [3]				
Switching frequency 5 kHz	$[0.07 * I_M^2 + 7.3 * I_M + 40]$ W			
Switching frequency 10 kHz	$[0.2 * I_M^2 + 11.1 * I_M + 130]$ W			
Switching frequency 20 kHz	$[1.85 * I_M^2 + 3.8 * I_M + 300]$ W			
DC bus capacitance	990 µF			
Design	ACOPOSmulti backplane			
24 VDC supply				
Input voltage	25 VDC ±1.6%			
Input capacitance	32.9 µF			
Max. power consumption	31 W + P_{SMC1} + P_{SLOT2} + $P_{24\ V\ Out}$ + $P_{HoldingBrake}$ + 2 * $P_{Fan8B0M...}$ [4]		25 W + P_{SMC1} + P_{SLOT2} + $P_{24\ V\ Out}$ + $P_{HoldingBrake}$ + $P_{Fan8B0M...}$ [5]	
Design	ACOPOSmulti backplane			
24 VDC output				
Quantity	2			
Output voltage				
DC bus voltage (U_{DC}): 260 to 315 VDC	25 VDC * (U_{DC}/315)			
DC bus voltage (U_{DC}): 315 to 800 VDC	24 VDC ±6%			
Protection	250 mA (slow-blow) electronic, automatic reset			
Motor connection [6]				
Quantity	1			
Continuous power per motor connection [2]	24 kW			
Continuous current per motor connection [2]	33 A_{eff}			

Table 33: 8BVI0330HCSS.000-1, 8BVI0330HWSS.000-1, 8BVI0330HCSA.000-1, 8BVI0330HWSA.000-1 - Technical data

Product ID	8BVI0330HCSS.000-1	8BVI0330HWSS.000-1	8BVI0330HCSA.000-1	8BVI0330HWSA.000-1
Reduction of continuous current depending on the switching frequency [7]				
Switching frequency 5 kHz	-	1.57 A/K (from 40°C) [8]	-	1.57 A/K (from 40°C) [8]
Switching frequency 10 kHz	-	0.5 A/K (from -10°C) [9]	-	0.5 A/K (from -10°C) [9]
Switching frequency 20 kHz	-	0.36 A/K (from -77°C) [9]	-	0.36 A/K (from -77°C) [9]
Reduction of continuous current depending on the switching frequency and mounting method [10]				
Switching frequency 5 kHz				
Cold plate mounting [11]	0.8 A/K (from 45°C) [8]	-	0.8 A/K (from 45°C) [8]	-
Feed-through mounting	1.26 A/K (from 40°C) [8]	-	1.26 A/K (from 40°C) [8]	-
Switching frequency 10 kHz				
Cold plate mounting [11]	0.62 A/K (from 6°C) [12]	-	0.62 A/K (from 6°C) [12]	-
Feed-through mounting	0.37 A/K (from -36°C) [9]	-	0.37 A/K (from -36°C) [9]	-
Switching frequency 20 kHz				
Cold plate mounting [11]	0.32 A/K (from -82°C) [12]	-	0.32 A/K (from -82°C) [12]	-
Feed-through mounting	0.24 A/K (from -137°C) [9]	-	0.24 A/K (from -137°C) [9]	-
Reduction of continuous current depending on the installation elevation				
Starting at 500 m above sea level	3.3 A_{eff} per 1000 m			
Peak current	83 A_{eff}			
Nominal switching frequency	5 kHz			
Possible switching frequencies [13]	5/10/20 kHz			
Electrical stress of the connected motor in accordance with IEC TS 60034-25 [14]	Limit value curve A			
Protective measures				
Overload protection	Yes			
Short circuit and ground fault protection	Yes			
Max. output frequency	598 Hz [15]			
Design				
U, V, W, PE	Male connector			
Shield connection	Yes			
Terminal connection cross section				
Flexible and fine wire lines				
With wire end sleeves	0.5 to 16 mm²			
Approbation data				
UL/C-UL-US	20 to 6			
CSA	20 to 6			
Terminal cable cross section dimension of shield connection	23 to 35 mm			
Max. motor line length depending on the switching frequency				
Switching frequency 5 kHz	25 m			
Switching frequency 10 kHz	25 m			
Switching frequency 20 kHz	25 m			
Motor holding brake connection				
Quantity	1			
Output voltage [16]	24 VDC +5.8% / -0.5% [17]			
Continuous current	4.2 A			
Max. internal resistance	0.15 Ω			
Extinction potential	Approx. 30 V			
Max. extinction energy per switching operation	3 Ws			
Max. switching frequency	0.5 Hz			
Protective measures				
Overload and short circuit protection	Yes			
Open line monitoring	Yes			
Undervoltage monitoring	Yes			
Response threshold for open line monitoring	Approx. 0.5 A			
Response threshold for undervoltage monitoring	24 VDC -2% / -4%			
Encoder interfaces [18]				
Quantity	1			
Type	EnDat 2.2 [19]		SinCos	
Connections	9-pin female DSUB connector		15-pin female DSUB connector	
Status indicators	UP/DN LEDs			
Electrical isolation				
Encoder - ACOPOSmulti	No			
Encoder monitoring	Yes			
Max. encoder cable length	100 m Depends on the cross section of the encoder's supply wires [20]		50 m [21]	

Table 33: 8BVI0330HCSS.000-1, 8BVI0330HWSS.000-1, 8BVI0330HCSA.000-1, 8BVI0330HWSA.000-1 - Technical data

Product ID	8BVI0330HCSS.000-1	8BVI0330HWSS.000-1	8BVI0330HCSA.000-1	8BVI0330HWSA.000-1
Encoder supply				
Output voltage	Typ. 12.5 V		5 V ±5% [22]	
Load capability	350 mA		300 mA [23]	
Sense lines	-		2, compensation of max. 2 x 0.7 V	
Protective measures				
Short circuit protection	Yes			
Overload protection	Yes			
Synchronous serial interface				
Signal transmission	RS485			
Data transfer rate	6.25 Mbit/s		781.25 kbit/s	
Sine/Cosine inputs				
Signal transmission	-		Differential signals, symmetrical	
Differential voltage				
In motion	-		0.5 to 1.35 V [24]	
At standstill	-		0.8 to 1.35 V [25]	
Differential voltage deviation per signal period	-		±10% [26]	
Common-mode voltage	-		Max. ±7 V	
Terminating resistors	-		120 Ω	
Max. input frequency	-		200 kHz	
Signal frequency (-5 dB)	-		<300 kHz	
Signal frequency (-3 dB)	-		DC up to 200 kHz	
ADC resolution	-		12-bit	
Reference input				
Signal transmission	-		Differential signal, symmetrical	
Differential voltage for low	-		≤ -0.2 V	
Differential voltage for high	-		≥ 0.2 V	
Common-mode voltage	-		Max. -5 V to +9 V	
Terminating resistors	-		120 Ω	
Position				
Resolution @ 1 V_{SS} [27]	-		Number of encoder lines * 5700	
Precision [28]	-		---	
Noise [28]	-		---	
Max. power consumption per encoder interface	P_{SMC}[W] = 19 V * $I_{Encoder}$[A] [29]		P_{SMC}[W] = 25 V * (0.376 A + 0.35 * $I_{Encoder}$[A]) [29]	
Trigger inputs				
Quantity	2			
Wiring	Sink			
Electrical isolation				
Input - Inverter module	Yes			
Input - Input	Yes			
Input voltage				
Nominal	24 VDC			
Maximum	30 VDC			
Switching threshold				
Low	<5 V			
High	>15 V			
Input current at nominal voltage	Approx. 10 mA			
Switching delay				
Rising edge	52 µs ±0.5 µs (digitally filtered)			
Falling edge	53 µs ±0.5 µs (digitally filtered)			
Modulation compared to ground potential	Max. ±38 V			
Electrical characteristics				
Discharge capacitance	0.22 µF			
Operating conditions				
Permitted mounting orientations				
Hanging vertically	Yes			
Lying horizontally	Yes			
Standing horizontally	No			
Installation at elevations above sea level				
Nominal	0 to 500 m			
Maximum [30]	4000 m			
Degree of pollution in accordance with EN 60664-1	2 (non-conductive pollution)			
Overvoltage category in accordance with IEC 60364-4-443:1999	III			
EN 60529 protection	IP20 [31]			
Environmental conditions				
Temperature				
Operation				
Nominal	5 to 40°C			
Maximum [32]	55°C			
Storage	-25 to 55°C			
Transport	-25 to 70°C			

Table 33: 8BVI0330HCSS.000-1, 8BVI0330HWSS.000-1, 8BVI0330HCSA.000-1, 8BVI0330HWSA.000-1 - Technical data

Product ID	8BVI0330HCSS.000-1	8BVI0330HWSS.000-1	8BVI0330HCSA.000-1	8BVI0330HWSA.000-1
Relative humidity				
Operation	5 to 85%			
Storage	5 to 95%			
Transport	Max. 95% at 40°C			
Mechanical characteristics				
Dimensions 33)				
Width	106.5 mm			
Height	317 mm			
Depth				
Wall mounting	-	263 mm	-	263 mm
Cold plate	212 mm	-	212 mm	-
Feed-through mounting	209 mm	-	209 mm	-
Weight	Approx. 4.3 kg	Approx. 5.4 kg	Approx. 4.3 kg	Approx. 5.4 kg
Module width	2			

Table 33: 8BVI0330HCSS.000-1, 8BVI0330HWSS.000-1, 8BVI0330HCSA.000-1, 8BVI0330HWSA.000-1 - Technical data

1) SLOT 2 is not occupied. SLOT 1 of the ACOPOSmulti module is occupied by the SafeMOTION module.
2) Valid in the following conditions: 750 VDC DC bus voltage, 5 kHz switching frequency, 40°C ambient temperature, installation elevation <500 m above sea level, no derating due to cooling type.
3) I_M... Current on the motor connection [A].
4) P_{SMC1} ... Max. power consumption P_{SMC} [W] of the SafeMOTION module in SLOT1 (see the "Encoder interfaces" section).
P_{SLOT2} ... Max. power consumption P_{8BAC} [W] of the plug-in module in SLOT2 (see the technical data for the respective plug-in module).
$P_{24\ V\ Out}$... Power [W] that is output to the connections X2/+24 V Out 1 and X2/+24 V Out 2 on the module (max. 10 W).
$P_{Fan8B0M...}$... Portion of the power [W] that is used by the fan modules in the mounting plate or the 8B0M0040HFF0.000-1 fan module (see the technical data for the respective 8B0M... mounting plate / 8B0M0040HFF0.000-1 fan module).
5) P_{SMC1} ... Max. power consumption P_{SMC} [W] of the SafeMOTION module in SLOT1 (see the "Encoder interfaces" section).
P_{SLOT2} ... Max. power consumption P_{8BAC} [W] of the plug-in module in SLOT2 (see the technical data for the respective plug-in module).
$P_{24\ V\ Out}$ ... Power [W] that is output to the connections X2/+24 V Out 1 and X2/+24 V Out 2 on the module (max. 10 W).
$P_{Fan8B0M...}$ ... Portion of the power [W] that is used by the fan modules in the mounting plate or the 8B0M0040HFF0.000-1 fan module (see the technical data for the respective 8B0M... mounting plate / 8B0M0040HFF0.000-1 fan module).
6) Only 8BCM motor cables from B&R are permitted to be connected to the motor connectors.
7) Valid in the following conditions: 750 VDC DC bus voltage. The temperature specifications refer to the ambient temperature.
8) Value for the nominal switching frequency.
9) The module cannot supply the full continuous current at this switching frequency. This unusual value for the ambient temperature, at which derating of the continuous current must be taken into account, ensures that the derating of the continuous current can be determined in the same manner as at other switching frequencies.
10) Valid in the following conditions: 750 VDC DC bus voltage, minimum permissible coolant flow volume (3 l/min).
11) The temperature specifications refer to the return temperature of the cold plate mounting plate.
12) The module cannot supply the full continuous current at this switching frequency. This unusual value for the return temperature, at which derating of the continuous current must be taken into account, ensures that the derating of the continuous current can be determined in the same manner as at other switching frequencies.
Caution! Condensation can occur at low flow temperatures and return temperatures.
13) B&R recommends operating the module at its nominal switching frequency. Operating the module at a higher switching frequency for application-specific reasons reduces the continuous current and increases the CPU load.
14) If necessary, the stress of the motor isolation system can be reduced by an additional externally wired dU/dt choke. For example, the RWK 305 three-phase du/dt choke from Schaffner (www.schaffner.com) can be used. Important: Even when using a dU/dt choke, it is necessary to ensure that an EMC-compatible, low inductance shield connection is used!
15) The module's electrical output frequency (SCTRL_SPEED_ACT * MOTOR_POLEPAIRS) is monitored to protect against dual use in accordance with EC regulation 428/2009 | 3A225. If the electrical output frequency of the module exceeds the limit value of 598 Hz uninterrupted for more than 0.5 s, then the current movement is aborted and error 6060 is output (Power element: Limit speed exceeded).
16) During project development, it is necessary to check if the minimum voltage can be maintained on the holding brake with the specified wiring. The operating voltage range of the holding brake can be found in the user's manual for the respective motor.
17) The specified value is only valid under the following conditions:
- The 24 VDC supply for the module is provided by an 8B0C auxiliary supply module installed on the same mounting plate.
If the 24 VDC supply for the module is applied to the mounting plate using an 8BVE expansion module, then the output voltage is reduced because of voltage drops on the expansion cable. In this case, undervoltage monitoring must be disabled.
18) Only 8BCF EnDat 2.2 cables from B&R are permitted to be connected to the encoder interfaces.
19) An EnDat 2.2 functional safety encoder is required when using ACOPOSmulti SafeMOTION inverter modules! With standard EnDat 2.2 encoders, only the STO, SBC and SS1 functions are monitored with respect to timing!
20) The maximum encoder cable length l_{max} can be calculated as follows (the maximum permissible encoder cable length of 100 m must not be exceeded):

$l_{max} = 7.9 / I_G * A * 1/(2*\rho)$

I_G ... Max. current consumption of the encoder [A].
A ... Cross section of the supply wire [mm²].
ρ ... Specific resistance [Ω mm²/m] (e.g. for copper: ρ = 0.0178).
21) The maximum permitted cable length is 50 m.
22) During the power-on procedure for the encoder supply voltage (2 seconds), the monitoring limit for the supply voltage is increased from 5.25 V to 6 V. In this phase, overvoltages up to 6 V are not detected.
A short-term overvoltage of maximum 6 V should not damage the encoder electronics in any way.
An undervoltage on the encoder supply will result in a sine or cosine signal outside the specification.
23) An actual reserve of 12 mA exists for the terminating resistor.
24) The sine-cosine output signals from the measuring instrument are checked by the evaluation circuit using pointer length monitoring.
The pointer length $z = 2\sqrt{((Sin - nSin)^2 + (Cos - nCos)^2)}$ is monitored according to the specified limits.
25) The sine-cosine output signals from the measuring instrument are checked by the evaluation circuit using pointer length monitoring.
The pointer length $z = 2\sqrt{((Sin - nSin)^2 + (Cos - nCos)^2)}$ is also monitored according to the specified limits from the time the evaluation circuit is switched on until a signal period has passed.
26) The sine-cosine output signals from the measuring instrument are checked by the evaluation circuit using pointer length monitoring.
The pointer length $z = 2\sqrt{((Sin - nSin)^2 + (Cos - nCos)^2)}$ is only permitted to vary by maximum ±10% per signal period.

27) This value does not correspond to the encoder resolution that must be configured in Automation Studio (16384 * number of encoder lines).
28) Limited by the encoder in practice.
29) $I_{Encoder}$ ... Max. power consumption of the connected encoder [A].
30) Continuous operation at elevations ranging from 500 m to 4000 m above sea level is possible (taking the specified continuous current reductions into consideration).
31) This value only applies in its delivered state (SLOT2 of the module is sealed by a slot cover / shield plate). If SLOT2 on the module is not sealed, then the level of protection is reduced to IP10. It is important to note that a 8SCS005.0000-00 shield set (slot cover / shield plate) or plug-in module must always be inserted!
32) Continuous operation at ambient temperatures ranging from 40°C to max. 55°C is possible (taking the specified continuous current reductions into consideration), but this will result in a shorter service life.
33) These dimensions refer to the actual device dimensions including the respective mounting plate. Make sure to leave additional space above and below the devices for mounting, connections and air circulation.

3.3.2.4 Wiring

For details, see 3.3.4 "Wiring: Safe double-width inverter modules (single-axis modules)" on page 73.

For general information, see 6 "Wiring" on page 142.

3.3.3 8BVI0440HCSS.000-1, 8BVI0440HWSS.000-1, 8BVI0440HCSA.000-1, 8BVI0440HWSA.000-1

3.3.3.1 General information

- Clearly structured, straightforward implementation via network-based safety technology
- Modular expandability through virtual wiring
- Immediate triggering of safety function due to short cycle times
- Easy implementation with transparent control and status information, even in the standard application
- Compact design

3.3.3.2 Order data

Model number	Short description	Figure
	Cold plate or feed-through mounting	
8BVI0440HCSS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 44 A, HV, cold plate or feed-through mounting	
8BVI0440HCSA.000-1	ACOPOSmulti SafeMOTION SinCos inverter module, 44 A, HV, cold plate or feed-through mounting	
	Wall mounting	
8BVI0440HWSS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 44 A, HV, wall mounting	
8BVI0440HWSA.000-1	ACOPOSmulti SafeMOTION SinCos inverter module, 44 A, HV, wall mounting	
	Required accessories	
	Terminal block sets	
8BZVI0440SS.000-1A	Screw clamp set for ACOPOSmulti 8BVI0440HxSS and 8BVI0440HxSA modules: 1x 8TB2108.2010-00, 1x 8TB2104.203L-00, 1x 8TB4104.204G-10	
	Optional accessories	
	Accessory sets	
8BXB000.0000-00	ACPmulti accessory set for encoder buffering consisting of: 1 lithium battery AA 3.6 V; 1 protective cap for battery holder	
	Fan modules	
8BXF001.0000-00	ACOPOSmulti fan module, replacement fan for ACOPOSmulti modules (8BVP / 8B0C / 8BVI / 8BVE / 8B0K)	
	POWERLINK cables	
X20CA0E61.00020	POWERLINK connection cable, RJ45 to RJ45, 0.2 m	
X20CA0E61.00025	POWERLINK connection cable, RJ45 to RJ45, 0.25 m	
X20CA0E61.00030	POWERLINK connection cable, RJ45 to RJ45, 0.3 m	
X20CA0E61.00035	POWERLINK connection cable, RJ45 to RJ45, 0.35 m	
X20CA0E61.00050	POWERLINK connection cable, RJ45 to RJ45, 0.5 m	
X20CA0E61.00100	POWERLINK connection cable, RJ45 to RJ45, 1 m	
	Plug-in modules	
8BAC0120.000-1	ACOPOSmulti plug-in module, EnDat 2.1 interface	
8BAC0120.001-2	ACOPOSmulti plug-in module, EnDat 2.2 interface	
8BAC0121.000-1	ACOPOSmulti plug-in module, HIPERFACE interface	
8BAC0122.000-1	ACOPOSmulti plug-in module, resolver interface 10 kHz	
8BAC0123.000-1	ACOPOSmulti plug-in module, incremental encoder and SSI absolute encoder interface for RS422 signals	
8BAC0123.001-1	ACOPOSmulti plug-in module, incremental encoder interface for 5 V single-ended and 5 V differential signals	
8BAC0123.002-1	ACOPOSmulti plug-in module, incremental encoder interface for 24 V single-ended and 24 V differential signals	
8BAC0124.000-1	ACOPOSmulti plug-in module, SinCos interface	
8BAC0125.000-1	ACOPOSmulti plug-in module, SinCos EnDat 2.1/SSI interface	
8BAC0130.000-1	ACOPOSmulti plug-in module, 2 digital outputs, 50 mA, max. 62,5 kHz, 4 digital outputs, 500 mA, max. 1,25 kHz, 2 digital inputs 24 VDC	
8BAC0130.001-1	ACOPOSmulti plug-in module, 2 digital outputs, 50 mA, max. 62.5 kHz, 4 digital outputs, 500 mA, max. 1.25 kHz	
8BAC0132.000-1	ACOPOSmulti input module, 4 analog inputs ±10 V	
8BAC0133.000-1	ACOPOSmulti plug-in module, 3 RS422 outputs for ABR encoder emulation, 1 Mhz	
	Shield component sets	
8SCS002.0000-00	ACOPOSmulti shield component set: 1x clamping plate; 2x clamps D 4-13.5 mm; 4x screws	
8SCS007.0000-00	ACOPOSmulti shield component set: 1x shield mounting plate 2x 45°; 4x screws	
8SCS008.0000-00	ACOPOSmulti shield component set: 1x shield plate 2x type 0; 1x hose clamp, B 9 mm, D 23-35 mm	
8SCS010.0000-00	ACOPOSmulti shield component set: 1x ACOPOSmulti holding plate SK14-20; 1x shield terminal SK20	
	Terminal blocks	

Table 34: 8BVI0440HCSS.000-1, 8BVI0440HCSA.000-1, 8BVI0440HWSS.000-1, 8BVI0440HWSA.000-1 - Order data

Model number	Short description	Figure
8TB2104.203L-00	Screw clamp 4-pin, single row, spacing: 5.08 mm, label 3: T- T + B- B+, L keying: 1010	
8TB2108.2010-00	Screw clamp 8-pin, single row, spacing: 5.08 mm, label 1: numbered serially	
8TB4104.204G-10	Screw clamp 4-pin, single row, spacing: 10.16 mm, label 4: PE W V U, G keying: 0110	

Table 34: 8BVI0440HCSS.000-1, 8BVI0440HCSA.000-1, 8BVI0440HWSS.000-1, 8BVI0440HWSA.000-1 - Order data

Information:

Only 8BCM motor cables from B&R are permitted to be connected to the motor connectors.

ACOPOSmulti SafeMOTION EnDat 2.2

Information:

Only 8BCF EnDat 2.2 cables from B&R or 8BCH hybrid motor cables from B&R are permitted to be connected to the encoder interfaces.

ACOPOSmulti SafeMOTION SinCos

Information:

Only 8BCS encoder cables from B&R are permitted to be connected to the encoder interfaces on B&R standard motors.

For details, see 1.2 "Safe power transmission system " on page 167.

3.3.3.3 Technical data

Product ID	8BVI0440HCSS.000-1	8BVI0440HWSS.000-1	8BVI0440HCSA.000-1	8BVI0440HWSA.000-1
General information				
B&R ID code	0xAA1F	0xAA20	0xD5CB	0xC5FE
Cooling and mounting method	Cold plate or feed-through mounting	Wall mounting	Cold plate or feed-through mounting	Wall mounting
Slots for plug-in modules	2 [1]			
Certification				
CE	Yes			
cULus	Yes			
KC	Yes		-	Yes
FSC	Yes			
DC bus connection				
Voltage				
Nominal	750 VDC			
Continuous power consumption [2]	32.5 kW			
Power loss depending on the switching frequency [3]				
Switching frequency 5 kHz	[0.07 * I_M^2 + 7.3 * I_M + 40] W			
Switching frequency 10 kHz	[0.2 * I_M^2 + 11.1 * I_M + 130] W			
Switching frequency 20 kHz	[1.85 * I_M^2 + 3.8 * I_M + 300] W			
DC bus capacitance	990 µF			
Design	ACOPOSmulti backplane			
24 VDC supply				
Input voltage	25 VDC ±1.6%			
Input capacitance	32.9 µF			
Max. power consumption	31 W + P_{SMC1} + P_{SLOT2} + $P_{24\ V\ Out}$ + $P_{HoldingBrake}$ + 2 * $P_{Fan8B0M...}$ [4]		25 W + P_{SMC1} + P_{SLOT2} + $P_{24\ V\ Out}$ + $P_{HoldingBrake}$ + $P_{Fan8B0M...}$ [5]	
Design	ACOPOSmulti backplane			
24 VDC output				
Quantity	2			
Output voltage				
DC bus voltage (U_{DC}): 260 to 315 VDC	25 VDC * (U_{DC}/315)			
DC bus voltage (U_{DC}): 315 to 800 VDC	24 VDC ±6%			
Protection	250 mA (slow-blow) electronic, automatic reset			
Motor connection [6]				
Quantity	1			
Continuous power per motor connection [2]	32 kW			
Continuous current per motor connection [2]	44 A_{eff}			

Table 35: 8BVI0440HCSS.000-1, 8BVI0440HWSS.000-1, 8BVI0440HCSA.000-1, 8BVI0440HWSA.000-1 - Technical data

Product ID	8BVI0440HCSS.000-1	8BVI0440HWSS.000-1	8BVI0440HCSA.000-1	8BVI0440HWSA.000-1
Reduction of continuous current depending on the switching frequency [7)				
Switching frequency 5 kHz	-	1.57 A/K (from 40°C) [8)	-	1.57 A/K (from 40°C) [8)
Switching frequency 10 kHz	-	0.5 A/K (from -10°C) [9)	-	0.5 A/K (from -10°C) [9)
Switching frequency 20 kHz	-	0.36 A/K (from -77°C) [9)	-	0.36 A/K (from -77°C) [9)
Reduction of continuous current depending on the switching frequency and mounting method [10)				
Switching frequency 5 kHz				
Cold plate mounting [11)	0.8 A/K (from 45°C) [8)	-	0.8 A/K (from 45°C) [8)	-
Feed-through mounting	1.26 A/K (from 40°C) [8)	-	1.26 A/K (from 40°C) [8)	-
Switching frequency 10 kHz				
Cold plate mounting [11)	0.62 A/K (from 6°C) [12)	-	0.62 A/K (from 6°C) [12)	-
Feed-through mounting	0.37 A/K (from -36°C) [9)	-	0.37 A/K (from -36°C) [9)	-
Switching frequency 20 kHz				
Cold plate mounting [11)	0.32 A/K (from -82°C) [12)	-	0.32 A/K (from -82°C) [12)	-
Feed-through mounting	0.24 A/K (from -137°C) [9)	-	0.24 A/K (from -137°C) [9)	-
Reduction of continuous current depending on the installation elevation				
Starting at 500 m above sea level	4.4 A_{eff} per 1000 m			
Peak current	88 A_{eff}			
Nominal switching frequency	5 kHz			
Possible switching frequencies [13)	5/10/20 kHz			
Electrical stress of the connected motor in accordance with IEC TS 60034-25 [14)	Limit value curve A			
Protective measures				
Overload protection	Yes			
Short circuit and ground fault protection	Yes			
Max. output frequency	598 Hz [15)			
Design				
U, V, W, PE	Male connector			
Shield connection	Yes			
Terminal connection cross section				
Flexible and fine wire lines				
With wire end sleeves	0.5 to 16 mm²			
Approbation data				
UL/C-UL-US	20 to 6			
CSA	20 to 6			
Terminal cable cross section dimension of shield connection	23 to 35 mm			
Max. motor line length depending on the switching frequency				
Switching frequency 5 kHz	25 m			
Switching frequency 10 kHz	25 m			
Switching frequency 20 kHz	25 m			
Motor holding brake connection				
Quantity	1			
Output voltage [16)	24 VDC +5.8% / -0.5% [17)			
Continuous current	4.2 A			
Max. internal resistance	0.15 Ω			
Extinction potential	Approx. 30 V			
Max. extinction energy per switching operation	3 Ws			
Max. switching frequency	0.5 Hz			
Protective measures				
Overload and short circuit protection	Yes			
Open line monitoring	Yes			
Undervoltage monitoring	Yes			
Response threshold for open line monitoring	Approx. 0.5 A			
Response threshold for undervoltage monitoring	24 VDC -2% / -4%			
Encoder interfaces [18)				
Quantity	1			
Type	EnDat 2.2 [19)		SinCos	
Connections	9-pin female DSUB connector		15-pin female DSUB connector	
Status indicators	UP/DN LEDs			
Electrical isolation				
Encoder - ACOPOSmulti	No			
Encoder monitoring	Yes			
Max. encoder cable length	100 m Depends on the cross section of the encoder's supply wires [20)		50 m [21)	

Table 35: 8BVI0440HCSS.000-1, 8BVI0440HWSS.000-1, 8BVI0440HCSA.000-1, 8BVI0440HWSA.000-1 - Technical data

Product ID	8BVI0440HCSS.000-1	8BVI0440HWSS.000-1	8BVI0440HCSA.000-1	8BVI0440HWSA.000-1
Encoder supply				
Output voltage	Typ. 12.5 V		5 V ±5% [22]	
Load capability	350 mA		300 mA [23]	
Sense lines	-		2, compensation of max. 2 x 0.7 V	
Protective measures				
Short circuit protection	Yes			
Overload protection	Yes			
Synchronous serial interface				
Signal transmission	RS485			
Data transfer rate	6.25 Mbit/s		781.25 kbit/s	
Sine/Cosine inputs				
Signal transmission	-		Differential signals, symmetrical	
Differential voltage				
In motion	-		0.5 to 1.35 V [24]	
At standstill	-		0.8 to 1.35 V [25]	
Differential voltage deviation per signal period	-		±10% [26]	
Common-mode voltage	-		Max. ±7 V	
Terminating resistors	-		120 Ω	
Max. input frequency	-		200 kHz	
Signal frequency (-5 dB)	-		<300 kHz	
Signal frequency (-3 dB)	-		DC up to 200 kHz	
ADC resolution	-		12-bit	
Reference input				
Signal transmission	-		Differential signal, symmetrical	
Differential voltage for low	-		≤ -0.2 V	
Differential voltage for high	-		≥ 0.2 V	
Common-mode voltage	-		Max. -5 V to +9 V	
Terminating resistors	-		120 Ω	
Position				
Resolution @ 1 V_{SS} [27]	-		Number of encoder lines * 5700	
Precision [28]	-		---	
Noise [28]	-		---	
Max. power consumption per encoder interface	$P_{SMC}[W] = 19\ V * I_{Encoder}[A]$ [29]		$P_{SMC}[W] = 25\ V * (0.376\ A + 0.35 * I_{Encoder}[A])$ [29]	
Trigger inputs				
Quantity	2			
Wiring	Sink			
Electrical isolation				
Input - Inverter module	Yes			
Input - Input	Yes			
Input voltage				
Nominal	24 VDC			
Maximum	30 VDC			
Switching threshold				
Low	<5 V			
High	>15 V			
Input current at nominal voltage	Approx. 10 mA			
Switching delay				
Rising edge	52 µs ±0.5 µs (digitally filtered)			
Falling edge	53 µs ±0.5 µs (digitally filtered)			
Modulation compared to ground potential	Max. ±38 V			
Electrical characteristics				
Discharge capacitance	0.22 µF			
Operating conditions				
Permitted mounting orientations				
Hanging vertically	Yes			
Lying horizontally	Yes			
Standing horizontally	No			
Installation at elevations above sea level				
Nominal	0 to 500 m			
Maximum [30]	4000 m			
Degree of pollution in accordance with EN 60664-1	2 (non-conductive pollution)			
Overvoltage category in accordance with IEC 60364-4-443:1999	III			
EN 60529 protection	IP20 [31]			
Environmental conditions				
Temperature				
Operation				
Nominal	5 to 40°C			
Maximum [32]	55°C			
Storage	-25 to 55°C			
Transport	-25 to 70°C			

Table 35: 8BVI0440HCSS.000-1, 8BVI0440HWSS.000-1, 8BVI0440HCSA.000-1, 8BVI0440HWSA.000-1 - Technical data

Product ID	8BVI0440HCSS.000-1	8BVI0440HWSS.000-1	8BVI0440HCSA.000-1	8BVI0440HWSA.000-1
Relative humidity				
Operation	5 to 85%			
Storage	5 to 95%			
Transport	Max. 95% at 40°C			
Mechanical characteristics				
Dimensions [33]				
Width	106.5 mm			
Height	317 mm			
Depth				
Wall mounting	-	263 mm	-	263 mm
Cold plate	212 mm	-	212 mm	-
Feed-through mounting	209 mm	-	209 mm	-
Weight	Approx. 4.3 kg	Approx. 5.4 kg	Approx. 4.3 kg	Approx. 5.4 kg
Module width	2			

Table 35: 8BVI0440HCSS.000-1, 8BVI0440HWSS.000-1, 8BVI0440HCSA.000-1, 8BVI0440HWSA.000-1 - Technical data

1) SLOT 2 is not occupied. SLOT 1 of the ACOPOSmulti module is occupied by the SafeMOTION module.
2) Valid in the following conditions: 750 VDC DC bus voltage, 5 kHz switching frequency, 40°C ambient temperature, installation elevation <500 m above sea level, no derating due to cooling type.
3) I_M... Current on the motor connection [A].
4) P_{SMC1} ... Max. power consumption P_{SMC} [W] of the SafeMOTION module in SLOT1 (see the "Encoder interfaces" section).
P_{SLOT2} ... Max. power consumption P_{8BAC} [W] of the plug-in module in SLOT2 (see the technical data for the respective plug-in module).
$P_{24\ V\ Out}$... Power [W] that is output to the connections X2/+24 V Out 1 and X2/+24 V Out 2 on the module (max. 10 W).
$P_{Fan8B0M...}$... Portion of the power [W] that is used by the fan modules in the mounting plate or the 8B0M0040HFF0.000-1 fan module (see the technical data for the respective 8B0M... mounting plate / 8B0M0040HFF0.000-1 fan module).
5) P_{SMC1} ... Max. power consumption P_{SMC} [W] of the SafeMOTION module in SLOT1 (see the "Encoder interfaces" section).
P_{SLOT2} ... Max. power consumption P_{8BAC} [W] of the plug-in module in SLOT2 (see the technical data for the respective plug-in module).
$P_{24\ V\ Out}$ ... Power [W] that is output to the connections X2/+24 V Out 1 and X2/+24 V Out 2 on the module (max. 10 W).
$P_{Fan8B0M...}$ ... Portion of the power [W] that is used by the fan modules in the mounting plate or the 8B0M0040HFF0.000-1 fan module (see the technical data for the respective 8B0M... mounting plate / 8B0M0040HFF0.000-1 fan module).
6) Only 8BCM motor cables from B&R are permitted to be connected to the motor connectors.
7) Valid in the following conditions: 750 VDC DC bus voltage. The temperature specifications refer to the ambient temperature.
8) Value for the nominal switching frequency.
9) The module cannot supply the full continuous current at this switching frequency. This unusual value for the ambient temperature, at which derating of the continuous current must be taken into account, ensures that the derating of the continuous current can be determined in the same manner as at other switching frequencies.
10) Valid in the following conditions: 750 VDC DC bus voltage, minimum permissible coolant flow volume (3 l/min).
11) The temperature specifications refer to the return temperature of the cold plate mounting plate.
12) The module cannot supply the full continuous current at this switching frequency. This unusual value for the return temperature, at which derating of the continuous current must be taken into account, ensures that the derating of the continuous current can be determined in the same manner as at other switching frequencies.
Caution! Condensation can occur at low flow temperatures and return temperatures.
13) B&R recommends operating the module at its nominal switching frequency. Operating the module at a higher switching frequency for application-specific reasons reduces the continuous current and increases the CPU load.
14) If necessary, the stress of the motor isolation system can be reduced by an additional externally wired dU/dt choke. For example, the RWK 305 three-phase du/dt choke from Schaffner (www.schaffner.com) can be used. Important: Even when using a dU/dt choke, it is necessary to ensure that an EMC-compatible, low inductance shield connection is used!
15) The module's electrical output frequency (SCTRL_SPEED_ACT * MOTOR_POLEPAIRS) is monitored to protect against dual use in accordance with EC regulation 428/2009 | 3A225. If the electrical output frequency of the module exceeds the limit value of 598 Hz uninterrupted for more than 0.5 s, then the current movement is aborted and error 6060 is output (Power element: Limit speed exceeded).
16) During project development, it is necessary to check if the minimum voltage can be maintained on the holding brake with the specified wiring. The operating voltage range of the holding brake can be found in the user's manual for the respective motor.
17) The specified value is only valid under the following conditions:
- The 24 VDC supply for the module is provided by an 8B0C auxiliary supply module installed on the same mounting plate.
If the 24 VDC supply for the module is applied to the mounting plate using an 8BVE expansion module, then the output voltage is reduced because of voltage drops on the expansion cable. In this case, undervoltage monitoring must be disabled.
18) Only 8BCF EnDat 2.2 cables from B&R are permitted to be connected to the encoder interfaces.
19) An EnDat 2.2 functional safety encoder is required when using ACOPOSmulti SafeMOTION inverter modules! With standard EnDat 2.2 encoders, only the STO, SBC and SS1 functions are monitored with respect to timing!
20) The maximum encoder cable length l_{max} can be calculated as follows (the maximum permissible encoder cable length of 100 m must not be exceeded):

$l_{max} = 7.9 / I_G * A * 1/(2*\rho)$

I_G ... Max. current consumption of the encoder [A].
A ... Cross section of the supply wire [mm²].
ρ ... Specific resistance [Ω mm²/m] (e.g. for copper: ρ = 0.0178).
21) The maximum permitted cable length is 50 m.
22) During the power-on procedure for the encoder supply voltage (2 seconds), the monitoring limit for the supply voltage is increased from 5.25 V to 6 V. In this phase, overvoltages up to 6 V are not detected.
A short-term overvoltage of maximum 6 V should not damage the encoder electronics in any way.
An undervoltage on the encoder supply will result in a sine or cosine signal outside the specification.
23) An actual reserve of 12 mA exists for the terminating resistor.
24) The sine-cosine output signals from the measuring instrument are checked by the evaluation circuit using pointer length monitoring.
The pointer length $z = 2\ \sqrt{(Sin - nSin)^2 + (Cos - nCos)^2}$ is monitored according to the specified limits.
25) The sine-cosine output signals from the measuring instrument are checked by the evaluation circuit using pointer length monitoring.
The pointer length $z = 2\ \sqrt{(Sin - nSin)^2 + (Cos - nCos)^2}$ is also monitored according to the specified limits from the time the evaluation circuit is switched on until a signal period has passed.
26) The sine-cosine output signals from the measuring instrument are checked by the evaluation circuit using pointer length monitoring.
The pointer length $z = 2\ \sqrt{(Sin - nSin)^2 + (Cos - nCos)^2}$ is only permitted to vary by maximum ±10% per signal period.

27) This value does not correspond to the encoder resolution that must be configured in Automation Studio (16384 * number of encoder lines).
28) Limited by the encoder in practice.
29) $I_{Encoder}$ ... Max. power consumption of the connected encoder [A].
30) Continuous operation at elevations ranging from 500 m to 4000 m above sea level is possible (taking the specified continuous current reductions into consideration).
31) This value only applies in its delivered state (SLOT2 of the module is sealed by a slot cover / shield plate). If SLOT2 on the module is not sealed, then the level of protection is reduced to IP10. It is important to note that a 8SCS005.0000-00 shield set (slot cover / shield plate) or plug-in module must always be inserted!
32) Continuous operation at ambient temperatures ranging from 40°C to max. 55°C is possible (taking the specified continuous current reductions into consideration), but this will result in a shorter service life.
33) These dimensions refer to the actual device dimensions including the respective mounting plate. Make sure to leave additional space above and below the devices for mounting, connections and air circulation.

3.3.3.4 Wiring

For details, see 3.3.4 "Wiring: Safe double-width inverter modules (single-axis modules)" on page 73.

For general information, see 6 "Wiring" on page 142.

3.3.4 Wiring: Safe double-width inverter modules (single-axis modules)

3.3.4.1 ACOPOSmulti SafeMOTION EnDat 2.2 - Pinout overview

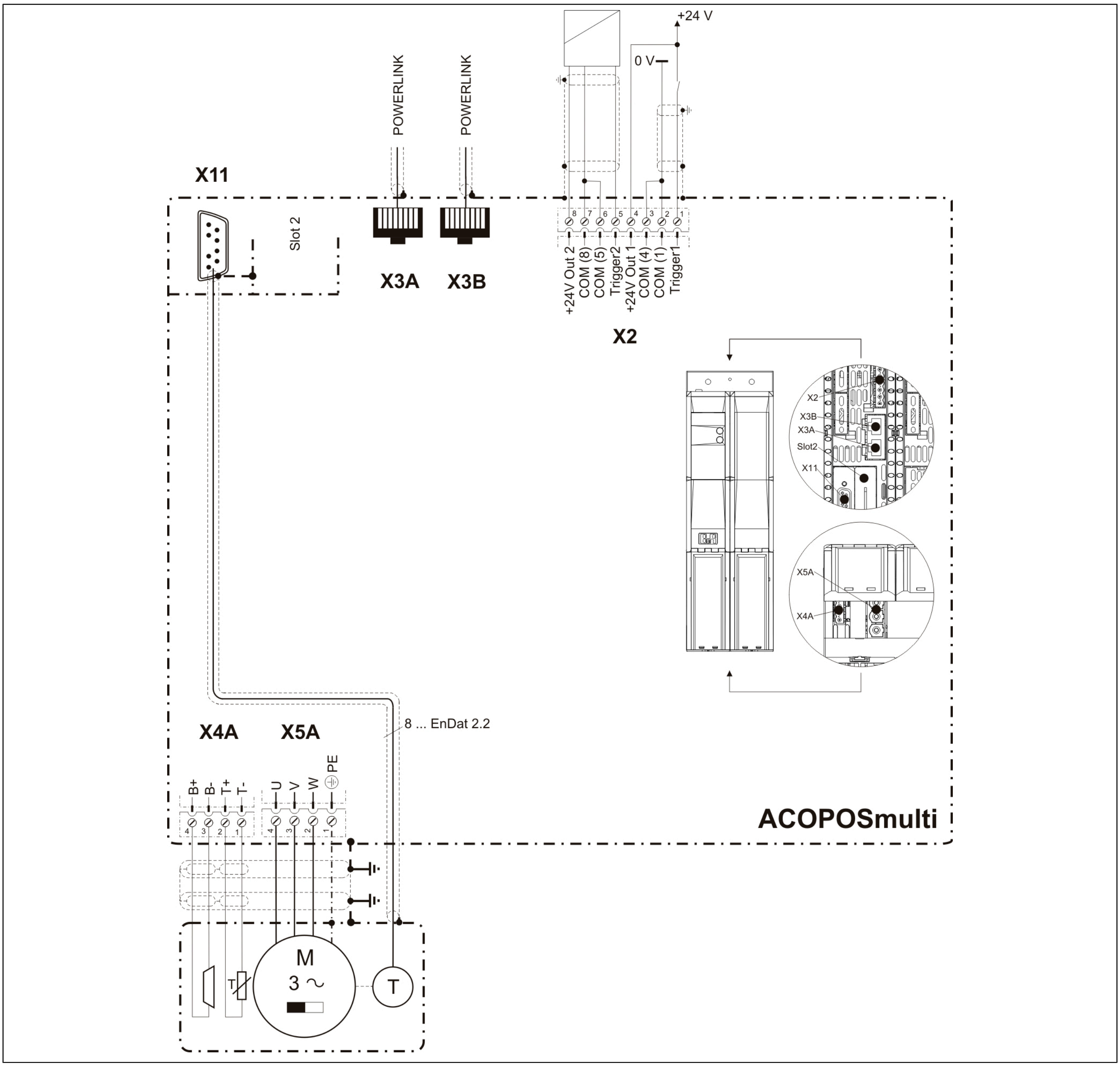


Figure 8: Pinout overview

3.3.4.2 ACOPOSmulti SafeMOTION SinCos - Pinout overview

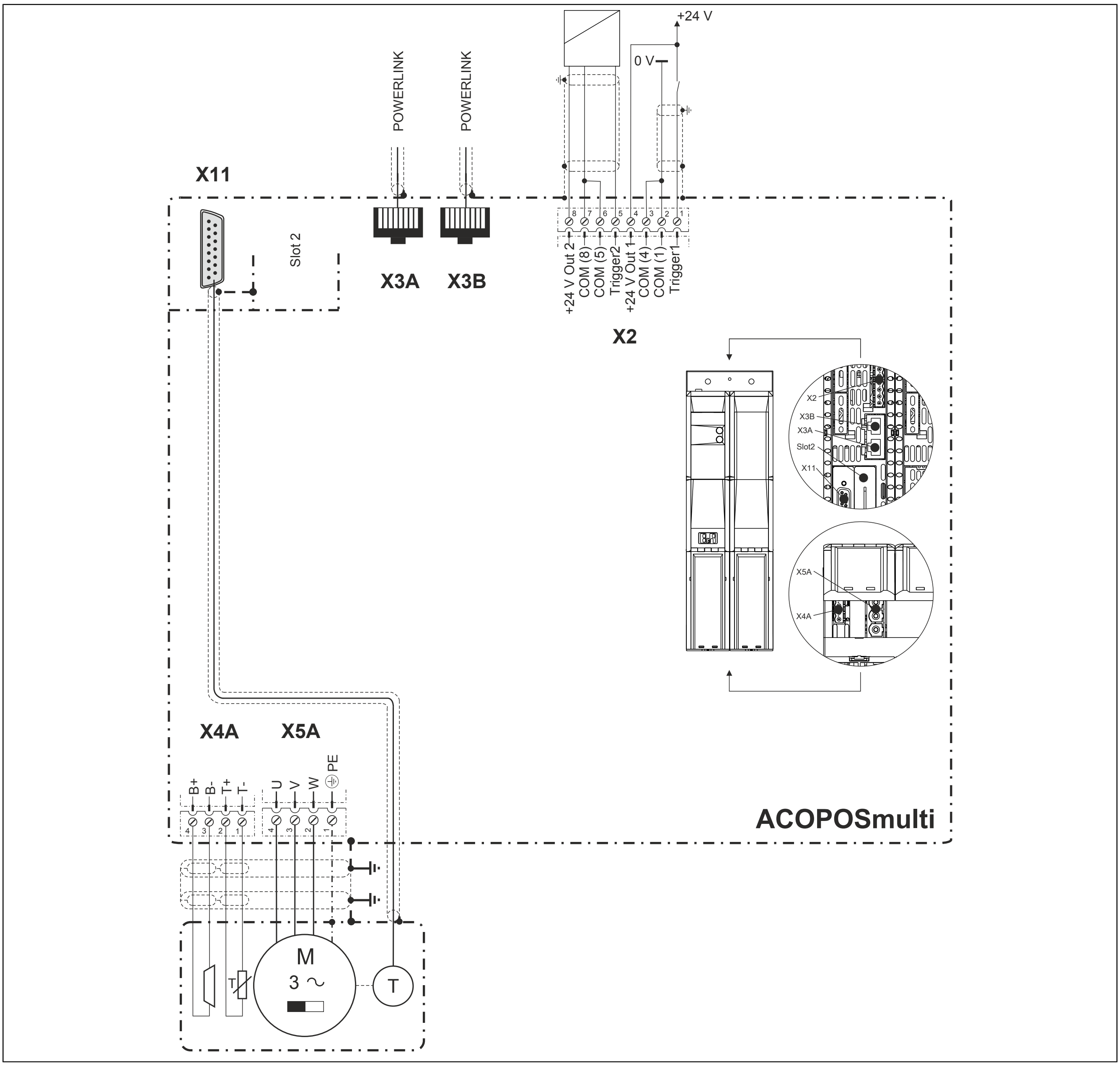


Figure 9: Pinout overview

3.3.4.3 X2 connector - Pinout

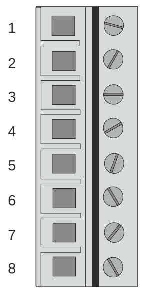
X2	Pin	Name	Function
	1	Trigger 1	Trigger 1
	2	COM (1)	Trigger 1 0 V
	3	COM (2)	+24 V output 1 0 V
	4	+24 V Out 1	+24 V output 1
	5	Trigger 2	Trigger 2
	6	COM (5)	Trigger 2 0 V
	7	COM (8)	+24 V output 2 0 V
	8	+24 V Out 2	+24 V output 2

Table 36: X2 connector - Pinout

3.3.4.4 X3A, X3B connectors - Pinout

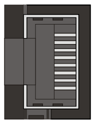
X3A, X3B	Pin	Name	Function
	1	RXD	Receive signal
	2	RXD\	Receive signal inverted
	3	TXD	Transmit signal
	4	Shield	Shield
	5	Shield	Shield
	6	TXD\	Transmit signal inverted
	7	Shield	Shield
	8	Shield	Shield

Table 37: X3A, X3B connectors - Pinout

3.3.4.5 X4A connector - Pinout

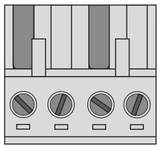
X4A	Name	Function
	T-	Axis 1: Temperature sensor -
	T+	Axis 1: Temperature sensor +
	B- [1)]	Axis 1: Brake -
	B+ [1)]	Axis 1: Brake +

Table 38: X4A connector - Pinout

1) Wiring is not permitted to exceed a total length of 3 m.

Danger!

The FUNCTIONAL FAIL SAFE state is activated if the SBC output B+ is shorted to 24 V (i.e. safe pulse disabling is activated). The brake always remains on/released, however, due to the short circuit to 24 V! This can lead to dangerous situations because the motor holding brake cannot brake or prevent the spin-out movement (or the unrestrained lowering in the case of hanging loads)!
Appropriate wiring measures must be implemented to ensure that the SBC output B+ is not shorted to 24 V!

Danger!

The SBC output

- **is not permitted to be wired to multiple modules!**
- **is not permitted to be wired as an open emitter!**
- **is not permitted to be wired as an open collector!**

Danger!

Only an output voltage of ≤5 V can be ensured for the safe motor holding brake output when shut off. When selecting a motor holding brake, the user must ensure that the required braking torque is reached at a voltage of 5 V.

Information:

The transistors of the SBC output stage are tested cyclically. When the output channels are active, this test emits low pulses on the output with a maximum length of 600 µs.

This must be taken into consideration when choosing the motor holding brake!

Danger!

The connections for the motor temperature sensors and the motor holding brake are safely isolated circuits. These connections are therefore only permitted to be connected to devices or components that have sufficient isolation in accordance with IEC 60364-4-41 or EN 61800-5-1.

Caution!

If B+ and B- are swapped when connecting the permanent magnet holding brakes, then the brakes cannot be opened! ACOPOSmulti inverter modules cannot determine if a holding brake is connected with reverse polarity!

Warning!

Temperature sensors are only permitted to be connected to the X4A/T+ and X4A/T- connectors on an ACOPOSmulti module under the following conditions:

- **There is no ACOPOSmulti plug-in module in SLOT1 on the ACOPOSmulti module with a temperature sensor connected to T+ and T-**

Otherwise, the temperature monitoring functions on the ACOPOSmulti module may become ineffective, which in extreme cases can cause the hardware (e.g. motors) connected to the ACOPOSmulti module to be destroyed!

3.3.4.6 X5A connector - Pinout

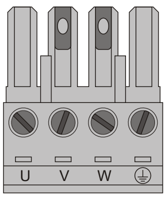
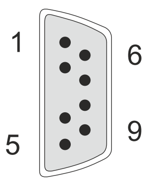
X5A	Name	Function
	⏚	Axis 1: Protective ground conductor
	W	Axis 1: Motor connection W
	V	Axis 1: Motor connection V
	U	Axis 1: Motor connection U

Table 39: X5A connector - Pinout

Information:

Only 8BCM motor cables from B&R are permitted to be connected to the motor connectors.

3.3.4.7 SafeMOTION EnDat 2.2 module - Pinout

Figure	X11 (X12)	Pin	Name	Function
		1	U+	Encoder supply +12.5 V
		2	---	---
		3	---	---
		4	D	Data input
		5	T	Clock output
		6	COM (1)	Encoder supply 0 V
		7	---	---
		8	D\	Data input inverted
		9	T\	Clock output inverted

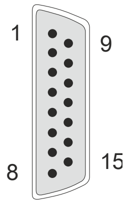
Information:

Only 8BCF EnDat 2.2 cables from B&R or 8BCH hybrid motor cables from B&R are permitted to be connected to the encoder interfaces.

Information:

SafeMOTION modules cannot be replaced! SafeMOTION modules and the corresponding inverter module form a single unit. In the event of an error, the entire inverter module must be replaced.

3.3.4.8 SafeMOTION SinCos module - Pinout

Figure	X11 (X12)	Pin	Name	Function
		1	A	Channel A/Sin
		2	COM	Ground
		3	B	Channel B/COS
		4	+5 V	Encoder supply +
		5	D	Data
		6	---	---
		7	R\	Reference pulse inverted/nREF
		8	T	Clock
		9	A\	Channel A inverted/nSIN
		10	Sense COM	Sense ground
		11	B\	Channel B inverted/nCOS
		12	Sense +5V	Sense input +5 V
		13	D\	Data inverted
		14	R	Reference pulse/REF
		15	T\	Clock cycle inverted

Information:

SafeMOTION modules cannot be replaced! SafeMOTION modules and the corresponding inverter module form a single unit. In the event of an error, the entire inverter module must be replaced.

3.4 Safe single-width inverter modules (dual-axis modules)

3.4.1 8BVI0014HCDS.000-1, 8BVI0014HWDS.000-1

3.4.1.1 General information

- Clearly structured, straightforward implementation via network-based safety technology
- Modular expandability through virtual wiring
- Immediate triggering of safety function due to short cycle times
- Easy implementation with transparent control and status information, even in the standard application
- Compact design
- Complete safety functionality, even in dual-axis modules

3.4.1.2 Order data

Model number	Short description	Figure
	Cold plate or feed-through mounting	
8BVI0014HCDS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 1.9 A, HV, cold plate or feed-through mounting, 2 axes	
	Wall mounting	
8BVI0014HWDS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 1.9 A, HV, wall mounting, 2 axes	
	Required accessories	
	Terminal block sets	
8BZVI0055DS.000-1A	Screw clamp set for ACOPOSmulti 8BVI00xxHxDS modules: 1x 8TB2108.2010-00, 1x 8TB2104.203L-00, 1x 8TB2104.203F-00, 1x 8TB3104.204G-11, 1x 8TB3104.204K-11	
	Optional accessories	
	Accessory sets	
8BXB000.0000-00	ACPmulti accessory set for encoder buffering consisting of: 1 lithium battery AA 3.6 V; 1 protective cap for battery holder	
	Fan modules	
8BXF001.0000-00	ACOPOSmulti fan module, replacement fan for ACOPOSmulti modules (8BVP / 8B0C / 8BVI / 8BVE / 8B0K)	
	POWERLINK cables	
X20CA0E61.00020	POWERLINK connection cable, RJ45 to RJ45, 0.2 m	
X20CA0E61.00025	POWERLINK connection cable, RJ45 to RJ45, 0.25 m	
X20CA0E61.00030	POWERLINK connection cable, RJ45 to RJ45, 0.3 m	
X20CA0E61.00035	POWERLINK connection cable, RJ45 to RJ45, 0.35 m	
X20CA0E61.00050	POWERLINK connection cable, RJ45 to RJ45, 0.5 m	
X20CA0E61.00100	POWERLINK connection cable, RJ45 to RJ45, 1 m	
	Shield component sets	
8SCS000.0000-00	ACOPOSmulti shielding components set: 1x shielding plate 1fold type 0; 1x hose clamp, W 9 mm, D 12-22 mm	
8SCS002.0000-00	ACOPOSmulti shield component set: 1x clamping plate; 2x clamps D 4-13.5 mm; 4x screws	
8SCS009.0000-00	ACOPOSmulti shield component set: 1x ACOPOSmulti holding plate SK8-14; 1x shield terminal SK14	
	Terminal blocks	
8TB2104.203F-00	Screw clamp 4-pin, single row, spacing: 5.08 mm, label 3: T- T + B- B+, F keying: 0101	
8TB2104.203L-00	Screw clamp 4-pin, single row, spacing: 5.08 mm, label 3: T- T + B- B+, L keying: 1010	
8TB2108.2010-00	Screw clamp 8-pin, single row, spacing: 5.08 mm, label 1: numbered serially	
8TB3104.204G-11	Screw clamp 4-pin, single row, spacing: 7.62 mm, label 4: PE W V U, G coding: 0110	
8TB3104.204K-11	Screw clamp 4-pin, single row, spacing: 7.62 mm, label 4: PE W V U, K keying: 1001	

Table 40: 8BVI0014HCDS.000-1, 8BVI0014HWDS.000-1 - Order data

Information:

Only 8BCM motor cables from B&R are permitted to be connected to the motor connectors.

ACOPOSmulti SafeMOTION EnDat 2.2

Information:

Only 8BCF EnDat 2.2 cables from B&R or 8BCH hybrid motor cables from B&R are permitted to be connected to the encoder interfaces.

For details, see 1.2 "Safe power transmission system " on page 167.

3.4.1.3 Technical data

Product ID	8BVI0014HCDS.000-1	8BVI0014HWDS.000-1
General information		
B&R ID code	0xAA0B	0xAA0D
Cooling and mounting method	Cold plate or feed-through mounting	Wall mounting
Slots for plug-in modules	2 [1]	
Certification		
CE	Yes	
cULus	Yes	
KC	Yes	
FSC	Yes	
DC bus connection		
Voltage		
Nominal	750 VDC	
Continuous power consumption [2]	2.91 kW	
Power loss depending on the switching frequency [3]		
Switching frequency 5 kHz	$[1.2 * I_M^2 + 2.62 * I_M + 100]$ W	
Switching frequency 10 kHz	$[2.56 * I_M^2 + 2.8 * I_M + 200]$ W	
Switching frequency 20 kHz	$[6 * I_M^2 - 9.4 * I_M + 430]$ W	
DC bus capacitance	165 µF	
Design	ACOPOSmulti backplane	
24 VDC supply		
Input voltage	25 VDC ±1.6%	
Input capacitance	23.5 µF	
Max. power consumption	28 W + P_{SMC1} + P_{SMC2} + $P_{24\ V\ Out}$ + $P_{HoldingBrake(s)}$ + $P_{Fan8B0M...}$ [4]	
Design	ACOPOSmulti backplane	
24 VDC output		
Quantity	2	
Output voltage		
DC bus voltage (U_{DC}): 260 to 315 VDC	25 VDC * (U_{DC}/315)	
DC bus voltage (U_{DC}): 315 to 800 VDC	24 VDC ±6%	
Protection	250 mA (slow-blow) electronic, automatic reset	
Motor connection [5]		
Quantity	2	
Continuous power per motor connection [2]	1.4 kW	
Continuous current per motor connection [2]	1.9 A_{eff}	
Reduction of continuous current depending on the switching frequency [6]		
Switching frequency 5 kHz	-	No reduction [7]
Switching frequency 10 kHz	-	No reduction
Switching frequency 20 kHz	-	0.11 A/K (from 15°C) [8]
Reduction of continuous current depending on the switching frequency and mounting method [9]		
Switching frequency 5 kHz		
Cold plate mounting [10]	No reduction [7]	-
Feed-through mounting	No reduction [7]	-
Switching frequency 10 kHz		
Cold plate mounting [10]	No reduction	-
Feed-through mounting	No reduction	-
Switching frequency 20 kHz		
Cold plate mounting [10]	0.13 A/K (from 45°C)	-
Feed-through mounting	0.14 A/K (from 32°C) [8]	-
Reduction of continuous current depending on the installation elevation		
Starting at 500 m above sea level	0.19 A_{eff} per 1000 m	
Peak current per motor connection	4.7 A_{eff}	
Nominal switching frequency	5 kHz	
Possible switching frequencies [11]	5/10/20 kHz	
Electrical stress of the connected motor in accordance with IEC TS 60034-25 [12]	Limit value curve A	
Protective measures		
Overload protection	Yes	
Short circuit and ground fault protection	Yes	
Max. output frequency	598 Hz [13]	
Design		
U, V, W, PE	Male connector	
Shield connection	Yes	

Table 41: 8BVI0014HCDS.000-1, 8BVI0014HWDS.000-1 - Technical data

Product ID	8BVI0014HCDS.000-1	8BVI0014HWDS.000-1
Terminal connection cross section		
Flexible and fine wire lines		
With wire end sleeves	0.25 to 4 mm²	
Approbation data		
UL/C-UL-US	30 to 10	
CSA	28 to 10	
Terminal cable cross section dimension of shield connection	12 to 22 mm	
Max. motor line length depending on the switching frequency		
Switching frequency 5 kHz	25 m	
Switching frequency 10 kHz	25 m	
Switching frequency 20 kHz	10 m	
Motor holding brake connection		
Quantity	2	
Output voltage [14]	24 VDC +5.8% / -0% [15]	
Continuous current	1.1 A	
Max. internal resistance	0.5 Ω	
Extinction potential	Approx. 30 V	
Max. extinction energy per switching operation	1.5 Ws	
Max. switching frequency	0.5 Hz	
Protective measures		
Overload and short circuit protection	Yes	
Open line monitoring	Yes	
Undervoltage monitoring	Yes	
Response threshold for open line monitoring	Approx. 0.25 A	
Response threshold for undervoltage monitoring	24 VDC -2% / -4%	
Encoder interfaces [16]		
Quantity	2	
Type	EnDat 2.2 [17]	
Connections	9-pin female DSUB connector	
Status indicators	UP/DN LEDs	
Electrical isolation		
Encoder - ACOPOSmulti	No	
Encoder monitoring	Yes	
Max. encoder cable length	100 m Depends on the cross section of the encoder's supply wires [18]	
Encoder supply		
Output voltage	Typ. 12.5 V	
Load capability	350 mA	
Protective measures		
Short circuit protection	Yes	
Overload protection	Yes	
Synchronous serial interface		
Signal transmission	RS485	
Data transfer rate	6.25 Mbit/s	
Max. power consumption per encoder interface	P_{SMC}[W] = 19 V * $I_{Encoder}$[A] [19]	
Trigger inputs		
Quantity	2	
Wiring	Sink	
Electrical isolation		
Input - Inverter module	Yes	
Input - Input	Yes	
Input voltage		
Nominal	24 VDC	
Maximum	30 VDC	
Switching threshold		
Low	<5 V	
High	>15 V	
Input current at nominal voltage	Approx. 10 mA	
Switching delay		
Rising edge	52 µs ±0.5 µs (digitally filtered)	
Falling edge	53 µs ±0.5 µs (digitally filtered)	
Modulation compared to ground potential	Max. ±38 V	
Electrical characteristics		
Discharge capacitance	0.2 µF	
Operating conditions		
Permitted mounting orientations		
Hanging vertically	Yes	
Lying horizontally	Yes	
Standing horizontally	No	
Installation at elevations above sea level		
Nominal	0 to 500 m	
Maximum [20]	4000 m	

Table 41: 8BVI0014HCDS.000-1, 8BVI0014HWDS.000-1 - Technical data

Product ID	8BVI0014HCDS.000-1	8BVI0014HWDS.000-1
Degree of pollution in accordance with EN 60664-1	2 (non-conductive pollution)	
Overvoltage category in accordance with IEC 60364-4-443:1999	III	
EN 60529 protection	IP20	
Environmental conditions		
Temperature		
Operation		
Nominal	5 to 40°C	
Maximum [21]	55°C	
Storage	-25 to 55°C	
Transport	-25 to 70°C	
Relative humidity		
Operation	5 to 85%	
Storage	5 to 95%	
Transport	Max. 95% at 40°C	
Mechanical characteristics		
Dimensions [22]		
Width	53 mm	
Height	317 mm	
Depth		
Wall mounting	-	263 mm
Cold plate	212 mm	-
Feed-through mounting	209 mm	-
Weight	Approx. 2.3 kg	Approx. 2.8 kg
Module width	1	

Table 41: 8BVI0014HCDS.000-1, 8BVI0014HWDS.000-1 - Technical data

1) SLOT 1 and SLOT 2 of the ACOPOSmulti module are occupied by the encoder interfaces.
2) Valid in the following conditions: 750 VDC DC bus voltage, 5 kHz switching frequency, 40°C ambient temperature, installation elevation <500 m above sea level, no derating due to cooling type.
3) I_M... Average value of the currents on both motor connectors [A].
4) P_{SMC1} ... Max. power consumption P_{SMC} [W] of the SafeMOTION module in SLOT1 (see the "Encoder interfaces" section).
   P_{SMC2} ... Max. power consumption P_{SMC} [W] of the SafeMOTION module in SLOT2 (see the "Encoder interfaces" section).
   $P_{24\ V\ Out}$... Power [W] that is output to the connections X2/+24 V Out 1 and X2/+24 V Out 2 on the module (max. 10 W).
   $P_{Fan8B0M...}$... Portion of the power [W] that is used by the fan modules in the mounting plate or the 8B0M0040HFF0.000-1 fan module (see the technical data for the respective 8B0M... mounting plate / 8B0M0040HFF0.000-1 fan module).
5) Only 8BCM motor cables from B&R are permitted to be connected to the motor connectors.
6) Valid in the following conditions: 750 VDC DC bus voltage. The temperature specifications refer to the ambient temperature.
7) Value for the nominal switching frequency.
8) The module cannot supply the full continuous current at this switching frequency. This unusual value for the ambient temperature, at which derating of the continuous current must be taken into account, ensures that the derating of the continuous current can be determined in the same manner as at other switching frequencies.
9) Valid in the following conditions: 750 VDC DC bus voltage, minimum permissible coolant flow volume (3 l/min).
10) The temperature specifications refer to the return temperature of the cold plate mounting plate.
11) B&R recommends operating the module at its nominal switching frequency. Operating the module at a higher switching frequency for application-specific reasons reduces the continuous current and increases the CPU load. When using dual-axis modules, the increased CPU load reduces the functionality of the drive; if this is not taken into consideration, the computing time can be exceeded in extreme cases.
12) If necessary, the stress of the motor isolation system can be reduced by an additional externally wired dU/dt choke. For example, the RWK 305 three-phase du/dt choke from Schaffner (www.schaffner.com) can be used. Important: Even when using a dU/dt choke, it is necessary to ensure that an EMC-compatible, low inductance shield connection is used!
13) The module's electrical output frequency (SCTRL_SPEED_ACT * MOTOR_POLEPAIRS) is monitored to protect against dual use in accordance with EC regulation 428/2009 | 3A225. If the electrical output frequency of the module exceeds the limit value of 598 Hz uninterrupted for more than 0.5 s, then the current movement is aborted and error 6060 is output (Power element: Limit speed exceeded).
14) During project development, it is necessary to check if the minimum voltage can be maintained on the holding brake with the specified wiring. The operating voltage range of the holding brake can be found in the user's manual for the respective motor.
15) The specified value is only valid under the following conditions:
   - The 24 VDC supply for the module is provided by an 8B0C auxiliary supply module installed on the same mounting plate.
   If the 24 VDC supply for the module is applied to the mounting plate using an 8BVE expansion module, then the output voltage is reduced because of voltage drops on the expansion cable. In this case, undervoltage monitoring must be disabled.
16) Only 8BCF EnDat 2.2 cables from B&R are permitted to be connected to the encoder interfaces.
17) An EnDat 2.2 functional safety encoder is required when using ACOPOSmulti SafeMOTION inverter modules! With standard EnDat 2.2 encoders, only the STO, SBC and SS1 functions are monitored with respect to timing!
18) The maximum encoder cable length l_{max} can be calculated as follows (the maximum permissible encoder cable length of 100 m must not be exceeded):

   $l_{max} = 7.9 / I_G * A * 1/(2*\rho)$

   I_G ... Max. current consumption of the encoder [A].
   A ... Cross section of the supply wire [mm²].
   ρ ... Specific resistance [Ω mm²/m] (e.g. for copper: ρ = 0.0178).
19) $I_{Encoder}$ ... Max. power consumption of the connected encoder [A].
20) Continuous operation at elevations ranging from 500 m to 4000 m above sea level is possible (taking the specified continuous current reductions into consideration).
21) Continuous operation at ambient temperatures ranging from 40°C to max. 55°C is possible (taking the specified continuous current reductions into consideration), but this will result in a shorter service life.
22) These dimensions refer to the actual device dimensions including the respective mounting plate. Make sure to leave additional space above and below the devices for mounting, connections and air circulation.

3.4.1.4 Wiring

For details, see 3.4.4 "Wiring: Safe single-width inverter modules (dual-axis modules)" on page 92.

For general information, see 6 "Wiring" on page 142.

3.4.2 8BVI0028HCDS.000-1, 8BVI0028HWDS.000-1

3.4.2.1 General information

- Clearly structured, straightforward implementation via network-based safety technology
- Modular expandability through virtual wiring
- Immediate triggering of safety function due to short cycle times
- Easy implementation with transparent control and status information, even in the standard application
- Compact design
- Complete safety functionality, even in dual-axis modules

3.4.2.2 Order data

Model number	Short description	Figure
	Cold plate or feed-through mounting	
8BVI0028HCDS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 3.8 A, HV, cold plate or feed-through mounting, 2 axes	
	Wall mounting	
8BVI0028HWDS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 3.8 A, HV, wall mounting, 2 axes	
	Required accessories	
	Terminal block sets	
8BZVI0055DS.000-1A	Screw clamp set for ACOPOSmulti 8BVI00xxHxDS modules: 1x 8TB2108.2010-00, 1x 8TB2104.203L-00, 1x 8TB2104.203F-00, 1x 8TB3104.204G-11, 1x 8TB3104.204K-11	
	Optional accessories	
	Accessory sets	
8BXB000.0000-00	ACPmulti accessory set for encoder buffering consisting of: 1 lithium battery AA 3.6 V; 1 protective cap for battery holder	
	Fan modules	
8BXF001.0000-00	ACOPOSmulti fan module, replacement fan for ACOPOSmulti modules (8BVP / 8B0C / 8BVI / 8BVE / 8B0K)	
	POWERLINK cables	
X20CA0E61.00020	POWERLINK connection cable, RJ45 to RJ45, 0.2 m	
X20CA0E61.00025	POWERLINK connection cable, RJ45 to RJ45, 0.25 m	
X20CA0E61.00030	POWERLINK connection cable, RJ45 to RJ45, 0.3 m	
X20CA0E61.00035	POWERLINK connection cable, RJ45 to RJ45, 0.35 m	
X20CA0E61.00050	POWERLINK connection cable, RJ45 to RJ45, 0.5 m	
X20CA0E61.00100	POWERLINK connection cable, RJ45 to RJ45, 1 m	
	Shield component sets	
8SCS000.0000-00	ACOPOSmulti shielding components set: 1x shielding plate 1fold type 0; 1x hose clamp, W 9 mm, D 12-22 mm	
8SCS002.0000-00	ACOPOSmulti shield component set: 1x clamping plate; 2x clamps D 4-13.5 mm; 4x screws	
8SCS009.0000-00	ACOPOSmulti shield component set: 1x ACOPOSmulti holding plate SK8-14; 1x shield terminal SK14	
	Terminal blocks	
8TB2104.203F-00	Screw clamp 4-pin, single row, spacing: 5.08 mm, label 3: T- T + B- B+, F keying: 0101	
8TB2104.203L-00	Screw clamp 4-pin, single row, spacing: 5.08 mm, label 3: T- T + B- B+, L keying: 1010	
8TB2108.2010-00	Screw clamp 8-pin, single row, spacing: 5.08 mm, label 1: numbered serially	
8TB3104.204G-11	Screw clamp 4-pin, single row, spacing: 7.62 mm, label 4: PE W V U, G coding: 0110	
8TB3104.204K-11	Screw clamp 4-pin, single row, spacing: 7.62 mm, label 4: PE W V U, K keying: 1001	

Table 42: 8BVI0028HCDS.000-1, 8BVI0028HWDS.000-1 - Order data

Information:

Only 8BCM motor cables from B&R are permitted to be connected to the motor connectors.

ACOPOSmulti SafeMOTION EnDat 2.2

Information:

Only 8BCF EnDat 2.2 cables from B&R or 8BCH hybrid motor cables from B&R are permitted to be connected to the encoder interfaces.

For details, see 1.2 "Safe power transmission system " on page 167.

3.4.2.3 Technical data

Product ID	8BVI0028HCDS.000-1	8BVI0028HWDS.000-1
General information		
B&R ID code	0xAA0F	0xAA11
Cooling and mounting method	Cold plate or feed-through mounting	Wall mounting
Slots for plug-in modules	2 [1]	
Certification		
CE	Yes	
cULus	Yes	
KC	Yes	
FSC	Yes	
DC bus connection		
Voltage		
Nominal	750 VDC	
Continuous power consumption [2]	5.73 kW	
Power loss depending on the switching frequency [3]		
Switching frequency 5 kHz	$[1.2 * I_M^2 + 2.62 * I_M + 100]$ W	
Switching frequency 10 kHz	$[2.56 * I_M^2 + 2.8 * I_M + 200]$ W	
Switching frequency 20 kHz	$[6 * I_M^2 - 9.4 * I_M + 430]$ W	
DC bus capacitance	165 µF	
Design	ACOPOSmulti backplane	
24 VDC supply		
Input voltage	25 VDC ±1.6%	
Input capacitance	23.5 µF	
Max. power consumption	$28\ W + P_{SMC1} + P_{SMC2} + P_{24\ V\ Out} + P_{HoldingBrake(s)} + P_{Fan8B0M...}$ [4]	
Design	ACOPOSmulti backplane	
24 VDC output		
Quantity	2	
Output voltage		
DC bus voltage (U_{DC}): 260 to 315 VDC	25 VDC * (U_{DC}/315)	
DC bus voltage (U_{DC}): 315 to 800 VDC	24 VDC ±6%	
Protection	250 mA (slow-blow) electronic, automatic reset	
Motor connection [5]		
Quantity	2	
Continuous power per motor connection [2]	2.8 kW	
Continuous current per motor connection [2]	3.8 A_{eff}	
Reduction of continuous current depending on the switching frequency [6]		
Switching frequency 5 kHz	-	No reduction [7]
Switching frequency 10 kHz	-	No reduction
Switching frequency 20 kHz	-	0.12 A/K (from 13°C) [8]
Reduction of continuous current depending on the switching frequency and mounting method [9]		
Switching frequency 5 kHz		
Cold plate mounting [10]	No reduction [7]	-
Feed-through mounting	No reduction [7]	-
Switching frequency 10 kHz		
Cold plate mounting [10]	0.6 A/K (from 57°C)	-
Feed-through mounting	No reduction	-
Switching frequency 20 kHz		
Cold plate mounting [10]	0.12 A/K (from 34°C) [11]	-
Feed-through mounting	0.09 A/K (from 6°C) [8]	-
Reduction of continuous current depending on the installation elevation		
Starting at 500 m above sea level	0.38 A_{eff} per 1000 m	
Peak current per motor connection	9.5 A_{eff}	
Nominal switching frequency	5 kHz	
Possible switching frequencies [12]	5/10/20 kHz	
Electrical stress of the connected motor in accordance with IEC TS 60034-25 [13]	Limit value curve A	
Protective measures		
Overload protection	Yes	
Short circuit and ground fault protection	Yes	
Max. output frequency	598 Hz [14]	
Design		
U, V, W, PE	Male connector	
Shield connection	Yes	
Terminal connection cross section		
Flexible and fine wire lines		
With wire end sleeves	0.25 to 4 mm²	
Approbation data		
UL/C-UL-US	30 to 10	
CSA	28 to 10	

Table 43: 8BVI0028HCDS.000-1, 8BVI0028HWDS.000-1 - Technical data

Product ID	**8BVI0028HCDS.000-1**	**8BVI0028HWDS.000-1**
Terminal cable cross section dimension of shield connection	12 to 22 mm	
Max. motor line length depending on the switching frequency		
Switching frequency 5 kHz	25 m	
Switching frequency 10 kHz	25 m	
Switching frequency 20 kHz	10 m	
Motor holding brake connection		
Quantity	2	
Output voltage [15]	24 VDC +5.8% / -0% [16]	
Continuous current	1.1 A	
Max. internal resistance	0.5 Ω	
Extinction potential	Approx. 30 V	
Max. extinction energy per switching operation	1.5 Ws	
Max. switching frequency	0.5 Hz	
Protective measures		
Overload and short circuit protection	Yes	
Open line monitoring	Yes	
Undervoltage monitoring	Yes	
Response threshold for open line monitoring	Approx. 0.25 A	
Response threshold for undervoltage monitoring	24 VDC -2% / -4%	
Encoder interfaces [17]		
Quantity	2	
Type	EnDat 2.2 [18]	
Connections	9-pin female DSUB connector	
Status indicators	UP/DN LEDs	
Electrical isolation		
Encoder - ACOPOSmulti	No	
Encoder monitoring	Yes	
Max. encoder cable length	100 m Depends on the cross section of the encoder's supply wires [19]	
Encoder supply		
Output voltage	Typ. 12.5 V	
Load capability	350 mA	
Protective measures		
Short circuit protection	Yes	
Overload protection	Yes	
Synchronous serial interface		
Signal transmission	RS485	
Data transfer rate	6.25 Mbit/s	
Max. power consumption per encoder interface	P_{SMC}[W] = 19 V * $I_{Encoder}$[A] [20]	
Trigger inputs		
Quantity	2	
Wiring	Sink	
Electrical isolation		
Input - Inverter module	Yes	
Input - Input	Yes	
Input voltage		
Nominal	24 VDC	
Maximum	30 VDC	
Switching threshold		
Low	<5 V	
High	>15 V	
Input current at nominal voltage	Approx. 10 mA	
Switching delay		
Rising edge	52 µs ±0.5 µs (digitally filtered)	
Falling edge	53 µs ±0.5 µs (digitally filtered)	
Modulation compared to ground potential	Max. ±38 V	
Electrical characteristics		
Discharge capacitance	0.14 µF	0.2 µF
Operating conditions		
Permitted mounting orientations		
Hanging vertically	Yes	
Lying horizontally	Yes	
Standing horizontally	No	
Installation at elevations above sea level		
Nominal	0 to 500 m	
Maximum [21]	4000 m	
Degree of pollution in accordance with EN 60664-1	2 (non-conductive pollution)	
Overvoltage category in accordance with IEC 60364-4-443:1999	III	
EN 60529 protection	IP20	

Table 43: 8BVI0028HCDS.000-1, 8BVI0028HWDS.000-1 - Technical data

Product ID	8BVI0028HCDS.000-1	8BVI0028HWDS.000-1
Environmental conditions		
Temperature		
Operation		
Nominal	5 to 40°C	
Maximum [22]	55°C	
Storage	-25 to 55°C	
Transport	-25 to 70°C	
Relative humidity		
Operation	5 to 85%	
Storage	5 to 95%	
Transport	Max. 95% at 40°C	
Mechanical characteristics		
Dimensions [23]		
Width	53 mm	
Height	317 mm	
Depth		
Wall mounting	-	263 mm
Cold plate	212 mm	-
Feed-through mounting	209 mm	-
Weight	Approx. 2.3 kg	Approx. 2.8 kg
Module width	1	

Table 43: 8BVI0028HCDS.000-1, 8BVI0028HWDS.000-1 - Technical data

1) SLOT 1 and SLOT 2 of the ACOPOSmulti module are occupied by the encoder interfaces.
2) Valid in the following conditions: 750 VDC DC bus voltage, 5 kHz switching frequency, 40°C ambient temperature, installation elevation <500 m above sea level, no derating due to cooling type.
3) I_M... Average value of the currents on both motor connectors [A].
4) P_{SMC1} ... Max. power consumption P_{SMC} [W] of the SafeMOTION module in SLOT1 (see the "Encoder interfaces" section).
P_{SMC2} ... Max. power consumption P_{SMC} [W] of the SafeMOTION module in SLOT2 (see the "Encoder interfaces" section).
$P_{24\ V\ Out}$... Power [W] that is output to the connections X2/+24 V Out 1 and X2/+24 V Out 2 on the module (max. 10 W).
$P_{Fan8B0M...}$... Portion of the power [W] that is used by the fan modules in the mounting plate or the 8B0M0040HFF0.000-1 fan module (see the technical data for the respective 8B0M... mounting plate / 8B0M0040HFF0.000-1 fan module).
5) Only 8BCM motor cables from B&R are permitted to be connected to the motor connectors.
6) Valid in the following conditions: 750 VDC DC bus voltage. The temperature specifications refer to the ambient temperature.
7) Value for the nominal switching frequency.
8) The module cannot supply the full continuous current at this switching frequency. This unusual value for the ambient temperature, at which derating of the continuous current must be taken into account, ensures that the derating of the continuous current can be determined in the same manner as at other switching frequencies.
9) Valid in the following conditions: 750 VDC DC bus voltage, minimum permissible coolant flow volume (3 l/min).
10) The temperature specifications refer to the return temperature of the cold plate mounting plate.
11) The module cannot supply the full continuous current at this switching frequency. This unusual value for the return temperature, at which derating of the continuous current must be taken into account, ensures that the derating of the continuous current can be determined in the same manner as at other switching frequencies.
Caution! Condensation can occur at low flow temperatures and return temperatures.
12) B&R recommends operating the module at its nominal switching frequency. Operating the module at a higher switching frequency for application-specific reasons reduces the continuous current and increases the CPU load. When using dual-axis modules, the increased CPU load reduces the functionality of the drive; if this is not taken into consideration, the computing time can be exceeded in extreme cases.
13) If necessary, the stress of the motor isolation system can be reduced by an additional externally wired dU/dt choke. For example, the RWK 305 three-phase du/dt choke from Schaffner (www.schaffner.com) can be used. Important: Even when using a dU/dt choke, it is necessary to ensure that an EMC-compatible, low inductance shield connection is used!
14) The module's electrical output frequency (SCTRL_SPEED_ACT * MOTOR_POLEPAIRS) is monitored to protect against dual use in accordance with EC regulation 428/2009 | 3A225. If the electrical output frequency of the module exceeds the limit value of 598 Hz uninterrupted for more than 0.5 s, then the current movement is aborted and error 6060 is output (Power element: Limit speed exceeded).
15) During project development, it is necessary to check if the minimum voltage can be maintained on the holding brake with the specified wiring. The operating voltage range of the holding brake can be found in the user's manual for the respective motor.
16) The specified value is only valid under the following conditions:
- The 24 VDC supply for the module is provided by an 8B0C auxiliary supply module installed on the same mounting plate.
If the 24 VDC supply for the module is applied to the mounting plate using an 8BVE expansion module, then the output voltage is reduced because of voltage drops on the expansion cable. In this case, undervoltage monitoring must be disabled.
17) Only 8BCF EnDat 2.2 cables from B&R are permitted to be connected to the encoder interfaces.
18) An EnDat 2.2 functional safety encoder is required when using ACOPOSmulti SafeMOTION inverter modules! With standard EnDat 2.2 encoders, only the STO, SBC and SS1 functions are monitored with respect to timing!
19) The maximum encoder cable length l_{max} can be calculated as follows (the maximum permissible encoder cable length of 100 m must not be exceeded):

$l_{max} = 7.9 / I_G * A * 1/(2*\rho)$

I_G ... Max. current consumption of the encoder [A].
A ... Cross section of the supply wire [mm²].
ρ ... Specific resistance [Ω mm²/m] (e.g. for copper: ρ = 0.0178).
20) $I_{Encoder}$ ... Max. power consumption of the connected encoder [A].
21) Continuous operation at elevations ranging from 500 m to 4000 m above sea level is possible (taking the specified continuous current reductions into consideration).
22) Continuous operation at ambient temperatures ranging from 40°C to max. 55°C is possible (taking the specified continuous current reductions into consideration), but this will result in a shorter service life.
23) These dimensions refer to the actual device dimensions including the respective mounting plate. Make sure to leave additional space above and below the devices for mounting, connections and air circulation.

3.4.2.4 Wiring

For details, see 3.4.4 "Wiring: Safe single-width inverter modules (dual-axis modules)" on page 92.

For general information, see 6 "Wiring" on page 142.

3.4.3 8BVI0055HCDS.000-1, 8BVI0055HWDS.000-1

3.4.3.1 General information

- Clearly structured, straightforward implementation via network-based safety technology
- Modular expandability through virtual wiring
- Immediate triggering of safety function due to short cycle times
- Easy implementation with transparent control and status information, even in the standard application
- Compact design
- Complete safety functionality, even in dual-axis modules

3.4.3.2 Order data

Model number	Short description	Figure
	Cold plate or feed-through mounting	
8BVI0055HCDS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 7.6 A, HV, cold plate or feed-through mounting, 2 axes	
	Wall mounting	
8BVI0055HWDS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 7.6 A, HV, wall mounting, 2 axes	
	Required accessories	
	Terminal block sets	
8BZVI0055DS.000-1A	Screw clamp set for ACOPOSmulti 8BVI00xxHxDS modules: 1x 8TB2108.2010-00, 1x 8TB2104.203L-00, 1x 8TB2104.203F-00, 1x 8TB3104.204G-11, 1x 8TB3104.204K-11	
	Optional accessories	
	Accessory sets	
8BXB000.0000-00	ACPmulti accessory set for encoder buffering consisting of: 1 lithium battery AA 3.6 V; 1 protective cap for battery holder	
	Fan modules	
8BXF001.0000-00	ACOPOSmulti fan module, replacement fan for ACOPOSmulti modules (8BVP / 8B0C / 8BVI / 8BVE / 8B0K)	
	POWERLINK cables	
X20CA0E61.00020	POWERLINK connection cable, RJ45 to RJ45, 0.2 m	
X20CA0E61.00025	POWERLINK connection cable, RJ45 to RJ45, 0.25 m	
X20CA0E61.00030	POWERLINK connection cable, RJ45 to RJ45, 0.3 m	
X20CA0E61.00035	POWERLINK connection cable, RJ45 to RJ45, 0.35 m	
X20CA0E61.00050	POWERLINK connection cable, RJ45 to RJ45, 0.5 m	
X20CA0E61.00100	POWERLINK connection cable, RJ45 to RJ45, 1 m	
	Shield component sets	
8SCS000.0000-00	ACOPOSmulti shielding components set: 1x shielding plate 1fold type 0; 1x hose clamp, W 9 mm, D 12-22 mm	
8SCS002.0000-00	ACOPOSmulti shield component set: 1x clamping plate; 2x clamps D 4-13.5 mm; 4x screws	
8SCS009.0000-00	ACOPOSmulti shield component set: 1x ACOPOSmulti holding plate SK8-14; 1x shield terminal SK14	
	Terminal blocks	
8TB2104.203F-00	Screw clamp 4-pin, single row, spacing: 5.08 mm, label 3: T- T + B- B+, F keying: 0101	
8TB2104.203L-00	Screw clamp 4-pin, single row, spacing: 5.08 mm, label 3: T- T + B- B+, L keying: 1010	
8TB2108.2010-00	Screw clamp 8-pin, single row, spacing: 5.08 mm, label 1: numbered serially	
8TB3104.204G-11	Screw clamp 4-pin, single row, spacing: 7.62 mm, label 4: PE W V U, G coding: 0110	
8TB3104.204K-11	Screw clamp 4-pin, single row, spacing: 7.62 mm, label 4: PE W V U, K keying: 1001	

Table 44: 8BVI0055HCDS.000-1, 8BVI0055HWDS.000-1 - Order data

> **Information:**
>
> **Only 8BCM motor cables from B&R are permitted to be connected to the motor connectors.**

ACOPOSmulti SafeMOTION EnDat 2.2

> **Information:**
>
> **Only 8BCF EnDat 2.2 cables from B&R or 8BCH hybrid motor cables from B&R are permitted to be connected to the encoder interfaces.**

For details, see 1.2 "Safe power transmission system " on page 167.

3.4.3.3 Technical data

Product ID	8BVI0055HCDS.000-1	8BVI0055HWDS.000-1
General information		
B&R ID code	0xAA13	0xAA15
Cooling and mounting method	Cold plate or feed-through mounting	Wall mounting
Slots for plug-in modules	2 [1]	
Certification		
CE	Yes	
cULus	Yes	
KC	Yes	
FSC	Yes	
DC bus connection		
Voltage		
Nominal	750 VDC	
Continuous power consumption [2]	11.19 kW	
Power loss depending on the switching frequency [3]		
Switching frequency 5 kHz	$[1.2 * I_M^2 + 2.62 * I_M + 100]$ W	
Switching frequency 10 kHz	$[2.56 * I_M^2 + 2.8 * I_M + 200]$ W	
Switching frequency 20 kHz	$[6 * I_M^2 - 9.4 * I_M + 430]$ W	
DC bus capacitance	330 µF	
Design	ACOPOSmulti backplane	
24 VDC supply		
Input voltage	25 VDC ±1.6%	
Input capacitance	23.5 µF	
Max. power consumption	28 W + P_{SMC1} + P_{SMC2} + $P_{24\ V\ Out}$ + $P_{HoldingBrake(s)}$ + $P_{Fan8B0M...}$ [4]	
Design	ACOPOSmulti backplane	
24 VDC output		
Quantity	2	
Output voltage		
DC bus voltage (U_{DC}): 260 to 315 VDC	25 VDC * (U_{DC}/315)	
DC bus voltage (U_{DC}): 315 to 800 VDC	24 VDC ±6%	
Protection	250 mA (slow-blow) electronic, automatic reset	
Motor connection [5]		
Quantity	2	
Continuous power per motor connection [2]	5.5 kW	
Continuous current per motor connection [2]	7.6 A_{eff}	
Reduction of continuous current depending on the switching frequency [6]		
Switching frequency 5 kHz	-	No reduction [7]
Switching frequency 10 kHz	-	0.22 A/K (from 43°C)
Switching frequency 20 kHz	-	0.15 A/K (from -14°C) [8]
Reduction of continuous current depending on the switching frequency and mounting method [9]		
Switching frequency 5 kHz		
Cold plate mounting [10]	0.72 A/K (from 56°C) [7]	-
Feed-through mounting	No reduction [7]	-
Switching frequency 10 kHz		
Cold plate mounting [10]	0.28 A/K (from 43°C)	-
Feed-through mounting	0.17 A/K (from 23°C) [8]	-
Switching frequency 20 kHz		
Cold plate mounting [10]	0.13 A/K (from 3°C) [11]	-
Feed-through mounting	0.12 A/K (from -21°C) [8]	-
Reduction of continuous current depending on the installation elevation		
Starting at 500 m above sea level	0.76 A_{eff} per 1000 m	
Peak current per motor connection	18.9 A_{eff}	
Nominal switching frequency	5 kHz	
Possible switching frequencies [12]	5/10/20 kHz	
Electrical stress of the connected motor in accordance with IEC TS 60034-25 [13]	Limit value curve A	
Protective measures		
Overload protection	Yes	
Short circuit and ground fault protection	Yes	
Max. output frequency	598 Hz [14]	
Design		
U, V, W, PE	Male connector	
Shield connection	Yes	
Terminal connection cross section		
Flexible and fine wire lines		
With wire end sleeves	0.25 to 4 mm²	
Approbation data		
UL/C-UL-US	30 to 10	
CSA	28 to 10	

Table 45: 8BVI0055HCDS.000-1, 8BVI0055HWDS.000-1 - Technical data

Product ID	8BVI0055HCDS.000-1	8BVI0055HWDS.000-1
Terminal cable cross section dimension of shield connection	12 to 22 mm	
Max. motor line length depending on the switching frequency		
Switching frequency 5 kHz	25 m	
Switching frequency 10 kHz	25 m	
Switching frequency 20 kHz	10 m	
Motor holding brake connection		
Quantity	2	
Output voltage [15]	24 VDC +5.8% / -0% [16]	
Continuous current	1.1 A	
Max. internal resistance	0.5 Ω	
Extinction potential	Approx. 30 V	
Max. extinction energy per switching operation	1.5 Ws	
Max. switching frequency	0.5 Hz	
Protective measures		
Overload and short circuit protection	Yes	
Open line monitoring	Yes	
Undervoltage monitoring	Yes	
Response threshold for open line monitoring	Approx. 0.25 A	
Response threshold for undervoltage monitoring	24 VDC -2% / -4%	
Encoder interfaces [17]		
Quantity	2	
Type	EnDat 2.2 [18]	
Connections	9-pin female DSUB connector	
Status indicators	UP/DN LEDs	
Electrical isolation		
Encoder - ACOPOSmulti	No	
Encoder monitoring	Yes	
Max. encoder cable length	100 m Depends on the cross section of the encoder's supply wires [19]	
Encoder supply		
Output voltage	Typ. 12.5 V	
Load capability	350 mA	
Protective measures		
Short circuit protection	Yes	
Overload protection	Yes	
Synchronous serial interface		
Signal transmission	RS485	
Data transfer rate	6.25 Mbit/s	
Max. power consumption per encoder interface	P_{SMC}[W] = 19 V * $I_{Encoder}$[A] [20]	
Trigger inputs		
Quantity	2	
Wiring	Sink	
Electrical isolation		
Input - Inverter module	Yes	
Input - Input	Yes	
Input voltage		
Nominal	24 VDC	
Maximum	30 VDC	
Switching threshold		
Low	<5 V	
High	>15 V	
Input current at nominal voltage	Approx. 10 mA	
Switching delay		
Rising edge	52 µs ±0.5 µs (digitally filtered)	
Falling edge	53 µs ±0.5 µs (digitally filtered)	
Modulation compared to ground potential	Max. ±38 V	
Electrical characteristics		
Discharge capacitance	0.2 µF	
Operating conditions		
Permitted mounting orientations		
Hanging vertically	Yes	
Lying horizontally	Yes	
Standing horizontally	No	
Installation at elevations above sea level		
Nominal	0 to 500 m	
Maximum [21]	4000 m	
Degree of pollution in accordance with EN 60664-1	2 (non-conductive pollution)	
Overvoltage category in accordance with IEC 60364-4-443:1999	III	
EN 60529 protection	IP20	

Table 45: 8BVI0055HCDS.000-1, 8BVI0055HWDS.000-1 - Technical data

Product ID	8BVI0055HCDS.000-1	8BVI0055HWDS.000-1
Environmental conditions		
Temperature		
Operation		
Nominal	5 to 40°C	
Maximum [22]	55°C	
Storage	-25 to 55°C	
Transport	-25 to 70°C	
Relative humidity		
Operation	5 to 85%	
Storage	5 to 95%	
Transport	Max. 95% at 40°C	
Mechanical characteristics		
Dimensions [23]		
Width	53 mm	
Height	317 mm	
Depth		
Wall mounting	-	263 mm
Cold plate	212 mm	-
Feed-through mounting	209 mm	-
Weight	Approx. 2.3 kg	Approx. 2.9 kg
Module width	1	

Table 45: 8BVI0055HCDS.000-1, 8BVI0055HWDS.000-1 - Technical data

1) SLOT 1 and SLOT 2 of the ACOPOSmulti module are occupied by the encoder interfaces.
2) Valid in the following conditions: 750 VDC DC bus voltage, 5 kHz switching frequency, 40°C ambient temperature, installation elevation <500 m above sea level, no derating due to cooling type.
3) I_M... Average value of the currents on both motor connectors [A].
4) P_{SMC1} ... Max. power consumption P_{SMC} [W] of the SafeMOTION module in SLOT1 (see the "Encoder interfaces" section).
P_{SMC2} ... Max. power consumption P_{SMC} [W] of the SafeMOTION module in SLOT2 (see the "Encoder interfaces" section).
$P_{24\ V\ Out}$... Power [W] that is output to the connections X2/+24 V Out 1 and X2/+24 V Out 2 on the module (max. 10 W).
$P_{Fan8B0M...}$... Portion of the power [W] that is used by the fan modules in the mounting plate or the 8B0M0040HFF0.000-1 fan module (see the technical data for the respective 8B0M... mounting plate / 8B0M0040HFF0.000-1 fan module).
5) Only 8BCM motor cables from B&R are permitted to be connected to the motor connectors.
6) Valid in the following conditions: 750 VDC DC bus voltage. The temperature specifications refer to the ambient temperature.
7) Value for the nominal switching frequency.
8) The module cannot supply the full continuous current at this switching frequency. This unusual value for the ambient temperature, at which derating of the continuous current must be taken into account, ensures that the derating of the continuous current can be determined in the same manner as at other switching frequencies.
9) Valid in the following conditions: 750 VDC DC bus voltage, minimum permissible coolant flow volume (3 l/min).
10) The temperature specifications refer to the return temperature of the cold plate mounting plate.
11) The module cannot supply the full continuous current at this switching frequency. This unusual value for the return temperature, at which derating of the continuous current must be taken into account, ensures that the derating of the continuous current can be determined in the same manner as at other switching frequencies.
Caution! Condensation can occur at low flow temperatures and return temperatures.
12) B&R recommends operating the module at its nominal switching frequency. Operating the module at a higher switching frequency for application-specific reasons reduces the continuous current and increases the CPU load. When using dual-axis modules, the increased CPU load reduces the functionality of the drive; if this is not taken into consideration, the computing time can be exceeded in extreme cases.
13) If necessary, the stress of the motor isolation system can be reduced by an additional externally wired dU/dt choke. For example, the RWK 305 three-phase du/dt choke from Schaffner (www.schaffner.com) can be used. Important: Even when using a dU/dt choke, it is necessary to ensure that an EMC-compatible, low inductance shield connection is used!
14) The module's electrical output frequency (SCTRL_SPEED_ACT * MOTOR_POLEPAIRS) is monitored to protect against dual use in accordance with EC regulation 428/2009 | 3A225. If the electrical output frequency of the module exceeds the limit value of 598 Hz uninterrupted for more than 0.5 s, then the current movement is aborted and error 6060 is output (Power element: Limit speed exceeded).
15) During project development, it is necessary to check if the minimum voltage can be maintained on the holding brake with the specified wiring. The operating voltage range of the holding brake can be found in the user's manual for the respective motor.
16) The specified value is only valid under the following conditions:
- The 24 VDC supply for the module is provided by an 8B0C auxiliary supply module installed on the same mounting plate.
If the 24 VDC supply for the module is applied to the mounting plate using an 8BVE expansion module, then the output voltage is reduced because of voltage drops on the expansion cable. In this case, undervoltage monitoring must be disabled.
17) Only 8BCF EnDat 2.2 cables from B&R are permitted to be connected to the encoder interfaces.
18) An EnDat 2.2 functional safety encoder is required when using ACOPOSmulti SafeMOTION inverter modules! With standard EnDat 2.2 encoders, only the STO, SBC and SS1 functions are monitored with respect to timing!
19) The maximum encoder cable length l_{max} can be calculated as follows (the maximum permissible encoder cable length of 100 m must not be exceeded):

$l_{max} = 7.9 / I_G * A * 1/(2*\rho)$

I_G ... Max. current consumption of the encoder [A].
A ... Cross section of the supply wire [mm²].
ρ ... Specific resistance [Ω mm²/m] (e.g. for copper: ρ = 0.0178).
20) $I_{Encoder}$ ... Max. power consumption of the connected encoder [A].
21) Continuous operation at elevations ranging from 500 m to 4000 m above sea level is possible (taking the specified continuous current reductions into consideration).
22) Continuous operation at ambient temperatures ranging from 40°C to max. 55°C is possible (taking the specified continuous current reductions into consideration), but this will result in a shorter service life.
23) These dimensions refer to the actual device dimensions including the respective mounting plate. Make sure to leave additional space above and below the devices for mounting, connections and air circulation.

3.4.3.4 Wiring

For details, see 3.4.4 "Wiring: Safe single-width inverter modules (dual-axis modules)" on page 92.

For general information, see 6 "Wiring" on page 142.

3.4.4 Wiring: Safe single-width inverter modules (dual-axis modules)

3.4.4.1 Pinout overview

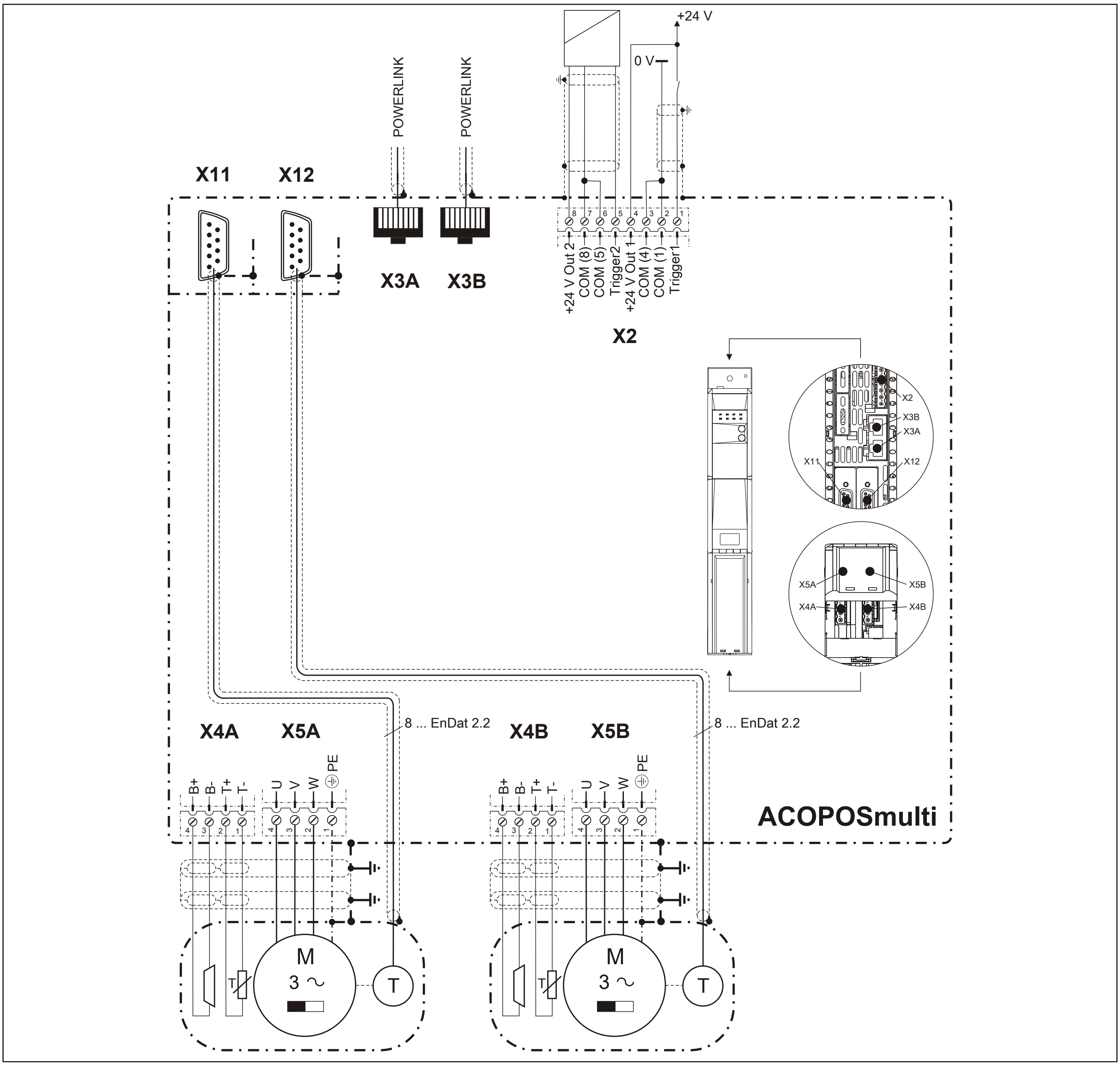


Figure 10: Pinout overview

3.4.4.2 X2 connector - Pinout

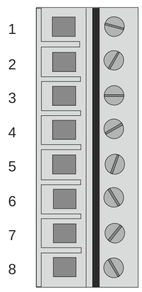
X2	Pin	Name	Function
	1	Trigger 1	Trigger 1
	2	COM (1)	Trigger 1 0 V
	3	COM (2)	+24 V output 1 0 V
	4	+24 V Out 1	+24 V output 1
	5	Trigger 2	Trigger 2
	6	COM (5)	Trigger 2 0 V
	7	COM (8)	+24 V output 2 0 V
	8	+24 V Out 2	+24 V output 2

Table 46: X2 connector - Pinout

3.4.4.3 X3A, X3B connectors - Pinout

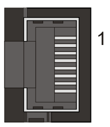
X3A, X3B	Pin	Name	Function
	1	RXD	Receive signal
	2	RXD\	Receive signal inverted
	3	TXD	Transmit signal
	4	Shield	Shield
	5	Shield	Shield
	6	TXD\	Transmit signal inverted
	7	Shield	Shield
	8	Shield	Shield

Table 47: X3A, X3B connectors - Pinout

3.4.4.4 X4A connector - Pinout

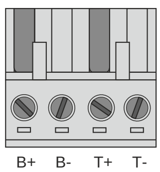
X4A	Name	Function
	T-	Axis 1: Temperature sensor -
	T+	Axis 1: Temperature sensor +
	B- 1)	Axis 1: Brake -
	B+ 1)	Axis 1: Brake +

Table 48: X4A connector - Pinout

1) Wiring is not permitted to exceed a total length of 3 m.

Danger!

The FUNCTIONAL FAIL SAFE state is activated if the SBC output B+ is shorted to 24 V (i.e. safe pulse disabling is activated). The brake always remains on/released, however, due to the short circuit to 24 V! This can lead to dangerous situations because the motor holding brake cannot brake or prevent the spin-out movement (or the unrestrained lowering in the case of hanging loads)!
Appropriate wiring measures must be implemented to ensure that the SBC output B+ is not shorted to 24 V!

For a dual-axis module, it is therefore especially important to prevent a cross fault between the two B+ connections of the two axes!

Danger!

The SBC output

- **is not permitted to be wired to multiple modules!**
- **is not permitted to be wired as an open emitter!**
- **is not permitted to be wired as an open collector!**

Danger!

Only an output voltage of ≤5 V can be ensured for the safe motor holding brake output when shut off. When selecting a motor holding brake, the user must ensure that the required braking torque is reached at a voltage of 5 V.

Information:

The transistors of the SBC output stage are tested cyclically. When the output channels are active, this test emits low pulses on the output with a maximum length of 600 µs.

This must be taken into consideration when choosing the motor holding brake!

Danger!

The connections for the motor temperature sensors and the motor holding brake are safely isolated circuits. These connections are therefore only permitted to be connected to devices or components that have sufficient isolation in accordance with IEC 60364-4-41 or EN 61800-5-1.

Caution!

If B+ and B- are swapped when connecting the permanent magnet holding brakes, then the brakes cannot be opened! ACOPOSmulti inverter modules cannot determine if a holding brake is connected with reverse polarity!

Warning!

Temperature sensors are only permitted to be connected to the X4A/T+ and X4A/T- connectors on an ACOPOSmulti module under the following conditions:

- **There is no ACOPOSmulti plug-in module in SLOT1 on the ACOPOSmulti module with a temperature sensor connected to T+ and T-**

Otherwise, the temperature monitoring functions on the ACOPOSmulti module may become ineffective, which in extreme cases can cause the hardware (e.g. motors) connected to the ACOPOSmulti module to be destroyed!

3.4.4.5 X4B connector - Pinout

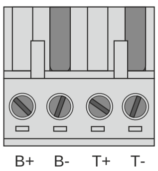
X4B	Name	Function
	T-	Axis 2: Temperature sensor -
	T+	Axis 2: Temperature sensor +
	B- [1)]	Axis 2: Brake -
	B+ [1)]	Axis 2: Brake +

Table 49: X4B connector - Pinout

1) Wiring is not permitted to exceed a total length of 3 m.

Danger!

The FUNCTIONAL FAIL SAFE state is activated if the SBC output B+ is shorted to 24 V (i.e. safe pulse disabling is activated). The brake always remains on/released, however, due to the short circuit to 24 V! This can lead to dangerous situations because the motor holding brake cannot brake or prevent the spin-out movement (or the unrestrained lowering in the case of hanging loads)!
Appropriate wiring measures must be implemented to ensure that the SBC output B+ is not shorted to 24 V!

For a dual-axis module, it is therefore especially important to prevent a cross fault between the two B+ connections of the two axes!

Danger!

The SBC output

- **is not permitted to be wired to multiple modules!**
- **is not permitted to be wired as an open emitter!**
- **is not permitted to be wired as an open collector!**

Danger!

Only an output voltage of ≤5 V can be ensured for the safe motor holding brake output when shut off. When selecting a motor holding brake, the user must ensure that the required braking torque is reached at a voltage of 5 V.

Information:

The transistors of the SBC output stage are tested cyclically. When the output channels are active, this test emits low pulses on the output with a maximum length of 600 µs.

This must be taken into consideration when choosing the motor holding brake!

Danger!

The connections for the motor temperature sensors and the motor holding brake are safely isolated circuits. These connections are therefore only permitted to be connected to devices or components that have sufficient isolation in accordance with IEC 60364-4-41 or EN 61800-5-1.

Caution!

If B+ and B- are swapped when connecting the permanent magnet holding brakes, then the brakes cannot be opened! ACOPOSmulti inverter modules cannot determine if a holding brake is connected with reverse polarity!

Warning!

Temperature sensors are only permitted to be connected to the X4B/T+ and X4B/T- connectors on an ACOPOSmulti module under the following conditions:

- **There is no ACOPOSmulti plug-in module in SLOT2 on the ACOPOSmulti module with a temperature sensor connected to T+ and T-**

Otherwise, the temperature monitoring functions on the ACOPOSmulti module may become ineffective, which in extreme cases can cause the hardware (e.g. motors) connected to the ACOPOSmulti module to be destroyed!

3.4.4.6 X5A connector - Pinout

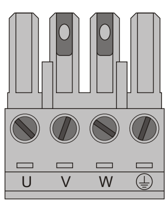
X5A	Name	Function
	⏚	Axis 1: Protective ground conductor
	W	Axis 1: Motor connection W
	V	Axis 1: Motor connection V
	U	Axis 1: Motor connection U

Table 50: X5A connector - Pinout

Information:

Only 8BCM motor cables from B&R are permitted to be connected to the motor connectors.

3.4.4.7 X5B connector - Pinout

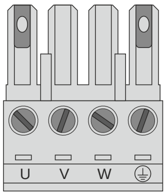
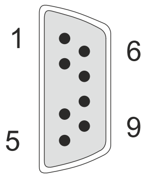
X5B	Name	Function
	⏚	Axis 2: Protective ground conductor
	W	Axis 2: Motor connection W
	V	Axis 2: Motor connection V
	U	Axis 2: Motor connection U

Table 51: X5B connector - Pinout

Information:

Only 8BCM motor cables from B&R are permitted to be connected to the motor connectors.

3.4.4.8 SafeMOTION EnDat 2.2 module - Pinout

Figure	X11 (X12)	Pin	Name	Function
		1	U+	Encoder supply +12.5 V
		2	---	---
		3	---	---
		4	D	Data input
		5	T	Clock output
		6	COM (1)	Encoder supply 0 V
		7	---	---
		8	D\	Data input inverted
		9	T\	Clock output inverted

Information:

Only 8BCF EnDat 2.2 cables from B&R or 8BCH hybrid motor cables from B&R are permitted to be connected to the encoder interfaces.

Information:

SafeMOTION modules cannot be replaced! SafeMOTION modules and the corresponding inverter module form a single unit. In the event of an error, the entire inverter module must be replaced.

3.5 Safe double-width inverter modules (dual-axis modules)

3.5.1 8BVI0110HCDS.000-1, 8BVI0110HWDS.000-1

3.5.1.1 General information

- Clearly structured, straightforward implementation via network-based safety technology
- Modular expandability through virtual wiring
- Immediate triggering of safety function due to short cycle times
- Easy implementation with transparent control and status information, even in the standard application
- Compact design
- Complete safety functionality, even in dual-axis modules

3.5.1.2 Order data

Model number	Short description	Figure
	Cold plate or feed-through mounting	
8BVI0110HCDS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 15.1 A, HV, cold plate or feed-through mounting, 2 axes	
	Wall mounting	
8BVI0110HWDS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 15.1 A, HV, wall mounting, 2 axes	
	Required accessories	
	Terminal block sets	
8BZVI0110DS.000-1A	Screw clamp set for ACOPOSmulti 8BVI0110HxDS modules: 1x 8TB2108.2010-00, 1x 8TB2104.203L-00, 1x 8TB2104.203F-00, 1x 8TB3104.204G-11, 1x 8TB3104.204K-11	
	Optional accessories	
	Accessory sets	
8BXB000.0000-00	ACPmulti accessory set for encoder buffering consisting of: 1 lithium battery AA 3.6 V; 1 protective cap for battery holder	
	Fan modules	
8BXF001.0000-00	ACOPOSmulti fan module, replacement fan for ACOPOSmulti modules (8BVP / 8B0C / 8BVI / 8BVE / 8B0K)	
	POWERLINK cables	
X20CA0E61.00020	POWERLINK connection cable, RJ45 to RJ45, 0.2 m	
X20CA0E61.00025	POWERLINK connection cable, RJ45 to RJ45, 0.25 m	
X20CA0E61.00030	POWERLINK connection cable, RJ45 to RJ45, 0.3 m	
X20CA0E61.00035	POWERLINK connection cable, RJ45 to RJ45, 0.35 m	
X20CA0E61.00050	POWERLINK connection cable, RJ45 to RJ45, 0.5 m	
X20CA0E61.00100	POWERLINK connection cable, RJ45 to RJ45, 1 m	
	Shield component sets	
8SCS000.0000-00	ACOPOSmulti shielding components set: 1x shielding plate 1fold type 0; 1x hose clamp, W 9 mm, D 12-22 mm	
8SCS002.0000-00	ACOPOSmulti shield component set: 1x clamping plate; 2x clamps D 4-13.5 mm; 4x screws	
8SCS009.0000-00	ACOPOSmulti shield component set: 1x ACOPOSmulti holding plate SK8-14; 1x shield terminal SK14	
	Terminal blocks	
8TB2104.203F-00	Screw clamp 4-pin, single row, spacing: 5.08 mm, label 3: T- T + B- B+, F keying: 0101	
8TB2104.203L-00	Screw clamp 4-pin, single row, spacing: 5.08 mm, label 3: T- T + B- B+, L keying: 1010	
8TB2108.2010-00	Screw clamp 8-pin, single row, spacing: 5.08 mm, label 1: numbered serially	
8TB3104.204G-11	Screw clamp 4-pin, single row, spacing: 7.62 mm, label 4: PE W V U, G coding: 0110	
8TB3104.204K-11	Screw clamp 4-pin, single row, spacing: 7.62 mm, label 4: PE W V U, K keying: 1001	

Table 52: 8BVI0110HCDS.000-1, 8BVI0110HWDS.000-1 - Order data

> **Information:**
>
> **Only 8BCM motor cables from B&R are permitted to be connected to the motor connectors.**

ACOPOSmulti SafeMOTION EnDat 2.2

> **Information:**
>
> **Only 8BCF EnDat 2.2 cables from B&R or 8BCH hybrid motor cables from B&R are permitted to be connected to the encoder interfaces.**

For details, see 1.2 "Safe power transmission system " on page 167.

3.5.1.3 Technical data

Product ID	8BVI0110HCDS.000-1	8BVI0110HWDS.000-1
General information		
B&R ID code	0xAA17	0xAA19
Cooling and mounting method	Cold plate or feed-through mounting	Wall mounting
Slots for plug-in modules	2 [1]	
Certification		
CE	Yes	
cULus	Yes	
KC	Yes	
FSC	Yes	
DC bus connection		
Voltage		
Nominal	750 VDC	
Continuous power consumption [2]	22.3 kW	
Power loss depending on the switching frequency [3]		
Switching frequency 5 kHz	[0.33 * I_M^2 + 11 * I_M + 90] W	
Switching frequency 10 kHz	[0.97 * I_M^2 + 9.5 * I_M + 170] W	
Switching frequency 20 kHz	[1.66 * I_M^2 + 21 * I_M + 380] W	
DC bus capacitance	660 µF	
Design	ACOPOSmulti backplane	
24 VDC supply		
Input voltage	25 VDC ±1.6%	
Input capacitance	23.5 µF	
Max. power consumption	32 W + P_{SMC1} + P_{SMC2} + $P_{24\ V\ Out}$ + $P_{HoldingBrake(s)}$ + 2 * $P_{Fan8B0M...}$ [4]	
Design	ACOPOSmulti backplane	
24 VDC output		
Quantity	2	
Output voltage		
DC bus voltage (U_{DC}): 260 to 315 VDC	25 VDC * (U_{DC}/315)	
DC bus voltage (U_{DC}): 315 to 800 VDC	24 VDC ±6%	
Protection	250 mA (slow-blow) electronic, automatic reset	
Motor connection [5]		
Quantity	2	
Continuous power per motor connection [2]	11 kW	
Continuous current per motor connection [2]	15.1 A_{eff}	
Reduction of continuous current depending on the switching frequency [6]		
Switching frequency 5 kHz	-	No reduction [7]
Switching frequency 10 kHz	-	0.19 A/K (from 29°C) [8]
Switching frequency 20 kHz	-	0.15 A/K (from -38°C) [8]
Reduction of continuous current depending on the switching frequency and mounting method [6]		
Switching frequency 5 kHz		
Cold plate mounting [9]	0.38 A/K (from 51°C) [7]	-
Feed-through mounting	0.27 A/K (from 46°C) [7]	-
Switching frequency 10 kHz		
Cold plate mounting [9]	0.25 A/K (from 24°C) [10]	-
Feed-through mounting	0.16 A/K (from 2°C) [8]	-
Switching frequency 20 kHz		
Cold plate mounting [9]	0.19 A/K (from -14°C) [10]	-
Feed-through mounting	0.14 A/K (from -74°C) [8]	-
Reduction of continuous current depending on the installation elevation		
Starting at 500 m above sea level	1.51 A_{eff} per 1000 m	
Peak current per motor connection	37.7 A_{eff}	
Nominal switching frequency	5 kHz	
Possible switching frequencies [11]	5/10/20 kHz	
Electrical stress of the connected motor in accordance with IEC TS 60034-25 [12]	Limit value curve A	
Protective measures		
Overload protection	Yes	
Short circuit and ground fault protection	Yes	
Max. output frequency	598 Hz [13]	
Design		
U, V, W, PE	Male connector	
Shield connection	Yes	

Table 53: 8BVI0110HCDS.000-1, 8BVI0110HWDS.000-1 - Technical data

Product ID	8BVI0110HCDS.000-1	8BVI0110HWDS.000-1
Terminal connection cross section		
Flexible and fine wire lines		
With wire end sleeves	0.25 to 4 mm²	
Approbation data		
UL/C-UL-US	30 to 10	
CSA	28 to 10	
Terminal cable cross section dimension of shield connection	12 to 22 mm	
Max. motor line length depending on the switching frequency		
Switching frequency 5 kHz	25 m	
Switching frequency 10 kHz	25 m	
Switching frequency 20 kHz	10 m	
Motor holding brake connection		
Quantity	2	
Output voltage [14]	24 VDC +5.8% / -0.5% [15]	
Continuous current	2.1 A	
Max. internal resistance	0.3 Ω	
Extinction potential	Approx. 30 V	
Max. extinction energy per switching operation	3 Ws	
Max. switching frequency	0.5 Hz	
Protective measures		
Overload and short circuit protection	Yes	
Open line monitoring	Yes	
Undervoltage monitoring	Yes	
Response threshold for open line monitoring	Approx. 0.5 A	
Response threshold for undervoltage monitoring	24 VDC -2% / -4%	
Encoder interfaces [16]		
Quantity	2	
Type	EnDat 2.2 [17]	
Connections	9-pin female DSUB connector	
Status indicators	UP/DN LEDs	
Electrical isolation		
Encoder - ACOPOSmulti	No	
Encoder monitoring	Yes	
Max. encoder cable length	100 m Depends on the cross section of the encoder's supply wires [18]	
Encoder supply		
Output voltage	Typ. 12.5 V	
Load capability	350 mA	
Protective measures		
Short circuit protection	Yes	
Overload protection	Yes	
Synchronous serial interface		
Signal transmission	RS485	
Data transfer rate	6.25 Mbit/s	
Max. power consumption per encoder interface	$P_{SMC}[W] = 19\ V * I_{Encoder}[A]$ [19]	
Trigger inputs		
Quantity	2	
Wiring	Sink	
Electrical isolation		
Input - Inverter module	Yes	
Input - Input	No	Yes
Input voltage		
Nominal	24 VDC	
Maximum	30 VDC	
Switching threshold		
Low	<5 V	
High	>15 V	
Input current at nominal voltage	Approx. 10 mA	
Switching delay		
Rising edge	52 µs ±0.5 µs (digitally filtered)	
Falling edge	53 µs ±0.5 µs (digitally filtered)	
Modulation compared to ground potential	Max. ±38 V	
Electrical characteristics		
Discharge capacitance	0.44 µF	
Operating conditions		
Permitted mounting orientations		
Hanging vertically	Yes	
Lying horizontally	Yes	
Standing horizontally	No	
Installation at elevations above sea level		
Nominal	0 to 500 m	
Maximum [20]	4000 m	

Table 53: 8BVI0110HCDS.000-1, 8BVI0110HWDS.000-1 - Technical data

Product ID	8BVI0110HCDS.000-1	8BVI0110HWDS.000-1
Degree of pollution in accordance with EN 60664-1	2 (non-conductive pollution)	
Overvoltage category in accordance with IEC 60364-4-443:1999	III	
EN 60529 protection	IP20	
Environmental conditions		
Temperature		
Operation		
Nominal	5 to 40°C	
Maximum [21]	55°C	
Storage	-25 to 55°C	
Transport	-25 to 70°C	
Relative humidity		
Operation	5 to 85%	
Storage	5 to 95%	
Transport	Max. 95% at 40°C	
Mechanical characteristics		
Dimensions [22]		
Width	106.5 mm	
Height	317 mm	
Depth		
Wall mounting	-	263 mm
Cold plate	212 mm	-
Feed-through mounting	209 mm	-
Weight	Approx. 4.1 kg	Approx. 5.3 kg
Module width	2	

Table 53: 8BVI0110HCDS.000-1, 8BVI0110HWDS.000-1 - Technical data

1) SLOT 1 and SLOT 2 of the ACOPOSmulti module are occupied by the encoder interfaces.
2) Valid in the following conditions: 750 VDC DC bus voltage, 5 kHz switching frequency, 40°C ambient temperature, installation elevation <500 m above sea level, no derating due to cooling type.
3) I_M... Average value of the currents on both motor connectors [A].
4) P_{SMC1} ... Max. power consumption P_{SMC} [W] of the SafeMOTION module in SLOT1 (see the "Encoder interfaces" section).
P_{SMC2} ... Max. power consumption P_{SMC} [W] of the SafeMOTION module in SLOT2 (see the "Encoder interfaces" section).
$P_{24\ V\ Out}$... Power [W] that is output to the connections X2/+24 V Out 1 and X2/+24 V Out 2 on the module (max. 10 W).
$P_{Fan8B0M...}$... Portion of the power [W] that is used by the fan modules in the mounting plate or the 8B0M0040HFF0.000-1 fan module (see the technical data for the respective 8B0M... mounting plate / 8B0M0040HFF0.000-1 fan module).
5) Only 8BCM motor cables from B&R are permitted to be connected to the motor connectors.
6) Valid in the following conditions: 750 VDC DC bus voltage, minimum permissible coolant flow volume (3 l/min). The temperature specifications refer to the return temperature of the cold plate mounting plate.
7) Value for the nominal switching frequency.
8) The module cannot supply the full continuous current at this switching frequency. This unusual value for the ambient temperature, at which derating of the continuous current must be taken into account, ensures that the derating of the continuous current can be determined in the same manner as at other switching frequencies.
9) The temperature specifications refer to the return temperature of the cold plate mounting plate.
10) The module cannot supply the full continuous current at this switching frequency. This unusual value for the return temperature, at which derating of the continuous current must be taken into account, ensures that the derating of the continuous current can be determined in the same manner as at other switching frequencies.
Caution! Condensation can occur at low flow temperatures and return temperatures.
11) B&R recommends operating the module at its nominal switching frequency. Operating the module at a higher switching frequency for application-specific reasons reduces the continuous current and increases the CPU load. When using dual-axis modules, the increased CPU load reduces the functionality of the drive; if this is not taken into consideration, the computing time can be exceeded in extreme cases.
12) If necessary, the stress of the motor isolation system can be reduced by an additional externally wired dU/dt choke. For example, the RWK 305 three-phase du/dt choke from Schaffner (www.schaffner.com) can be used. Important: Even when using a dU/dt choke, it is necessary to ensure that an EMC-compatible, low inductance shield connection is used!
13) The module's electrical output frequency (SCTRL_SPEED_ACT * MOTOR_POLEPAIRS) is monitored to protect against dual use in accordance with EC regulation 428/2009 | 3A225. If the electrical output frequency of the module exceeds the limit value of 598 Hz uninterrupted for more than 0.5 s, then the current movement is aborted and error 6060 is output (Power element: Limit speed exceeded).
14) During project development, it is necessary to check if the minimum voltage can be maintained on the holding brake with the specified wiring. The operating voltage range of the holding brake can be found in the user's manual for the respective motor.
15) The specified value is only valid under the following conditions:
- The 24 VDC supply for the module is provided by an 8B0C auxiliary supply module installed on the same mounting plate.
If the 24 VDC supply for the module is applied to the mounting plate using an 8BVE expansion module, then the output voltage is reduced because of voltage drops on the expansion cable. In this case, undervoltage monitoring must be disabled.
16) Only 8BCF EnDat 2.2 cables from B&R are permitted to be connected to the encoder interfaces.
17) An EnDat 2.2 functional safety encoder is required when using ACOPOSmulti SafeMOTION inverter modules! With standard EnDat 2.2 encoders, only the STO, SBC and SS1 functions are monitored with respect to timing!
18) The maximum encoder cable length l_{max} can be calculated as follows (the maximum permissible encoder cable length of 100 m must not be exceeded):

$l_{max} = 7.9 / I_G * A * 1/(2*\rho)$

I_G ... Max. current consumption of the encoder [A].
A ... Cross section of the supply wire [mm²].
ρ ... Specific resistance [Ω mm²/m] (e.g. for copper: ρ = 0.0178).
19) $I_{Encoder}$ ... Max. power consumption of the connected encoder [A].
20) Continuous operation at elevations ranging from 500 m to 4000 m above sea level is possible (taking the specified continuous current reductions into consideration).

21) Continuous operation at ambient temperatures ranging from 40°C to max. 55°C is possible (taking the specified continuous current reductions into consideration), but this will result in a shorter service life.

22) These dimensions refer to the actual device dimensions including the respective mounting plate. Make sure to leave additional space above and below the devices for mounting, connections and air circulation.

3.5.1.4 Wiring

For details, see 3.5.3 "Wiring: Safe double-width inverter modules (dual-axis modules)" on page 106.

For general information, see 6 "Wiring" on page 142.

3.5.2 8BVI0220HCDS.000-1, 8BVI0220HWDS.000-1

3.5.2.1 General information

- Clearly structured, straightforward implementation via network-based safety technology
- Modular expandability through virtual wiring
- Immediate triggering of safety function due to short cycle times
- Easy implementation with transparent control and status information, even in the standard application
- Compact design
- Complete safety functionality, even in dual-axis modules

3.5.2.2 Order data

Model number	Short description	Figure
	Cold plate or feed-through mounting	
8BVI0220HCDS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 22 A, HV, cold plate or feed-through mounting, 2 axes	
	Wall mounting	
8BVI0220HWDS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 22 A, HV, wall mounting, 2 axes	
	Required accessories	
	Terminal block sets	
8BZVI0220DS.000-1A	Screw clamp set for ACOPOSmulti 8BVI0220HxDS modules: 1x 8TB2108.2010-00, 1x 8TB2104.203L-00, 1x 8TB2104.203F-00, 1x 8TB3104.204G-11, 1x 8TB3104.204K-11	
	Optional accessories	
	Accessory sets	
8BXB000.0000-00	ACPmulti accessory set for encoder buffering consisting of: 1 lithium battery AA 3.6 V; 1 protective cap for battery holder	
	Fan modules	
8BXF001.0000-00	ACOPOSmulti fan module, replacement fan for ACOPOSmulti modules (8BVP / 8B0C / 8BVI / 8BVE / 8B0K)	
	POWERLINK cables	
X20CA0E61.00020	POWERLINK connection cable, RJ45 to RJ45, 0.2 m	
X20CA0E61.00025	POWERLINK connection cable, RJ45 to RJ45, 0.25 m	
X20CA0E61.00030	POWERLINK connection cable, RJ45 to RJ45, 0.3 m	
X20CA0E61.00035	POWERLINK connection cable, RJ45 to RJ45, 0.35 m	
X20CA0E61.00050	POWERLINK connection cable, RJ45 to RJ45, 0.5 m	
X20CA0E61.00100	POWERLINK connection cable, RJ45 to RJ45, 1 m	
	Shield component sets	
8SCS000.0000-00	ACOPOSmulti shielding components set: 1x shielding plate 1fold type 0; 1x hose clamp, W 9 mm, D 12-22 mm	
8SCS002.0000-00	ACOPOSmulti shield component set: 1x clamping plate; 2x clamps D 4-13.5 mm; 4x screws	
8SCS009.0000-00	ACOPOSmulti shield component set: 1x ACOPOSmulti holding plate SK8-14; 1x shield terminal SK14	
	Terminal blocks	
8TB2104.203F-00	Screw clamp 4-pin, single row, spacing: 5.08 mm, label 3: T- T + B- B+, F keying: 0101	
8TB2104.203L-00	Screw clamp 4-pin, single row, spacing: 5.08 mm, label 3: T- T + B- B+, L keying: 1010	
8TB2108.2010-00	Screw clamp 8-pin, single row, spacing: 5.08 mm, label 1: numbered serially	
8TB3104.204G-11	Screw clamp 4-pin, single row, spacing: 7.62 mm, label 4: PE W V U, G coding: 0110	
8TB3104.204K-11	Screw clamp 4-pin, single row, spacing: 7.62 mm, label 4: PE W V U, K keying: 1001	

Table 54: 8BVI0220HCDS.000-1, 8BVI0220HWDS.000-1 - Order data

> ## Information:
> **Only 8BCM motor cables from B&R are permitted to be connected to the motor connectors.**

ACOPOSmulti SafeMOTION EnDat 2.2

> ## Information:
> **Only 8BCF EnDat 2.2 cables from B&R or 8BCH hybrid motor cables from B&R are permitted to be connected to the encoder interfaces.**

For details, see 1.2 "Safe power transmission system " on page 167.

3.5.2.3 Technical data

Product ID	8BVI0220HCDS.000-1	8BVI0220HWDS.000-1
General information		
B&R ID code	0xAA1B	0xAA1D
Cooling and mounting method	Cold plate or feed-through mounting	Wall mounting
Slots for plug-in modules	2 [1)]	
Certification		
CE	Yes	
cULus	Yes	
KC	Yes	
FSC	Yes	
DC bus connection		
Voltage		
Nominal	750 VDC	
Continuous power consumption [2)]	32.37 kW	
Power loss depending on the switching frequency [3)]		
Switching frequency 5 kHz	$[0.65 * I_M^2 - 0.35 * I_M + 64]$ W	
Switching frequency 10 kHz	$[2.16 * I_M^2 - 10.912 * I_M + 190]$ W	
DC bus capacitance	1320 µF	
Design	ACOPOSmulti backplane	
24 VDC supply		
Input voltage	25 VDC ±1.6%	
Input capacitance	23.5 µF	
Max. power consumption	$32\ W + P_{SMC1} + P_{SMC2} + P_{24\ V\ Out} + P_{HoldingBrake(s)} + 2 * P_{Fan8B0M...}$ [4)]	
Design	ACOPOSmulti backplane	
24 VDC output		
Quantity	2	
Output voltage		
DC bus voltage (U_{DC}): 260 to 315 VDC	25 VDC * (U_{DC}/315)	
DC bus voltage (U_{DC}): 315 to 800 VDC	24 VDC ±6%	
Protection	250 mA (slow-blow) electronic, automatic reset	
Motor connection [5)]		
Quantity	2	
Continuous power per motor connection [2)]	16 kW	
Continuous current per motor connection [2)]	22 A_{eff}	
Reduction of continuous current depending on the switching frequency [6)]		
Switching frequency 5 kHz	-	0.33 A/K (from 40°C) [7)]
Switching frequency 10 kHz	-	0.17 A/K (from -25°C) [8)]
Reduction of continuous current depending on the switching frequency and mounting method [6)]		
Switching frequency 5 kHz		
Cold plate mounting [9)]	0.99 A/K (from 40°C) [7)]	-
Feed-through mounting	0.52 A/K (from 40°C) [7)]	-
Switching frequency 10 kHz		
Cold plate mounting [9)]	0.29 A/K (from 10°C) [10)]	-
Feed-through mounting	0.23 A/K (from 0°C) [8)]	-
Reduction of continuous current depending on the installation elevation		
Starting at 500 m above sea level	2.2 A_{eff} per 1000 m	
Peak current per motor connection	55 A_{eff} [11)]	
Nominal switching frequency	5 kHz	
Possible switching frequencies [12)]	5/10 kHz	
Electrical stress of the connected motor in accordance with IEC TS 60034-25 [13)]	Limit value curve A	
Protective measures		
Overload protection	Yes	
Short circuit and ground fault protection	Yes	
Max. output frequency	598 Hz [14)]	
Design		
U, V, W, PE	Male connector	
Shield connection	Yes	
Terminal connection cross section		
Flexible and fine wire lines		
With wire end sleeves	0.25 to 4 mm²	
Approbation data		
UL/C-UL-US	30 to 10	
CSA	28 to 10	
Terminal cable cross section dimension of shield connection	12 to 22 mm	
Max. motor line length depending on the switching frequency		
Switching frequency 5 kHz	25 m	
Switching frequency 10 kHz	25 m	

Table 55: 8BVI0220HCDS.000-1, 8BVI0220HWDS.000-1 - Technical data

Product ID	8BVI0220HCDS.000-1	8BVI0220HWDS.000-1
Motor holding brake connection		
Quantity	2	
Output voltage [15]	24 VDC +5.8% / -0.5% [16]	
Continuous current	2.1 A	
Max. internal resistance	0.3 Ω	
Extinction potential	Approx. 30 V	
Max. extinction energy per switching operation	3 Ws	
Max. switching frequency	0.5 Hz	
Protective measures		
Overload and short circuit protection	Yes	
Open line monitoring	Yes	
Undervoltage monitoring	Yes	
Response threshold for open line monitoring	Approx. 0.5 A	
Response threshold for undervoltage monitoring	24 VDC -2% / -4%	
Encoder interfaces [17]		
Quantity	2	
Type	EnDat 2.2 [18]	
Connections	9-pin female DSUB connector	
Status indicators	UP/DN LEDs	
Electrical isolation		
Encoder - ACOPOSmulti	No	
Encoder monitoring	Yes	
Max. encoder cable length	100 m Depends on the cross section of the encoder's supply wires [19]	
Encoder supply		
Output voltage	Typ. 12.5 V	
Load capability	350 mA	
Protective measures		
Short circuit protection	Yes	
Overload protection	Yes	
Synchronous serial interface		
Signal transmission	RS485	
Data transfer rate	6.25 Mbit/s	
Max. power consumption per encoder interface	P_{SMC}[W] = 19 V * $I_{Encoder}$[A] [20]	
Trigger inputs		
Quantity	2	
Wiring	Sink	
Electrical isolation		
Input - Inverter module	Yes	
Input - Input	Yes	
Input voltage		
Nominal	24 VDC	
Maximum	30 VDC	
Switching threshold		
Low	<5 V	
High	>15 V	
Input current at nominal voltage	Approx. 10 mA	
Switching delay		
Rising edge	52 µs ±0.5 µs (digitally filtered)	
Falling edge	53 µs ±0.5 µs (digitally filtered)	
Modulation compared to ground potential	Max. ±38 V	
Electrical characteristics		
Discharge capacitance	0.44 µF	
Operating conditions		
Permitted mounting orientations		
Hanging vertically	Yes	
Lying horizontally	Yes	
Standing horizontally	No	
Installation at elevations above sea level		
Nominal	0 to 500 m	
Maximum [21]	4000 m	
Degree of pollution in accordance with EN 60664-1	2 (non-conductive pollution)	
Overvoltage category in accordance with IEC 60364-4-443:1999	III	
EN 60529 protection	IP20	
Environmental conditions		
Temperature		
Operation		
Nominal	5 to 40°C	
Maximum [22]	55°C	
Storage	-25 to 55°C	
Transport	-25 to 70°C	

Table 55: 8BVI0220HCDS.000-1, 8BVI0220HWDS.000-1 - Technical data

Product ID	8BVI0220HCDS.000-1	8BVI0220HWDS.000-1
Relative humidity		
Operation	5 to 85%	
Storage	5 to 95%	
Transport	Max. 95% at 40°C	
Mechanical characteristics		
Dimensions [23]		
Width	106.5 mm	
Height	317 mm	
Depth		
Wall mounting	-	263 mm
Cold plate	212 mm	-
Feed-through mounting	209 mm	-
Weight	Approx. 4.4 kg	Approx. 5.7 kg
Module width	2	

Table 55: 8BVI0220HCDS.000-1, 8BVI0220HWDS.000-1 - Technical data

1) SLOT 1 and SLOT 2 of the ACOPOSmulti module are occupied by the encoder interfaces.
2) Valid in the following conditions: 750 VDC DC bus voltage, 5 kHz switching frequency, 40°C ambient temperature, installation elevation <500 m above sea level, no derating due to cooling type.
3) I_M... Average value of the currents on both motor connectors [A].
4) P_{SMC1} ... Max. power consumption P_{SMC} [W] of the SafeMOTION module in SLOT1 (see the "Encoder interfaces" section).
P_{SMC2} ... Max. power consumption P_{SMC} [W] of the SafeMOTION module in SLOT2 (see the "Encoder interfaces" section).
$P_{24\ V\ Out}$... Power [W] that is output to the connections X2/+24 V Out 1 and X2/+24 V Out 2 on the module (max. 10 W).
$P_{Fan8B0M...}$... Portion of the power [W] that is used by the fan modules in the mounting plate or the 8B0M0040HFF0.000-1 fan module (see the technical data for the respective 8B0M... mounting plate / 8B0M0040HFF0.000-1 fan module).
5) Only 8BCM motor cables from B&R are permitted to be connected to the motor connectors.
6) Valid in the following conditions: 750 VDC DC bus voltage, minimum permissible coolant flow volume (3 l/min). The temperature specifications refer to the return temperature of the cold plate mounting plate.
7) Value for the nominal switching frequency.
8) The module cannot supply the full continuous current at this switching frequency. This unusual value for the ambient temperature, at which derating of the continuous current must be taken into account, ensures that the derating of the continuous current can be determined in the same manner as at other switching frequencies.
9) The temperature specifications refer to the return temperature of the cold plate mounting plate.
10) The module cannot supply the full continuous current at this switching frequency. This unusual value for the return temperature, at which derating of the continuous current must be taken into account, ensures that the derating of the continuous current can be determined in the same manner as at other switching frequencies.
Caution! Condensation can occur at low flow temperatures and return temperatures.
11) The thermal pulse load capacity is lower than for the 8BVI0220HxS0.000-1 single-axis module. It is therefore not possible to simply replace two 8BVI0220HxS0.000-1 single-axis modules with one 8BVI0220HxD0.000-1 dual-axis module. If this is required, the load cycle must be examined in detail.
12) B&R recommends operating the module at its nominal switching frequency. Operating the module at a higher switching frequency for application-specific reasons reduces the continuous current and increases the CPU load. When using dual-axis modules, the increased CPU load reduces the functionality of the drive; if this is not taken into consideration, the computing time can be exceeded in extreme cases.
13) If necessary, the stress of the motor isolation system can be reduced by an additional externally wired dU/dt choke. For example, the RWK 305 three-phase du/dt choke from Schaffner (www.schaffner.com) can be used. Important: Even when using a dU/dt choke, it is necessary to ensure that an EMC-compatible, low inductance shield connection is used!
14) The module's electrical output frequency (SCTRL_SPEED_ACT * MOTOR_POLEPAIRS) is monitored to protect against dual use in accordance with EC regulation 428/2009 | 3A225. If the electrical output frequency of the module exceeds the limit value of 598 Hz uninterrupted for more than 0.5 s, then the current movement is aborted and error 6060 is output (Power element: Limit speed exceeded).
15) During project development, it is necessary to check if the minimum voltage can be maintained on the holding brake with the specified wiring. The operating voltage range of the holding brake can be found in the user's manual for the respective motor.
16) The specified value is only valid under the following conditions:
- The 24 VDC supply for the module is provided by an 8B0C auxiliary supply module installed on the same mounting plate.
If the 24 VDC supply for the module is applied to the mounting plate using an 8BVE expansion module, then the output voltage is reduced because of voltage drops on the expansion cable. In this case, undervoltage monitoring must be disabled.
17) Only 8BCF EnDat 2.2 cables from B&R are permitted to be connected to the encoder interfaces.
18) An EnDat 2.2 functional safety encoder is required when using ACOPOSmulti SafeMOTION inverter modules! With standard EnDat 2.2 encoders, only the STO, SBC and SS1 functions are monitored with respect to timing!
19) The maximum encoder cable length l_{max} can be calculated as follows (the maximum permissible encoder cable length of 100 m must not be exceeded):

$l_{max} = 7.9 / I_G * A * 1/(2*\rho)$

I_G ... Max. current consumption of the encoder [A].
A ... Cross section of the supply wire [mm²].
ρ ... Specific resistance [Ω mm²/m] (e.g. for copper: ρ = 0.0178).
20) $I_{Encoder}$ ... Max. power consumption of the connected encoder [A].
21) Continuous operation at elevations ranging from 500 m to 4000 m above sea level is possible (taking the specified continuous current reductions into consideration).
22) Continuous operation at ambient temperatures ranging from 40°C to max. 55°C is possible (taking the specified continuous current reductions into consideration), but this will result in a shorter service life.
23) These dimensions refer to the actual device dimensions including the respective mounting plate. Make sure to leave additional space above and below the devices for mounting, connections and air circulation.

3.5.2.4 Wiring

For details, see 3.5.3 "Wiring: Safe double-width inverter modules (dual-axis modules)" on page 106.

For general information, see 6 "Wiring" on page 142.

3.5.3 Wiring: Safe double-width inverter modules (dual-axis modules)

3.5.3.1 ACOPOSmulti SafeMOTION EnDat 2.2 - Pinout overview

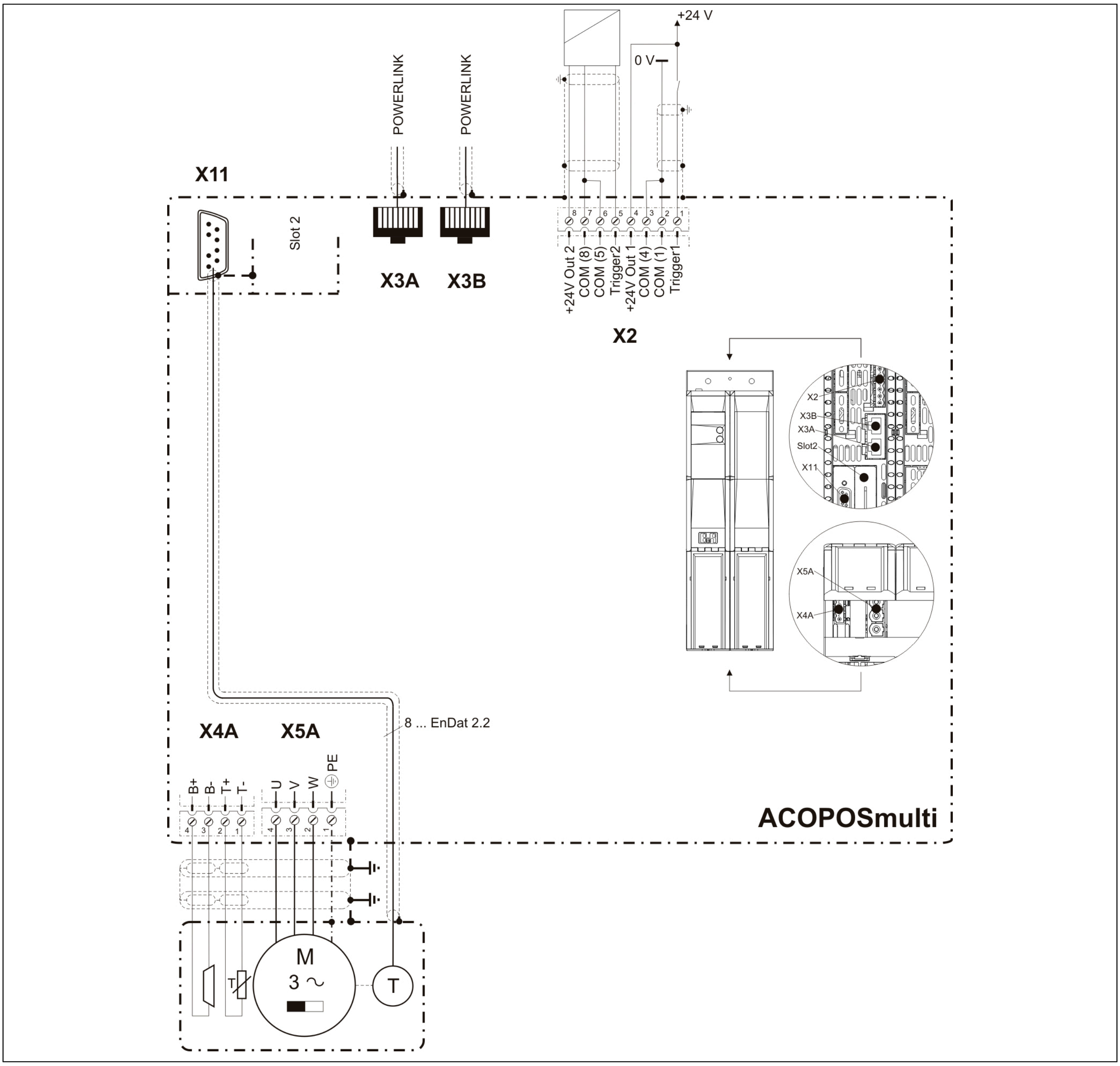


Figure 11: Pinout overview

3.5.3.2 X2 connector - Pinout

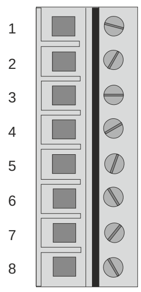
X2	Pin	Name	Function
	1	Trigger 1	Trigger 1
	2	COM (1)	Trigger 1 0 V
	3	COM (2)	+24 V output 1 0 V
	4	+24 V Out 1	+24 V output 1
	5	Trigger 2	Trigger 2
	6	COM (5)	Trigger 2 0 V
	7	COM (8)	+24 V output 2 0 V
	8	+24 V Out 2	+24 V output 2

Table 56: X2 connector - Pinout

3.5.3.3 X3A, X3B connectors - Pinout

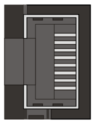
X3A, X3B	Pin	Name	Function
	1	RXD	Receive signal
	2	RXD\	Receive signal inverted
	3	TXD	Transmit signal
	4	Shield	Shield
	5	Shield	Shield
	6	TXD\	Transmit signal inverted
	7	Shield	Shield
	8	Shield	Shield

Table 57: X3A, X3B connectors - Pinout

3.5.3.4 X4A connector - Pinout

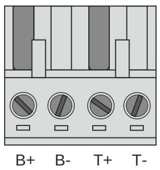
X4A	Name	Function
	T-	Axis 1: Temperature sensor -
	T+	Axis 1: Temperature sensor +
	B- [1]	Axis 1: Brake -
	B+ [1]	Axis 1: Brake +

Table 58: X4A connector - Pinout

1) Wiring is not permitted to exceed a total length of 3 m.

Danger!

The FUNCTIONAL FAIL SAFE state is activated if the SBC output B+ is shorted to 24 V (i.e. safe pulse disabling is activated). The brake always remains on/released, however, due to the short circuit to 24 V! This can lead to dangerous situations because the motor holding brake cannot brake or prevent the spin-out movement (or the unrestrained lowering in the case of hanging loads)!
Appropriate wiring measures must be implemented to ensure that the SBC output B+ is not shorted to 24 V!

For a dual-axis module, it is therefore especially important to prevent a cross fault between the two B+ connections of the two axes!

Danger!

The SBC output

- **is not permitted to be wired to multiple modules!**
- **is not permitted to be wired as an open emitter!**
- **is not permitted to be wired as an open collector!**

Danger!

Only an output voltage of ≤5 V can be ensured for the safe motor holding brake output when shut off. When selecting a motor holding brake, the user must ensure that the required braking torque is reached at a voltage of 5 V.

Information:

The transistors of the SBC output stage are tested cyclically. When the output channels are active, this test emits low pulses on the output with a maximum length of 600 µs.

This must be taken into consideration when choosing the motor holding brake!

Danger!

The connections for the motor temperature sensors and the motor holding brake are safely isolated circuits. These connections are therefore only permitted to be connected to devices or components that have sufficient isolation in accordance with IEC 60364-4-41 or EN 61800-5-1.

Caution!

If B+ and B- are swapped when connecting the permanent magnet holding brakes, then the brakes cannot be opened! ACOPOSmulti inverter modules cannot determine if a holding brake is connected with reverse polarity!

Warning!

Temperature sensors are only permitted to be connected to the X4A/T+ and X4A/T- connectors on an ACOPOSmulti module under the following conditions:

- **There is no ACOPOSmulti plug-in module in SLOT1 on the ACOPOSmulti module with a temperature sensor connected to T+ and T-**

Otherwise, the temperature monitoring functions on the ACOPOSmulti module may become ineffective, which in extreme cases can cause the hardware (e.g. motors) connected to the ACOPOSmulti module to be destroyed!

3.5.3.5 X4B connector - Pinout

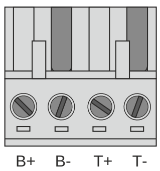
X4B	Name	Function
	T-	Axis 2: Temperature sensor -
	T+	Axis 2: Temperature sensor +
	B- [1)]	Axis 2: Brake -
	B+ [1)]	Axis 2: Brake +

Table 59: X4B connector - Pinout

1) Wiring is not permitted to exceed a total length of 3 m.

Danger!

The FUNCTIONAL FAIL SAFE state is activated if the SBC output B+ is shorted to 24 V (i.e. safe pulse disabling is activated). The brake always remains on/released, however, due to the short circuit to 24 V! This can lead to dangerous situations because the motor holding brake cannot brake or prevent the spin-out movement (or the unrestrained lowering in the case of hanging loads)!
Appropriate wiring measures must be implemented to ensure that the SBC output B+ is not shorted to 24 V!

For a dual-axis module, it is therefore especially important to prevent a cross fault between the two B+ connections of the two axes!

Danger!

The SBC output

- **is not permitted to be wired to multiple modules!**
- **is not permitted to be wired as an open emitter!**
- **is not permitted to be wired as an open collector!**

Danger!

Only an output voltage of ≤5 V can be ensured for the safe motor holding brake output when shut off. When selecting a motor holding brake, the user must ensure that the required braking torque is reached at a voltage of 5 V.

Information:

The transistors of the SBC output stage are tested cyclically. When the output channels are active, this test emits low pulses on the output with a maximum length of 600 µs.

This must be taken into consideration when choosing the motor holding brake!

Danger!

The connections for the motor temperature sensors and the motor holding brake are safely isolated circuits. These connections are therefore only permitted to be connected to devices or components that have sufficient isolation in accordance with IEC 60364-4-41 or EN 61800-5-1.

Caution!

If B+ and B- are swapped when connecting the permanent magnet holding brakes, then the brakes cannot be opened! ACOPOSmulti inverter modules cannot determine if a holding brake is connected with reverse polarity!

Warning!

Temperature sensors are only permitted to be connected to the X4B/T+ and X4B/T- connectors on an ACOPOSmulti module under the following conditions:

- **There is no ACOPOSmulti plug-in module in SLOT2 on the ACOPOSmulti module with a temperature sensor connected to T+ and T-**

Otherwise, the temperature monitoring functions on the ACOPOSmulti module may become ineffective, which in extreme cases can cause the hardware (e.g. motors) connected to the ACOPOSmulti module to be destroyed!

3.5.3.6 X5A connector - Pinout

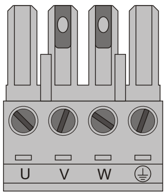
X5A	Name	Function
	⏚	Axis 1: Protective ground conductor
	W	Axis 1: Motor connection W
	V	Axis 1: Motor connection V
	U	Axis 1: Motor connection U

Table 60: X5A connector - Pinout

Information:

Only 8BCM motor cables from B&R are permitted to be connected to the motor connectors.

3.5.3.7 X5B connector - Pinout

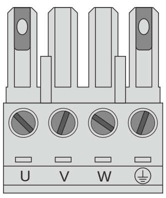
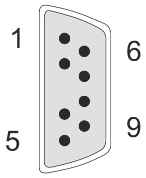
X5B	Name	Function
	⏚	Axis 2: Protective ground conductor
	W	Axis 2: Motor connection W
	V	Axis 2: Motor connection V
	U	Axis 2: Motor connection U

Table 61: X5B connector - Pinout

Information:

Only 8BCM motor cables from B&R are permitted to be connected to the motor connectors.

3.5.3.8 SafeMOTION EnDat 2.2 module - Pinout

Figure	X11 (X12)	Pin	Name	Function
		1	U+	Encoder supply +12.5 V
		2	---	---
		3	---	---
		4	D	Data input
		5	T	Clock output
		6	COM (1)	Encoder supply 0 V
		7	---	---
		8	D\	Data input inverted
		9	T\	Clock output inverted

Information:

Only 8BCF EnDat 2.2 cables from B&R or 8BCH hybrid motor cables from B&R are permitted to be connected to the encoder interfaces.

Information:

SafeMOTION modules cannot be replaced! SafeMOTION modules and the corresponding inverter module form a single unit. In the event of an error, the entire inverter module must be replaced.

3.6 Safe 4x width inverter modules (single-axis modules)

3.6.1 8BVI0660HCSS.000-1, 8BVI0660HWSS.000-1, 8BVI0660HCSA.000-1, 8BVI0660HWSA.000-1

3.6.1.1 General information

- Clearly structured, straightforward implementation via network-based safety technology
- Modular expandability through virtual wiring
- Immediate triggering of safety function due to short cycle times
- Easy implementation with transparent control and status information, even in the standard application
- Compact design

3.6.1.2 Order data

Model number	Short description	Figure
	Cold plate or feed-through mounting	
8BVI0660HCSS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 66 A, HV, cold plate or feed-through mounting	
8BVI0660HCSA.000-1	ACOPOSmulti SafeMOTION SinCos inverter module, 66 A, HV, cold plate or feed-through mounting	
	Wall mounting	
8BVI0660HWSS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 66 A, HV, wall mounting	
8BVI0660HWSA.000-1	ACOPOSmulti SafeMOTION SinCos inverter module, 66 A, HV, wall mounting	
	Required accessories	
	Terminal block sets	
8BZVI1650SS.000-1A	Screw clamp set for ACOPOSmulti 8BVI0660HxSS, 8BVI0880HxSS, 8BVI1650HxSS, 8BVI0660HxSA, 8BVI0880HxSA and 8BVI1650HxSA modules: 1x 8TB2104.203L-00, 1x 8TB2108.2010-00	
	Optional accessories	
	Accessory sets	
8BXB000.0000-00	ACPmulti accessory set for encoder buffering consisting of: 1 lithium battery AA 3.6 V; 1 protective cap for battery holder	
	Fan modules	
8BXF001.0000-00	ACOPOSmulti fan module, replacement fan for ACOPOSmulti modules (8BVP / 8B0C / 8BVI / 8BVE / 8B0K)	
	POWERLINK cables	
X20CA0E61.00020	POWERLINK connection cable, RJ45 to RJ45, 0.2 m	
X20CA0E61.00025	POWERLINK connection cable, RJ45 to RJ45, 0.25 m	
X20CA0E61.00030	POWERLINK connection cable, RJ45 to RJ45, 0.3 m	
X20CA0E61.00035	POWERLINK connection cable, RJ45 to RJ45, 0.35 m	
X20CA0E61.00050	POWERLINK connection cable, RJ45 to RJ45, 0.5 m	
X20CA0E61.00100	POWERLINK connection cable, RJ45 to RJ45, 1 m	
	Plug-in modules	
8BAC0120.000-1	ACOPOSmulti plug-in module, EnDat 2.1 interface	
8BAC0120.001-2	ACOPOSmulti plug-in module, EnDat 2.2 interface	
8BAC0121.000-1	ACOPOSmulti plug-in module, HIPERFACE interface	
8BAC0122.000-1	ACOPOSmulti plug-in module, resolver interface 10 kHz	
8BAC0123.000-1	ACOPOSmulti plug-in module, incremental encoder and SSI absolute encoder interface for RS422 signals	
8BAC0123.001-1	ACOPOSmulti plug-in module, incremental encoder interface for 5 V single-ended and 5 V differential signals	
8BAC0123.002-1	ACOPOSmulti plug-in module, incremental encoder interface for 24 V single-ended and 24 V differential signals	
8BAC0124.000-1	ACOPOSmulti plug-in module, SinCos interface	
8BAC0125.000-1	ACOPOSmulti plug-in module, SinCos EnDat 2.1/SSI interface	
8BAC0130.000-1	ACOPOSmulti plug-in module, 2 digital outputs, 50 mA, max. 62,5 kHz, 4 digital outputs, 500 mA, max. 1,25 kHz, 2 digital inputs 24 VDC	
8BAC0130.001-1	ACOPOSmulti plug-in module, 2 digital outputs, 50 mA, max. 62.5 kHz, 4 digital outputs, 500 mA, max. 1.25 kHz	
8BAC0132.000-1	ACOPOSmulti input module, 4 analog inputs ±10 V	
8BAC0133.000-1	ACOPOSmulti plug-in module, 3 RS422 outputs for ABR encoder emulation, 1 Mhz	
	Shield component sets	
8SCS001.0000-00	ACOPOSmulti shield component set: 1x shield plate 4x type 1; 1x hose clamp, B 9 mm, D 12-22 mm	
8SCS002.0000-00	ACOPOSmulti shield component set: 1x clamping plate; 2x clamps D 4-13.5 mm; 4x screws	
8SCS003.0000-00	ACOPOSmulti shield component set: 1x shield mounting plate 4x 45°; 8x screws	

Table 62: 8BVI0660HCSS.000-1, 8BVI0660HCSA.000-1, 8BVI0660HWSS.000-1, 8BVI0660HWSA.000-1 - Order data

Model number	Short description	Figure
8SCS004.0000-00	ACOPOSmulti shield component set: 1x shield plate 4x type 0; 2x hose clamps, B 9 mm, D 32-50 mm	
8SCS010.0000-00	ACOPOSmulti shield component set: 1x ACOPOSmulti holding plate SK14-20; 1x shield terminal SK20	
	Terminal blocks	
8TB2104.203L-00	Screw clamp 4-pin, single row, spacing: 5.08 mm, label 3: T- T + B- B+, L keying: 1010	
8TB2106.2010-00	Screw clamp 6-pin, single row, spacing: 5.08 mm, label 1: numbered serially	
8TB2108.2010-00	Screw clamp 8-pin, single row, spacing: 5.08 mm, label 1: numbered serially	

Table 62: 8BVI0660HCSS.000-1, 8BVI0660HCSA.000-1, 8BVI0660HWSS.000-1, 8BVI0660HWSA.000-1 - Order data

Information:

Only 8BCM motor cables from B&R are permitted to be connected to the motor connectors.

ACOPOSmulti SafeMOTION EnDat 2.2

Information:

Only 8BCF EnDat 2.2 cables from B&R or 8BCH hybrid motor cables from B&R are permitted to be connected to the encoder interfaces.

ACOPOSmulti SafeMOTION SinCos

Information:

Only 8BCS encoder cables from B&R are permitted to be connected to the encoder interfaces on B&R standard motors.

For details, see 1.2 "Safe power transmission system " on page 167.

3.6.1.3 Technical data

Product ID	8BVI0660HCSS.000-1	8BVI0660HWSS.000-1	8BVI0660HCSA.000-1	8BVI0660HWSA.000-1
General information				
B&R ID code	0xBE89	0xBE8B	0xE0B8	0xE0B9
Cooling and mounting method	Cold plate or feed-through mounting	Wall mounting	Cold plate or feed-through mounting	Wall mounting
Slots for plug-in modules	2 [1]			
Certification				
CE	Yes			
cULus	Yes			
KC	Yes		-	
FSC	Yes			
DC bus connection				
Voltage				
Nominal	750 VDC			
Continuous power consumption [2]	48.8 kW			
Power loss depending on the switching frequency [3]				
Switching frequency 5 kHz	$[0.03 * I_M^2 + 7.9 * I_M + 90]$ W			
Switching frequency 10 kHz	$[0.11 * I_M^2 + 11 * I_M + 185]$ W			
Switching frequency 20 kHz	$[0.17 * I_M^2 + 27 * I_M + 310]$ W			
DC bus capacitance	1980 µF			
Design	ACOPOSmulti backplane			
24 VDC supply				
Input voltage	25 VDC ±1.6%			
Input capacitance	32.9 µF			
Max. power consumption	33 W + P_{SMC1} + P_{SLOT2} + $P_{24 V Out}$ + $P_{HoldingBrake}$ + 4 * $P_{Fan8B0M...}$ [4]		25 W + P_{SMC1} + P_{SLOT2} + $P_{24 V Out}$ + $P_{HoldingBrake}$ + $P_{Fan8B0M...}$ [5]	
Design	ACOPOSmulti backplane			
24 VDC output				
Quantity	2			
Output voltage				
DC bus voltage (U_{DC}): 260 to 315 VDC	25 VDC * (U_{DC}/315)			
DC bus voltage (U_{DC}): 315 to 800 VDC	24 VDC ±6%			
Protection	250 mA (slow-blow) electronic, automatic reset			

Table 63: 8BVI0660HCSS.000-1, 8BVI0660HWSS.000-1, 8BVI0660HCSA.000-1, 8BVI0660HWSA.000-1 - Technical data

Product ID	8BVI0660HCSS.000-1	8BVI0660HWSS.000-1	8BVI0660HCSA.000-1	8BVI0660HWSA.000-1
Motor connection [6]				
Quantity	1			
Continuous power per motor connection [2]	48 kW			
Continuous current per motor connection [2]	66 A_{eff}			
Reduction of continuous current depending on the switching frequency [7]				
Switching frequency 5 kHz	-	1.4 A/K (from 41°C) [8]	-	1.4 A/K (from 41°C) [8]
Switching frequency 10 kHz	-	0.92 A/K (from -5°C) [9]	-	0.92 A/K (from -5°C) [9]
Switching frequency 20 kHz	-	0.56 A/K (from -90°C) [9]	-	0.56 A/K (from -90°C) [9]
Reduction of continuous current depending on the switching frequency and mounting method [10]				
Switching frequency 5 kHz				
Cold plate mounting [11]	1.9 A/K (from 58°C) [8]	-	1.9 A/K (from 58°C) [8]	-
Feed-through mounting	1.82 A/K (from 40°C) [8]	-	1.82 A/K (from 40°C) [8]	-
Switching frequency 10 kHz				
Cold plate mounting [11]	1.36 A/K (from 27°C) [12]	-	1.36 A/K (from 27°C) [12]	-
Feed-through mounting	0.88 A/K (from -12°C) [9]	-	0.88 A/K (from -12°C) [9]	-
Switching frequency 20 kHz				
Cold plate mounting [11]	0.75 A/K (from -37°C) [12]	-	0.75 A/K (from -37°C) [12]	-
Feed-through mounting	0.54 A/K (from -106°C) [9]	-	0.54 A/K (from -106°C) [9]	-
Reduction of continuous current depending on the installation elevation				
Starting at 500 m above sea level	6.6 A_{eff} per 1000 m			
Peak current	132 A_{eff}			
Nominal switching frequency	5 kHz			
Possible switching frequencies [13]	5/10/20 kHz			
Electrical stress of the connected motor in accordance with IEC TS 60034-25 [14]	Limit value curve A			
Protective measures				
Overload protection	Yes			
Short circuit and ground fault protection	Yes			
Max. output frequency	598 Hz [15]			
Design				
U, V, W, PE	M8 threaded bolt			
Shield connection	Yes			
Connection cross section range				
Flexible and fine wire lines	6 to 50 mm² [16]			
Approbation data				
UL/C-UL-US	In preparation			
CSA	In preparation			
Terminal cable cross section dimension of shield connection	12 to 50 mm [17]			
Max. motor line length depending on the switching frequency				
Switching frequency 5 kHz	25 m			
Switching frequency 10 kHz	25 m			
Switching frequency 20 kHz	25 m			
Motor holding brake connection				
Quantity	1			
Output voltage [18]	24 VDC +5.8% / -0.5% [19]			
Continuous current	4.2 A			
Max. internal resistance	0.15 Ω			
Extinction potential	Approx. 30 V			
Max. extinction energy per switching operation	3 Ws			
Max. switching frequency	0.5 Hz			
Protective measures				
Overload and short circuit protection	Yes			
Open line monitoring	Yes			
Undervoltage monitoring	Yes			
Response threshold for open line monitoring	Approx. 0.5 A			
Response threshold for undervoltage monitoring	24 VDC -2% / -4%			
Encoder interfaces [20]				
Quantity	1			
Type	EnDat 2.2 [21]		SinCos	
Connections	9-pin female DSUB connector		15-pin female DSUB connector	
Status indicators	UP/DN LEDs			

Table 63: 8BVI0660HCSS.000-1, 8BVI0660HWSS.000-1, 8BVI0660HCSA.000-1, 8BVI0660HWSA.000-1 - Technical data

Product ID	8BVI0660HCSS.000-1	8BVI0660HWSS.000-1	8BVI0660HCSA.000-1	8BVI0660HWSA.000-1
Electrical isolation				
Encoder - ACOPOSmulti	No			
Encoder monitoring	Yes			
Max. encoder cable length	100 m Depends on the cross section of the encoder's supply wires [22]		50 m [23]	
Encoder supply				
Output voltage	Typ. 12.5 V		5 V ±5% [24]	
Load capability	350 mA		300 mA [25]	
Sense lines	-		2, compensation of max. 2 x 0.7 V	
Protective measures				
Short circuit protection	Yes			
Overload protection	Yes			
Synchronous serial interface				
Signal transmission	RS485			
Data transfer rate	6.25 Mbit/s		781.25 kbit/s	
Sine/Cosine inputs				
Signal transmission	-		Differential signals, symmetrical	
Differential voltage				
In motion	-		0.5 to 1.35 V [26]	
At standstill	-		0.8 to 1.35 V [27]	
Differential voltage deviation per signal period	-		±10% [28]	
Common-mode voltage	-		Max. ±7 V	
Terminating resistors	-		120 Ω	
Max. input frequency	-		200 kHz	
Signal frequency (-5 dB)	-		<300 kHz	
Signal frequency (-3 dB)	-		DC up to 200 kHz	
ADC resolution	-		12-bit	
Reference input				
Signal transmission	-		Differential signal, symmetrical	
Differential voltage for low	-		≤ -0.2 V	
Differential voltage for high	-		≥ 0.2 V	
Common-mode voltage	-		Max. -5 V to +9 V	
Terminating resistors	-		120 Ω	
Position				
Resolution @ 1 V_{SS} [29]	-		Number of encoder lines * 5700	
Precision [30]	-		---	
Noise [30]	-		---	
Max. power consumption per encoder interface	P_{SMC}[W] = 19 V * $I_{Encoder}$[A] [31]		P_{SMC}[W] = 25 V * (0.376 A + 0.35 * $I_{Encoder}$[A]) [31]	
Trigger inputs				
Quantity	2			
Wiring	Sink			
Electrical isolation				
Input - Inverter module	Yes			
Input - Input	Yes			
Input voltage				
Nominal	24 VDC			
Maximum	30 VDC			
Switching threshold				
Low	<5 V			
High	>15 V			
Input current at nominal voltage	Approx. 10 mA			
Switching delay				
Rising edge	52 µs ±0.5 µs (digitally filtered)			
Falling edge	53 µs ±0.5 µs (digitally filtered)			
Modulation compared to ground potential	Max. ±38 V			
Electrical characteristics				
Discharge capacitance	0.45 µF			
Operating conditions				
Permitted mounting orientations				
Hanging vertically	Yes			
Lying horizontally	Yes			
Standing horizontally	No			
Installation at elevations above sea level				
Nominal	0 to 500 m			
Maximum [32]	4000 m			
Degree of pollution in accordance with EN 60664-1	2 (non-conductive pollution)			
Overvoltage category in accordance with IEC 60364-4-443:1999	III			
EN 60529 protection	IP20 [33]			

Table 63: 8BVI0660HCSS.000-1, 8BVI0660HWSS.000-1, 8BVI0660HCSA.000-1, 8BVI0660HWSA.000-1 - Technical data

Product ID	8BVI0660HCSS.000-1	8BVI0660HWSS.000-1	8BVI0660HCSA.000-1	8BVI0660HWSA.000-1
Environmental conditions				
Temperature				
Operation				
Nominal	5 to 40°C			
Maximum [34)]	55°C			
Storage	-25 to 55°C			
Transport	-25 to 70°C			
Relative humidity				
Operation	5 to 85%			
Storage	5 to 95%			
Transport	Max. 95% at 40°C			
Mechanical characteristics				
Dimensions [35)]				
Width	213.5 mm			
Height	317 mm			
Depth				
Wall mounting	-	263 mm	-	263 mm
Cold plate	212 mm	-	212 mm	-
Feed-through mounting	209 mm	-	209 mm	-
Weight	Approx. 8 kg	Approx. 10.2 kg	Approx. 8 kg	Approx. 10.9 kg
Module width	4			

Table 63: 8BVI0660HCSS.000-1, 8BVI0660HWSS.000-1, 8BVI0660HCSA.000-1, 8BVI0660HWSA.000-1 - Technical data

1) SLOT 2 is not occupied. SLOT 1 of the ACOPOSmulti module is occupied by the SafeMOTION module.
2) Valid in the following conditions: 750 VDC DC bus voltage, 5 kHz switching frequency, 40°C ambient temperature, installation elevation <500 m above sea level, no derating due to cooling type.
3) I_M... Current on the motor connection [A].
4) P_{SMC1} ... Max. power consumption P_{SMC} [W] of the SafeMOTION module in SLOT1 (see the "Encoder interfaces" section).
P_{SLOT2} ... Max. power consumption P_{8BAC} [W] of the plug-in module in SLOT2 (see the technical data for the respective plug-in module).
$P_{24\ V\ Out}$... Power [W] that is output to the connections X2/+24 V Out 1 and X2/+24 V Out 2 on the module (max. 10 W).
$P_{Fan8B0M...}$... Portion of the power [W] that is used by the fan modules in the mounting plate or the 8B0M0040HFF0.000-1 fan module (see the technical data for the respective 8B0M... mounting plate / 8B0M0040HFF0.000-1 fan module).
5) P_{SMC1} ... Max. power consumption P_{SMC} [W] of the SafeMOTION module in SLOT1 (see the "Encoder interfaces" section).
P_{SLOT2} ... Max. power consumption P_{8BAC} [W] of the plug-in module in SLOT2 (see the technical data for the respective plug-in module).
$P_{24\ V\ Out}$ ... Power [W] that is output to the connections X2/+24 V Out 1 and X2/+24 V Out 2 on the module (max. 10 W).
$P_{Fan8B0M...}$ ... Portion of the power [W] that is used by the fan modules in the mounting plate or the 8B0M0040HFF0.000-1 fan module (see the technical data for the respective 8B0M... mounting plate / 8B0M0040HFF0.000-1 fan module).
6) Only 8BCM motor cables from B&R are permitted to be connected to the motor connectors.
7) Valid in the following conditions: 750 VDC DC bus voltage. The temperature specifications refer to the ambient temperature.
8) Value for the nominal switching frequency.
9) The module cannot supply the full continuous current at this switching frequency. This unusual value for the ambient temperature, at which derating of the continuous current must be taken into account, ensures that the derating of the continuous current can be determined in the same manner as at other switching frequencies.
10) Valid in the following conditions: 750 VDC DC bus voltage, minimum permissible coolant flow volume (3 l/min).
11) The temperature specifications refer to the return temperature of the cold plate mounting plate.
12) The module cannot supply the full continuous current at this switching frequency. This unusual value for the return temperature, at which derating of the continuous current must be taken into account, ensures that the derating of the continuous current can be determined in the same manner as at other switching frequencies.
Caution! Condensation can occur at low flow temperatures and return temperatures.
13) B&R recommends operating the module at its nominal switching frequency. Operating the module at a higher switching frequency for application-specific reasons reduces the continuous current and increases the CPU load.
14) If necessary, the stress of the motor isolation system can be reduced by an additional externally wired dU/dt choke. For example, the RWK 305 three-phase du/dt choke from Schaffner (www.schaffner.com) can be used. Important: Even when using a dU/dt choke, it is necessary to ensure that an EMC-compatible, low inductance shield connection is used!
15) The module's electrical output frequency (SCTRL_SPEED_ACT * MOTOR_POLEPAIRS) is monitored to protect against dual use in accordance with EC regulation 428/2009 | 3A225. If the electrical output frequency of the module exceeds the limit value of 598 Hz uninterrupted for more than 0.5 s, then the current movement is aborted and error 6060 is output (Power element: Limit speed exceeded).
16) The connection is made with cable lugs using an M8 threaded bolt. The rated cross section of the cable lug must match the wire cross section of the cable that is to be connected.
17) The maximum diameter that can be clamped depends on the shield component set.
18) During project development, it is necessary to check if the minimum voltage can be maintained on the holding brake with the specified wiring. The operating voltage range of the holding brake can be found in the user's manual for the respective motor.
19) The specified value is only valid under the following conditions:
- The 24 VDC supply for the module is provided by an 8B0C auxiliary supply module installed on the same mounting plate.
- Connection between S1 and S2 (activation of the external holding brake) using a jumper with a max. length of 10 cm.
If the 24 VDC supply for the module is applied to the mounting plate using an 8BVE expansion module, then the output voltage is reduced because of voltage drops on the expansion cable. In this case, undervoltage monitoring must be disabled.
If jumpers longer than 10 cm are used to connect S1 and S2, then the output voltage is reduced because of voltage drops on the jumpers.
20) Only 8BCF EnDat 2.2 cables from B&R are permitted to be connected to the encoder interfaces.
21) An EnDat 2.2 functional safety encoder is required when using ACOPOSmulti SafeMOTION inverter modules! With standard EnDat 2.2 encoders, only the STO, SBC and SS1 functions are monitored with respect to timing!
22) The maximum encoder cable length l_{max} can be calculated as follows (the maximum permissible encoder cable length of 100 m must not be exceeded):

$l_{max} = 7.9 / I_G * A * 1/(2*\rho)$

I_G ... Max. current consumption of the encoder [A].
A ... Cross section of the supply wire [mm²].
ρ ... Specific resistance [Ω mm²/m] (e.g. for copper: ρ = 0.0178).
23) The maximum permitted cable length is 50 m.

24) During the power-on procedure for the encoder supply voltage (2 seconds), the monitoring limit for the supply voltage is increased from 5.25 V to 6 V. In this phase, overvoltages up to 6 V are not detected.
A short-term overvoltage of maximum 6 V should not damage the encoder electronics in any way.
An undervoltage on the encoder supply will result in a sine or cosine signal outside the specification.
25) An actual reserve of 12 mA exists for the terminating resistor.
26) The sine-cosine output signals from the measuring instrument are checked by the evaluation circuit using pointer length monitoring.
The pointer length $z = 2\sqrt{(Sin - nSin)^2 + (Cos - nCos)^2}$ is monitored according to the specified limits.
27) The sine-cosine output signals from the measuring instrument are checked by the evaluation circuit using pointer length monitoring.
The pointer length $z = 2\sqrt{(Sin - nSin)^2 + (Cos - nCos)^2}$ is also monitored according to the specified limits from the time the evaluation circuit is switched on until a signal period has passed.
28) The sine-cosine output signals from the measuring instrument are checked by the evaluation circuit using pointer length monitoring.
The pointer length $z = 2\sqrt{(Sin - nSin)^2 + (Cos - nCos)^2}$ is only permitted to vary by maximum ±10% per signal period.
29) This value does not correspond to the encoder resolution that must be configured in Automation Studio (16384 * number of encoder lines).
30) Limited by the encoder in practice.
31) $I_{Encoder}$ ... Max. power consumption of the connected encoder [A].
32) Continuous operation at elevations ranging from 500 m to 4000 m above sea level is possible (taking the specified continuous current reductions into consideration).
33) This value only applies in its delivered state (SLOT2 of the module is sealed by a slot cover / shield plate). If SLOT2 on the module is not sealed, then the level of protection is reduced to IP10. It is important to note that a 8SCS005.0000-00 shield set (slot cover / shield plate) or plug-in module must always be inserted!
34) Continuous operation at ambient temperatures ranging from 40°C to max. 55°C is possible (taking the specified continuous current reductions into consideration), but this will result in a shorter service life.
35) These dimensions refer to the actual device dimensions including the respective mounting plate. Make sure to leave additional space above and below the devices for mounting, connections and air circulation.

3.6.1.4 Wiring

For details, see 3.6.3 "Wiring: Safe 4x width inverter modules (single-axis modules)" on page 123.

For general information, see 6 "Wiring" on page 142.

3.6.2 8BVI0880HCSS.004-1, 8BVI0880HWSS.004-1, 8BVI0880HCSA.004-1, 8BVI0880HWSA.004-1

3.6.2.1 General information

- Clearly structured, straightforward implementation via network-based safety technology
- Modular expandability through virtual wiring
- Immediate triggering of safety function due to short cycle times
- Easy implementation with transparent control and status information, even in the standard application
- Compact design

3.6.2.2 Order data

Model number	Short description	Figure
	Cold plate or feed-through mounting	
8BVI0880HCSS.004-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 88 A, HV, cold plate or feed-through mounting	
8BVI0880HCSA.004-1	ACOPOSmulti SafeMOTION SinCos inverter module, 88 A, HV, cold plate or feed-through mounting	
	Wall mounting	
8BVI0880HWSS.004-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 88 A, HV, wall mounting	
8BVI0880HWSA.004-1	ACOPOSmulti SafeMOTION SinCos inverter module, 88 A, HV, wall mounting	
	Required accessories	
	Terminal block sets	
8BZVI1650SS.000-1A	Screw clamp set for ACOPOSmulti 8BVI0660HxSS, 8BVI0880HxSS, 8BVI1650HxSS, 8BVI0660HxSA, 8BVI0880HxSA and 8BVI1650HxSA modules: 1x 8TB2104.203L-00, 1x 8TB2108.2010-00	
	Optional accessories	
	Accessory sets	
8BXB000.0000-00	ACPmulti accessory set for encoder buffering consisting of: 1 lithium battery AA 3.6 V; 1 protective cap for battery holder	
	Fan modules	
8BXF001.0000-00	ACOPOSmulti fan module, replacement fan for ACOPOSmulti modules (8BVP / 8B0C / 8BVI / 8BVE / 8B0K)	
	POWERLINK cables	
X20CA0E61.00020	POWERLINK connection cable, RJ45 to RJ45, 0.2 m	
X20CA0E61.00025	POWERLINK connection cable, RJ45 to RJ45, 0.25 m	
X20CA0E61.00030	POWERLINK connection cable, RJ45 to RJ45, 0.3 m	
X20CA0E61.00035	POWERLINK connection cable, RJ45 to RJ45, 0.35 m	
X20CA0E61.00050	POWERLINK connection cable, RJ45 to RJ45, 0.5 m	
X20CA0E61.00100	POWERLINK connection cable, RJ45 to RJ45, 1 m	
	Plug-in modules	
8BAC0120.000-1	ACOPOSmulti plug-in module, EnDat 2.1 interface	
8BAC0120.001-2	ACOPOSmulti plug-in module, EnDat 2.2 interface	
8BAC0121.000-1	ACOPOSmulti plug-in module, HIPERFACE interface	
8BAC0122.000-1	ACOPOSmulti plug-in module, resolver interface 10 kHz	
8BAC0123.000-1	ACOPOSmulti plug-in module, incremental encoder and SSI absolute encoder interface for RS422 signals	
8BAC0123.001-1	ACOPOSmulti plug-in module, incremental encoder interface for 5 V single-ended and 5 V differential signals	
8BAC0123.002-1	ACOPOSmulti plug-in module, incremental encoder interface for 24 V single-ended and 24 V differential signals	
8BAC0124.000-1	ACOPOSmulti plug-in module, SinCos interface	
8BAC0125.000-1	ACOPOSmulti plug-in module, SinCos EnDat 2.1/SSI interface	
8BAC0130.000-1	ACOPOSmulti plug-in module, 2 digital outputs, 50 mA, max. 62,5 kHz, 4 digital outputs, 500 mA, max. 1,25 kHz, 2 digital inputs 24 VDC	
8BAC0130.001-1	ACOPOSmulti plug-in module, 2 digital outputs, 50 mA, max. 62.5 kHz, 4 digital outputs, 500 mA, max. 1.25 kHz	
8BAC0132.000-1	ACOPOSmulti input module, 4 analog inputs ±10 V	
8BAC0133.000-1	ACOPOSmulti plug-in module, 3 RS422 outputs for ABR encoder emulation, 1 Mhz	
	Shield component sets	
8SCS001.0000-00	ACOPOSmulti shield component set: 1x shield plate 4x type 1; 1x hose clamp, B 9 mm, D 12-22 mm	
8SCS002.0000-00	ACOPOSmulti shield component set: 1x clamping plate; 2x clamps D 4-13.5 mm; 4x screws	
8SCS003.0000-00	ACOPOSmulti shield component set: 1x shield mounting plate 4x 45°; 8x screws	
8SCS004.0000-00	ACOPOSmulti shield component set: 1x shield plate 4x type 0; 2x hose clamps, B 9 mm, D 32-50 mm	

Table 64: 8BVI0880HCSS.004-1, 8BVI0880HCSA.004-1, 8BVI0880HWSS.004-1, 8BVI0880HWSA.004-1 - Order data

Model number	Short description	Figure
8SCS010.0000-00	ACOPOSmulti shield component set: 1x ACOPOSmulti holding plate SK14-20; 1x shield terminal SK20	
	Terminal blocks	
8TB2104.203L-00	Screw clamp 4-pin, single row, spacing: 5.08 mm, label 3: T- T + B- B+, L keying: 1010	
8TB2106.2010-00	Screw clamp 6-pin, single row, spacing: 5.08 mm, label 1: numbered serially	
8TB2108.2010-00	Screw clamp 8-pin, single row, spacing: 5.08 mm, label 1: numbered serially	

Table 64: 8BVI0880HCSS.004-1, 8BVI0880HCSA.004-1, 8BVI0880HWSS.004-1, 8BVI0880HWSA.004-1 - Order data

Information:

Only 8BCM motor cables from B&R are permitted to be connected to the motor connectors.

ACOPOSmulti SafeMOTION EnDat 2.2

Information:

Only 8BCF EnDat 2.2 cables from B&R or 8BCH hybrid motor cables from B&R are permitted to be connected to the encoder interfaces.

ACOPOSmulti SafeMOTION SinCos

Information:

Only 8BCS encoder cables from B&R are permitted to be connected to the encoder interfaces on B&R standard motors.

For details, see 1.2 "Safe power transmission system " on page 167.

3.6.2.3 Technical data

Product ID	8BVI0880HCSS.004-1	8BVI0880HWSS.004-1	8BVI0880HCSA.004-1	8BVI0880HWSA.004-1
General information				
B&R ID code	0xB450	0xB451	0xDD1E	0xE0BA
Cooling and mounting method	Cold plate or feed-through mounting	Wall mounting	Cold plate or feed-through mounting	Wall mounting
Slots for plug-in modules	2 1)			
Certification				
CE	Yes			
cULus	Yes			
KC	Yes		-	
FSC	Yes			
DC bus connection				
Voltage				
Nominal	750 VDC			
Continuous power consumption 2)	65 kW			
Power loss depending on the switching frequency 3)				
Switching frequency 5 kHz	$[0.03 * I_M^2 + 7.9 * I_M + 90]$ W			
Switching frequency 10 kHz	$[0.11 * I_M^2 + 11 * I_M + 185]$ W			
Switching frequency 20 kHz	$[0.17 * I_M^2 + 27 * I_M + 310]$ W			
DC bus capacitance	1980 µF			
Design	ACOPOSmulti backplane			
24 VDC supply				
Input voltage	25 VDC ±1.6%			
Input capacitance	32.9 µF			
Max. power consumption	33 W + P_{SMC1} + P_{SLOT2} + $P_{24\ V\ Out}$ + $P_{HoldingBrake}$ + 4 * $P_{Fan8B0M...}$ 4)		25 W + P_{SMC1} + P_{SLOT2} + $P_{24\ V\ Out}$ + $P_{HoldingBrake}$ + $P_{Fan8B0M...}$ 5)	
Design	ACOPOSmulti backplane			
24 VDC output				
Quantity	2			
Output voltage				
DC bus voltage (U_{DC}): 260 to 315 VDC	25 VDC * (U_{DC}/315)			
DC bus voltage (U_{DC}): 315 to 800 VDC	24 VDC ±6%			
Protection	250 mA (slow-blow) electronic, automatic reset			
Motor connection 6)				
Quantity	1			

Table 65: 8BVI0880HCSS.004-1, 8BVI0880HWSS.004-1, 8BVI0880HCSA.004-1, 8BVI0880HWSA.004-1 - Technical data

Product ID	8BVI0880HCSS.004-1	8BVI0880HWSS.004-1	8BVI0880HCSA.004-1	8BVI0880HWSA.004-1
Continuous power per motor connection [2]	64 kW			
Continuous current per motor connection [2]	88 A_{eff}			
Reduction of continuous current depending on the switching frequency [7]				
Switching frequency 5 kHz	-	1.4 A/K (from 41°C) [8]	-	1.4 A/K (from 41°C) [8]
Switching frequency 10 kHz	-	0.92 A/K (from -5°C) [9]	-	0.92 A/K (from -5°C) [9]
Switching frequency 20 kHz	-	0.56 A/K (from -90°C) [9]	-	0.56 A/K (from -90°C) [9]
Reduction of continuous current depending on the switching frequency and mounting method [10]				
Switching frequency 5 kHz				
Cold plate mounting [11]	1.9 A/K (from 58°C) [8]	-	1.9 A/K (from 58°C) [8]	-
Feed-through mounting	1.82 A/K (from 40°C) [8]	-	1.82 A/K (from 40°C) [8]	-
Switching frequency 10 kHz				
Cold plate mounting [11]	1.36 A/K (from 27°C) [12]	-	1.36 A/K (from 27°C) [12]	-
Feed-through mounting	0.88 A/K (from -12°C) [9]	-	0.88 A/K (from -12°C) [9]	-
Switching frequency 20 kHz				
Cold plate mounting [11]	0.75 A/K (from -37°C) [12]	-	0.75 A/K (from -37°C) [12]	-
Feed-through mounting	0.54 A/K (from 106°C) [9]	-	0.54 A/K (from -106°C) [9]	-
Reduction of continuous current depending on the installation elevation				
Starting at 500 m above sea level	8.8 A_{eff} per 1000 m			
Peak current	176 A_{eff}			
Nominal switching frequency	5 kHz			
Possible switching frequencies [13]	5/10/20 kHz			
Electrical stress of the connected motor in accordance with IEC TS 60034-25 [14]	Limit value curve A			
Protective measures				
Overload protection	Yes			
Short circuit and ground fault protection	Yes			
Max. output frequency	598 Hz [15]			
Design				
U, V, W, PE	M8 threaded bolt			
Shield connection	Yes			
Connection cross section range				
Flexible and fine wire lines	6 to 50 mm² [16]			
Approbation data				
UL/C-UL-US	In preparation			
CSA	In preparation			
Terminal cable cross section dimension of shield connection	12 to 50 mm [17]			
Max. motor line length depending on the switching frequency				
Switching frequency 5 kHz	25 m			
Switching frequency 10 kHz	25 m			
Switching frequency 20 kHz	25 m			
Motor holding brake connection				
Quantity	1			
Output voltage [18]	24 VDC +5.8% / -0.5% [19]			
Continuous current	4.2 A			
Max. internal resistance	0.15 Ω			
Extinction potential	Approx. 30 V			
Max. extinction energy per switching operation	3 Ws			
Max. switching frequency	0.5 Hz			
Protective measures				
Overload and short circuit protection	Yes			
Open line monitoring	Yes			
Undervoltage monitoring	Yes			
Response threshold for open line monitoring	Approx. 0.5 A			
Response threshold for undervoltage monitoring	24 VDC -2% / -4%			
Encoder interfaces [20]				
Quantity	1			
Type	EnDat 2.2 [21]		SinCos	
Connections	9-pin female DSUB connector		15-pin female DSUB connector	
Status indicators	UP/DN LEDs			
Electrical isolation				
Encoder - ACOPOSmulti	No			
Encoder monitoring	Yes			

Table 65: 8BVI0880HCSS.004-1, 8BVI0880HWSS.004-1, 8BVI0880HCSA.004-1, 8BVI0880HWSA.004-1 - Technical data

Product ID	8BVI0880HCSS.004-1	8BVI0880HWSS.004-1	8BVI0880HCSA.004-1	8BVI0880HWSA.004-1
Max. encoder cable length	100 m Depends on the cross section of the encoder's supply wires [22]		50 m [23]	
Encoder supply				
Output voltage	Typ. 12.5 V		5 V ±5% [24]	
Load capability	350 mA		300 mA [25]	
Sense lines	-		2, compensation of max. 2 x 0.7 V	
Protective measures				
Short circuit protection	Yes			
Overload protection	Yes			
Synchronous serial interface				
Signal transmission	RS485			
Data transfer rate	6.25 Mbit/s		781.25 kbit/s	
Sine/Cosine inputs				
Signal transmission	-		Differential signals, symmetrical	
Differential voltage				
In motion	-		0.5 to 1.35 V [26]	
At standstill	-		0.8 to 1.35 V [27]	
Differential voltage deviation per signal period	-		±10% [28]	
Common-mode voltage	-		Max. ±7 V	
Terminating resistors	-		120 Ω	
Max. input frequency	-		200 kHz	
Signal frequency (-5 dB)	-		<300 kHz	
Signal frequency (-3 dB)	-		DC up to 200 kHz	
ADC resolution	-		12-bit	
Reference input				
Signal transmission	-		Differential signal, symmetrical	
Differential voltage for low	-		≤ -0.2 V	
Differential voltage for high	-		≥ 0.2 V	
Common-mode voltage	-		Max. -5 V to +9 V	
Terminating resistors	-		120 Ω	
Position				
Resolution @ 1 V_{SS} [29]	-		Number of encoder lines * 5700	
Precision [30]	-		---	
Noise [30]	-		---	
Max. power consumption per encoder interface	P_{SMC}[W] = 19 V * $I_{Encoder}$[A] [31]		P_{SMC}[W] = 25 V * (0.376 A + 0.35 * $I_{Encoder}$[A]) [31]	
Trigger inputs				
Quantity	2			
Wiring	Sink			
Electrical isolation				
Input - Inverter module	Yes			
Input - Input	Yes			
Input voltage				
Nominal	24 VDC			
Maximum	30 VDC			
Switching threshold				
Low	<5 V			
High	>15 V			
Input current at nominal voltage	Approx. 10 mA			
Switching delay				
Rising edge	52 µs ±0.5 µs (digitally filtered)			
Falling edge	53 µs ±0.5 µs (digitally filtered)			
Modulation compared to ground potential	Max. ±38 V			
Electrical characteristics				
Discharge capacitance	0.45 µF			
Operating conditions				
Permitted mounting orientations				
Hanging vertically	Yes			
Lying horizontally	Yes			
Standing horizontally	No			
Installation at elevations above sea level				
Nominal	0 to 500 m			
Maximum [32]	4000 m			
Degree of pollution in accordance with EN 60664-1	2 (non-conductive pollution)			
Overvoltage category in accordance with IEC 60364-4-443:1999	III			
EN 60529 protection	IP20 [33]			

Table 65: 8BVI0880HCSS.004-1, 8BVI0880HWSS.004-1, 8BVI0880HCSA.004-1, 8BVI0880HWSA.004-1 - Technical data

Product ID	8BVI0880HCSS.004-1	8BVI0880HWSS.004-1	8BVI0880HCSA.004-1	8BVI0880HWSA.004-1
Environmental conditions				
Temperature				
Operation				
Nominal	5 to 40°C			
Maximum 34)	55°C			
Storage	-25 to 55°C			
Transport	-25 to 70°C			
Relative humidity				
Operation	5 to 85%			
Storage	5 to 95%			
Transport	Max. 95% at 40°C			
Mechanical characteristics				
Dimensions 35)				
Width	213.5 mm			
Height	317 mm			
Depth				
Wall mounting	-	263 mm	-	263 mm
Cold plate	212 mm	-	212 mm	-
Feed-through mounting	209 mm	-	209 mm	-
Weight	Approx. 8 kg	Approx. 10.2 kg	Approx. 8 kg	Approx. 10.9 kg
Module width	4			

Table 65: 8BVI0880HCSS.004-1, 8BVI0880HWSS.004-1, 8BVI0880HCSA.004-1, 8BVI0880HWSA.004-1 - Technical data

1) SLOT 2 is not occupied. SLOT 1 of the ACOPOSmulti module is occupied by the SafeMOTION module.
2) Valid in the following conditions: 750 VDC DC bus voltage, 5 kHz switching frequency, 40°C ambient temperature, installation elevation <500 m above sea level, no derating due to cooling type.
3) I_M... Current on the motor connection [A].
4) P_{SMC1} ... Max. power consumption P_{SMC} [W] of the SafeMOTION module in SLOT1 (see the "Encoder interfaces" section).
P_{SLOT2} ... Max. power consumption P_{8BAC} [W] of the plug-in module in SLOT2 (see the technical data for the respective plug-in module).
$P_{24\ V\ Out}$... Power [W] that is output to the connections X2/+24 V Out 1 and X2/+24 V Out 2 on the module (max. 10 W).
$P_{Fan8B0M...}$... Portion of the power [W] that is used by the fan modules in the mounting plate or the 8B0M0040HFF0.000-1 fan module (see the technical data for the respective 8B0M... mounting plate / 8B0M0040HFF0.000-1 fan module).
5) P_{SMC1} ... Max. power consumption P_{SMC} [W] of the SafeMOTION module in SLOT1 (see the "Encoder interfaces" section).
P_{SLOT2} ... Max. power consumption P_{8BAC} [W] of the plug-in module in SLOT2 (see the technical data for the respective plug-in module).
$P_{24\ V\ Out}$ ... Power [W] that is output to the connections X2/+24 V Out 1 and X2/+24 V Out 2 on the module (max. 10 W).
$P_{Fan8B0M...}$ ... Portion of the power [W] that is used by the fan modules in the mounting plate or the 8B0M0040HFF0.000-1 fan module (see the technical data for the respective 8B0M... mounting plate / 8B0M0040HFF0.000-1 fan module).
6) Only 8BCM motor cables from B&R are permitted to be connected to the motor connectors.
7) Valid in the following conditions: 750 VDC DC bus voltage. The temperature specifications refer to the ambient temperature.
8) Value for the nominal switching frequency.
9) The module cannot supply the full continuous current at this switching frequency. This unusual value for the ambient temperature, at which derating of the continuous current must be taken into account, ensures that the derating of the continuous current can be determined in the same manner as at other switching frequencies.
10) Valid in the following conditions: 750 VDC DC bus voltage, minimum permissible coolant flow volume (3 l/min).
11) The temperature specifications refer to the return temperature of the cold plate mounting plate.
12) The module cannot supply the full continuous current at this switching frequency. This unusual value for the return temperature, at which derating of the continuous current must be taken into account, ensures that the derating of the continuous current can be determined in the same manner as at other switching frequencies.
Caution! Condensation can occur at low flow temperatures and return temperatures.
13) B&R recommends operating the module at its nominal switching frequency. Operating the module at a higher switching frequency for application-specific reasons reduces the continuous current and increases the CPU load.
14) If necessary, the stress of the motor isolation system can be reduced by an additional externally wired dU/dt choke. For example, the RWK 305 three-phase du/dt choke from Schaffner (www.schaffner.com) can be used. Important: Even when using a dU/dt choke, it is necessary to ensure that an EMC-compatible, low inductance shield connection is used!
15) The module's electrical output frequency (SCTRL_SPEED_ACT * MOTOR_POLEPAIRS) is monitored to protect against dual use in accordance with EC regulation 428/2009 | 3A225. If the electrical output frequency of the module exceeds the limit value of 598 Hz uninterrupted for more than 0.5 s, then the current movement is aborted and error 6060 is output (Power element: Limit speed exceeded).
16) The connection is made with cable lugs using an M8 threaded bolt. The rated cross section of the cable lug must match the wire cross section of the cable that is to be connected.
17) The maximum diameter that can be clamped depends on the shield component set.
18) During project development, it is necessary to check if the minimum voltage can be maintained on the holding brake with the specified wiring. The operating voltage range of the holding brake can be found in the user's manual for the respective motor.
19) The specified value is only valid under the following conditions:
- The 24 VDC supply for the module is provided by an 8B0C auxiliary supply module installed on the same mounting plate.
- Connection between S1 and S2 (activation of the external holding brake) using a jumper with a max. length of 10 cm.
If the 24 VDC supply for the module is applied to the mounting plate using an 8BVE expansion module, then the output voltage is reduced because of voltage drops on the expansion cable. In this case, undervoltage monitoring must be disabled.
If jumpers longer than 10 cm are used to connect S1 and S2, then the output voltage is reduced because of voltage drops on the jumpers.
20) Only 8BCF EnDat 2.2 cables from B&R are permitted to be connected to the encoder interfaces.
21) An EnDat 2.2 functional safety encoder is required when using ACOPOSmulti SafeMOTION inverter modules! With standard EnDat 2.2 encoders, only the STO, SBC and SS1 functions are monitored with respect to timing!
22) The maximum encoder cable length l_{max} can be calculated as follows (the maximum permissible encoder cable length of 100 m must not be exceeded):

$l_{max} = 7.9 / I_G * A * 1/(2*\rho)$

I_G ... Max. current consumption of the encoder [A].
A ... Cross section of the supply wire [mm²].
ρ ... Specific resistance [Ω mm²/m] (e.g. for copper: ρ = 0.0178).
23) The maximum permitted cable length is 50 m.

24) During the power-on procedure for the encoder supply voltage (2 seconds), the monitoring limit for the supply voltage is increased from 5.25 V to 6 V. In this phase, overvoltages up to 6 V are not detected.
A short-term overvoltage of maximum 6 V should not damage the encoder electronics in any way.
An undervoltage on the encoder supply will result in a sine or cosine signal outside the specification.
25) An actual reserve of 12 mA exists for the terminating resistor.
26) The sine-cosine output signals from the measuring instrument are checked by the evaluation circuit using pointer length monitoring.
The pointer length $z = 2 \sqrt{(Sin - nSin)^2 + (Cos - nCos)^2}$ is monitored according to the specified limits.
27) The sine-cosine output signals from the measuring instrument are checked by the evaluation circuit using pointer length monitoring.
The pointer length $z = 2 \sqrt{(Sin - nSin)^2 + (Cos - nCos)^2}$ is also monitored according to the specified limits from the time the evaluation circuit is switched on until a signal period has passed.
28) The sine-cosine output signals from the measuring instrument are checked by the evaluation circuit using pointer length monitoring.
The pointer length $z = 2 \sqrt{(Sin - nSin)^2 + (Cos - nCos)^2}$ is only permitted to vary by maximum ±10% per signal period.
29) This value does not correspond to the encoder resolution that must be configured in Automation Studio (16384 * number of encoder lines).
30) Limited by the encoder in practice.
31) $I_{Encoder}$ ... Max. power consumption of the connected encoder [A].
32) Continuous operation at elevations ranging from 500 m to 4000 m above sea level is possible (taking the specified continuous current reductions into consideration).
33) This value only applies in its delivered state (SLOT2 of the module is sealed by a slot cover / shield plate). If SLOT2 on the module is not sealed, then the level of protection is reduced to IP10. It is important to note that a 8SCS005.0000-00 shield set (slot cover / shield plate) or plug-in module must always be inserted!
34) Continuous operation at ambient temperatures ranging from 40°C to max. 55°C is possible (taking the specified continuous current reductions into consideration), but this will result in a shorter service life.
35) These dimensions refer to the actual device dimensions including the respective mounting plate. Make sure to leave additional space above and below the devices for mounting, connections and air circulation.

3.6.2.4 Wiring

For details, see 3.6.3 "Wiring: Safe 4x width inverter modules (single-axis modules)" on page 123.

For general information, see 6 "Wiring" on page 142.

3.6.3 Wiring: Safe 4x width inverter modules (single-axis modules)

3.6.3.1 ACOPOSmulti SafeMOTION EnDat 2.2 - Pinout overview

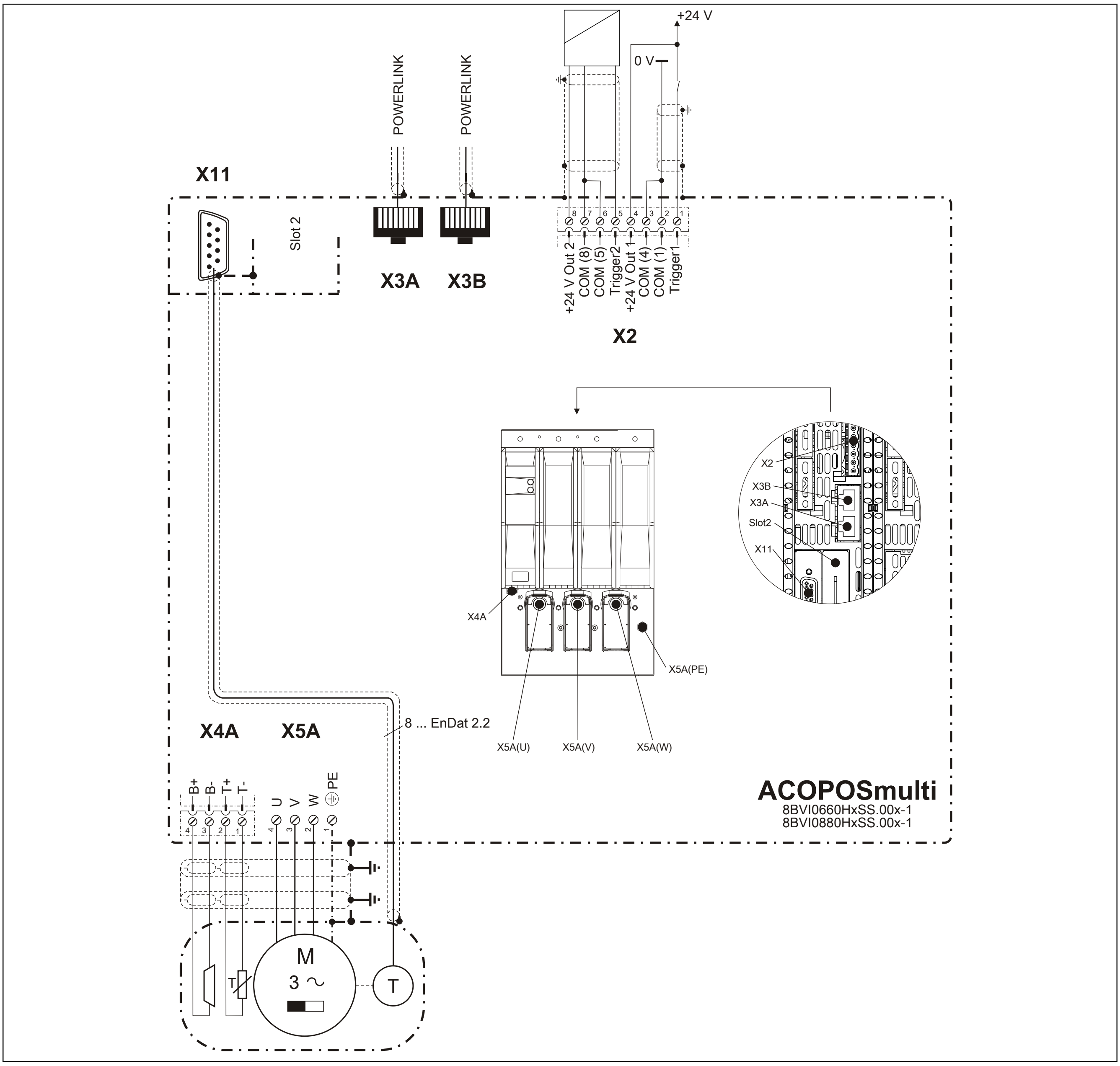


Figure 12: Pinout overview

3.6.3.2 ACOPOSmulti SafeMOTION SinCos - Pinout overview

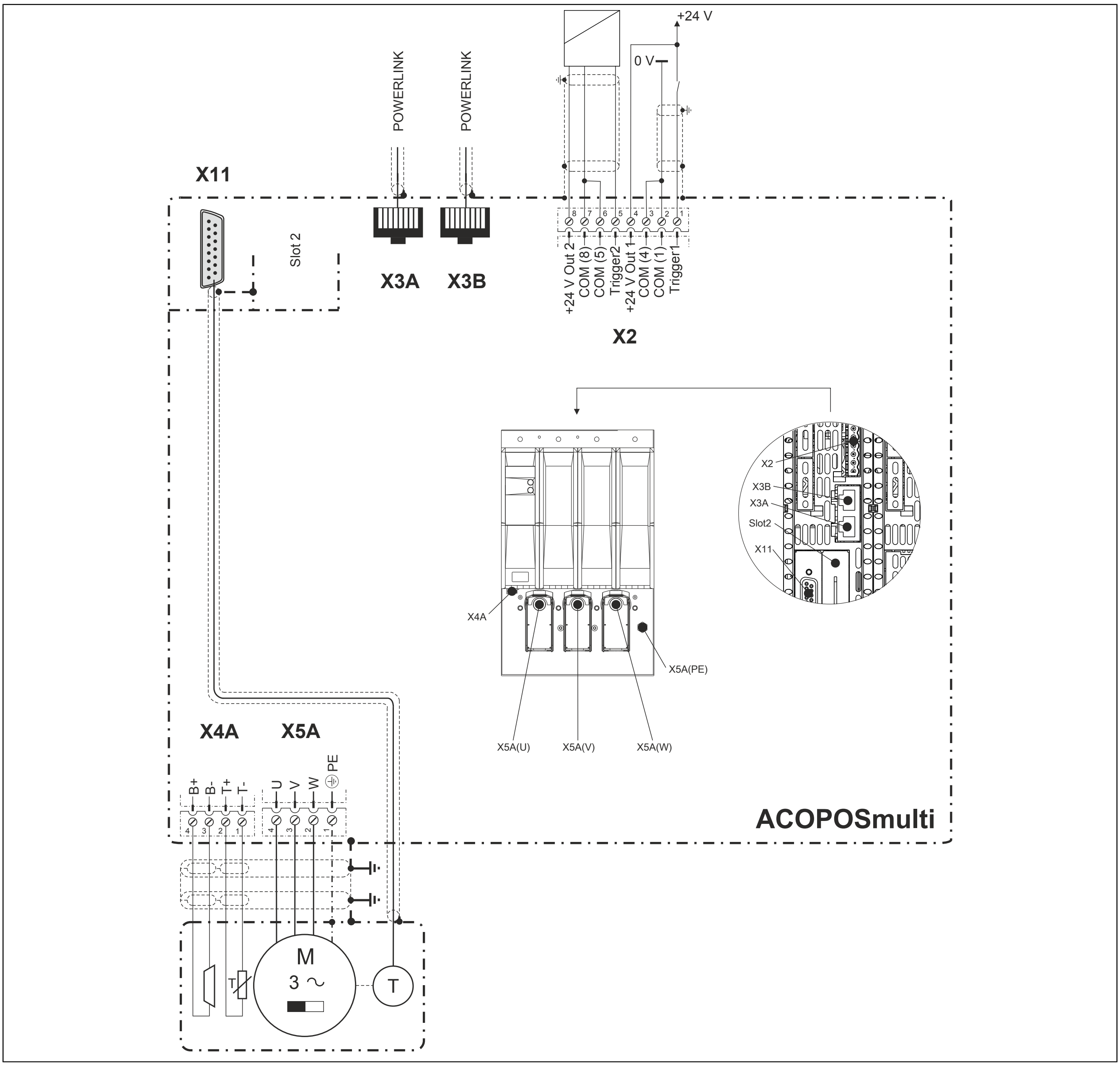


Figure 13: Pinout overview

3.6.3.3 X2 connector - Pinout

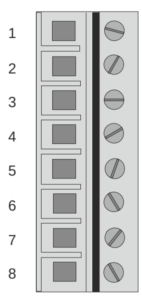
X2	Pin	Name	Function
	1	Trigger 1	Trigger 1
	2	COM (1)	Trigger 1 0 V
	3	COM (2)	+24 V output 1 0 V
	4	+24 V Out 1	+24 V output 1
	5	Trigger 2	Trigger 2
	6	COM (5)	Trigger 2 0 V
	7	COM (8)	+24 V output 2 0 V
	8	+24 V Out 2	+24 V output 2

Table 66: X2 connector - Pinout

3.6.3.4 X3A, X3B connectors - Pinout

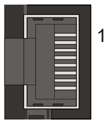
X3A, X3B	Pin	Name	Function
	1	RXD	Receive signal
	2	RXD\	Receive signal inverted
	3	TXD	Transmit signal
	4	Shield	Shield
	5	Shield	Shield
	6	TXD\	Transmit signal inverted
	7	Shield	Shield
	8	Shield	Shield

Table 67: X3A, X3B connectors - Pinout

3.6.3.5 X4A connector - Pinout

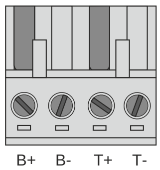
X4A	Name	Function
	T-	Axis 1: Temperature sensor -
	T+	Axis 1: Temperature sensor +
	B- [1)]	Axis 1: Brake -
	B+ [1)]	Axis 1: Brake +

Table 68: X4A connector - Pinout

1) Wiring is not permitted to exceed a total length of 3 m.

Danger!

The FUNCTIONAL FAIL SAFE state is activated if the SBC output B+ is shorted to 24 V (i.e. safe pulse disabling is activated). The brake always remains on/released, however, due to the short circuit to 24 V! This can lead to dangerous situations because the motor holding brake cannot brake or prevent the spin-out movement (or the unrestrained lowering in the case of hanging loads)!
Appropriate wiring measures must be implemented to ensure that the SBC output B+ is not shorted to 24 V!

Danger!

The SBC output

- **is not permitted to be wired to multiple modules!**
- **is not permitted to be wired as an open emitter!**
- **is not permitted to be wired as an open collector!**

Danger!

Only an output voltage of ≤5 V can be ensured for the safe motor holding brake output when shut off. When selecting a motor holding brake, the user must ensure that the required braking torque is reached at a voltage of 5 V.

Information:

The transistors of the SBC output stage are tested cyclically. When the output channels are active, this test emits low pulses on the output with a maximum length of 600 µs.

This must be taken into consideration when choosing the motor holding brake!

Danger!

The connections for the motor temperature sensors and the motor holding brake are safely isolated circuits. These connections are therefore only permitted to be connected to devices or components that have sufficient isolation in accordance with IEC 60364-4-41 or EN 61800-5-1.

Caution!

If B+ and B- are swapped when connecting the permanent magnet holding brakes, then the brakes cannot be opened! ACOPOSmulti inverter modules cannot determine if a holding brake is connected with reverse polarity!

Warning!

Temperature sensors are only permitted to be connected to the X4A/T+ and X4A/T- connectors on an ACOPOSmulti module under the following conditions:

- **There is no ACOPOSmulti plug-in module in SLOT1 on the ACOPOSmulti module with a temperature sensor connected to T+ and T-**

Otherwise, the temperature monitoring functions on the ACOPOSmulti module may become ineffective, which in extreme cases can cause the hardware (e.g. motors) connected to the ACOPOSmulti module to be destroyed!

3.6.3.6 X5A - Pinout

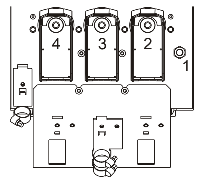
X5A	Name	Function
	1	Axis 1: Protective ground conductor
	2	Axis 1: Motor connection W
	3	Axis 1: Motor connection V
	4	Axis 1: Motor connection U

Table 69: X5A - Pinout

Information:

Only 8BCM motor cables from B&R are permitted to be connected to the motor connectors.

Motor connections U, V, W - Cable installation

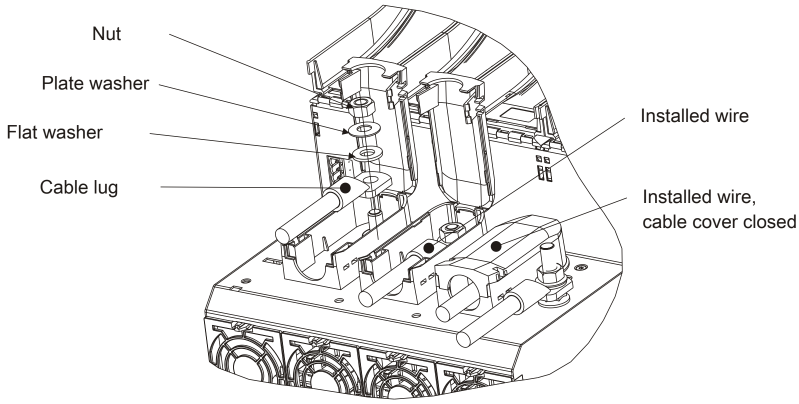


Figure 14: X5A - Cable installation

PE connection (1-wire) - Cable installation

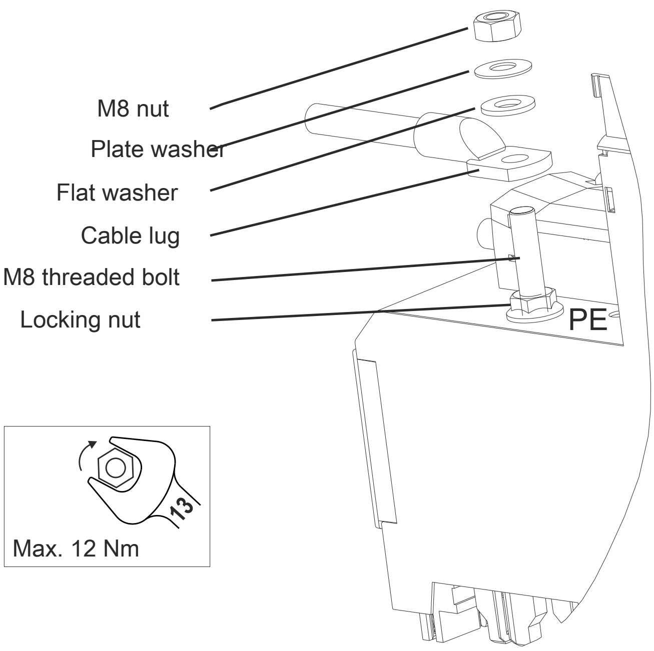
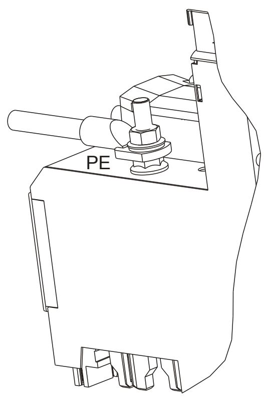
	
PE connection (1-wire) - Overview of installation material	Installed wire

Table 70: PE connection (1-wire) - Cable installation

PE connection (3-wire) - Cable installation

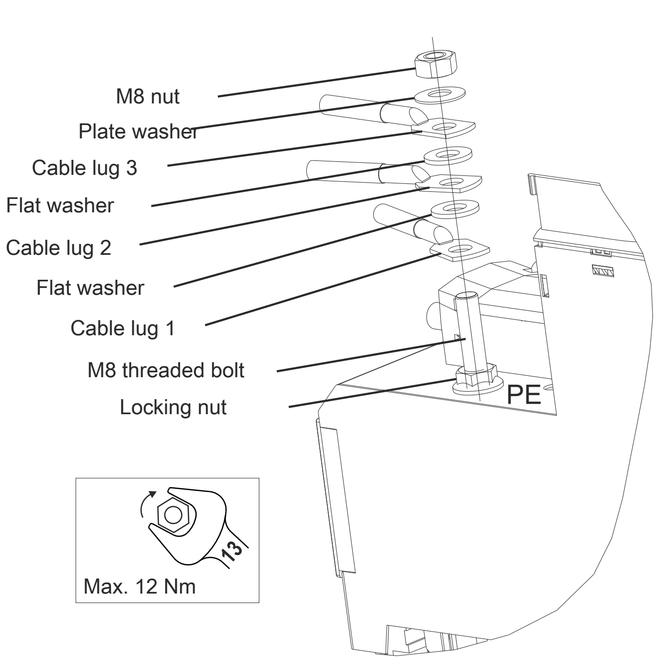
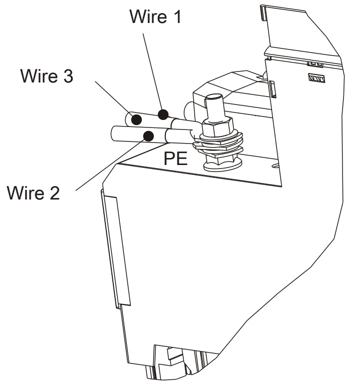
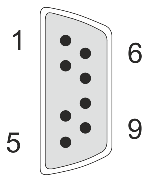
	
PE connection (3-wire) - Overview of installation material	Installed wire

Table 71: PE connection (3-wire) - Cable installation

3.6.3.7 SafeMOTION EnDat 2.2 module - Pinout

Figure	X11 (X12)	Pin	Name	Function
		1	U+	Encoder supply +12.5 V
		2	---	---
		3	---	---
		4	D	Data input
		5	T	Clock output
		6	COM (1)	Encoder supply 0 V
		7	---	---
		8	D\	Data input inverted
		9	T\	Clock output inverted

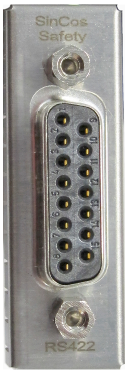
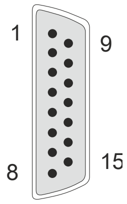
Information:

Only 8BCF EnDat 2.2 cables from B&R or 8BCH hybrid motor cables from B&R are permitted to be connected to the encoder interfaces.

Information:

SafeMOTION modules cannot be replaced! SafeMOTION modules and the corresponding inverter module form a single unit. In the event of an error, the entire inverter module must be replaced.

3.6.3.8 SafeMOTION SinCos module - Pinout

Figure	X11 (X12)	Pin	Name	Function
		1	A	Channel A/Sin
		2	COM	Ground
		3	B	Channel B/COS
		4	+5 V	Encoder supply +
		5	D	Data
		6	---	---
		7	R\	Reference pulse inverted/nREF
		8	T	Clock
		9	A\	Channel A inverted/nSIN
		10	Sense COM	Sense ground
		11	B\	Channel B inverted/nCOS
		12	Sense +5V	Sense input +5 V
		13	D\	Data inverted
		14	R	Reference pulse/REF
		15	T\	Clock cycle inverted

Information:

SafeMOTION modules cannot be replaced! SafeMOTION modules and the corresponding inverter module form a single unit. In the event of an error, the entire inverter module must be replaced.

3.7 Safe 8x width inverter modules (single-axis modules)

3.7.1 8BVI1650HCSS.000-1

3.7.1.1 General information

- Clearly structured, straightforward implementation via network-based safety technology
- Modular expandability through virtual wiring
- Immediate triggering of safety function due to short cycle times
- Easy implementation with transparent control and status information, even in the standard application
- Compact design

3.7.1.2 Order data

Model number	Short description	Figure
	Cold plate or feed-through mounting	
8BVI1650HCSS.000-1	ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, 165 A, HV, cold plate or feed-through mounting	
	Required accessories	
	Terminal block sets	
8BZVI1650SS.000-1A	Screw clamp set for ACOPOSmulti 8BVI0660HxSS, 8BVI0880HxSS, 8BVI1650HxSS, 8BVI0660HxSA, 8BVI0880HxSA and 8BVI1650HxSA modules: 1x 8TB2104.203L-00, 1x 8TB2108.2010-00	
	Optional accessories	
	Accessory sets	
8BXB000.0000-00	ACPmulti accessory set for encoder buffering consisting of: 1 lithium battery AA 3.6 V; 1 protective cap for battery holder	
	Fan modules	
8BXF001.0000-00	ACOPOSmulti fan module, replacement fan for ACOPOSmulti modules (8BVP / 8B0C / 8BVI / 8BVE / 8B0K)	
	Plug-in modules	
8BAC0120.000-1	ACOPOSmulti plug-in module, EnDat 2.1 interface	
8BAC0120.001-2	ACOPOSmulti plug-in module, EnDat 2.2 interface	
8BAC0121.000-1	ACOPOSmulti plug-in module, HIPERFACE interface	
8BAC0122.000-1	ACOPOSmulti plug-in module, resolver interface 10 kHz	
8BAC0123.000-1	ACOPOSmulti plug-in module, incremental encoder and SSI absolute encoder interface for RS422 signals	
8BAC0123.001-1	ACOPOSmulti plug-in module, incremental encoder interface for 5 V single-ended and 5 V differential signals	
8BAC0123.002-1	ACOPOSmulti plug-in module, incremental encoder interface for 24 V single-ended and 24 V differential signals	
8BAC0124.000-1	ACOPOSmulti plug-in module, SinCos interface	
8BAC0125.000-1	ACOPOSmulti plug-in module, SinCos EnDat 2.1/SSI interface	
8BAC0130.000-1	ACOPOSmulti plug-in module, 2 digital outputs, 50 mA, max. 62,5 kHz, 4 digital outputs, 500 mA, max. 1,25 kHz, 2 digital inputs 24 VDC	
8BAC0130.001-1	ACOPOSmulti plug-in module, 2 digital outputs, 50 mA, max. 62.5 kHz, 4 digital outputs, 500 mA, max. 1.25 kHz	
8BAC0132.000-1	ACOPOSmulti input module, 4 analog inputs ±10 V	
8BAC0133.000-1	ACOPOSmulti plug-in module, 3 RS422 outputs for ABR encoder emulation, 1 Mhz	
	POWERLINK cables	
X20CA0E61.00020	POWERLINK connection cable, RJ45 to RJ45, 0.2 m	
X20CA0E61.00025	POWERLINK connection cable, RJ45 to RJ45, 0.25 m	
X20CA0E61.00030	POWERLINK connection cable, RJ45 to RJ45, 0.3 m	
X20CA0E61.00035	POWERLINK connection cable, RJ45 to RJ45, 0.35 m	
X20CA0E61.00050	POWERLINK connection cable, RJ45 to RJ45, 0.5 m	
X20CA0E61.00100	POWERLINK connection cable, RJ45 to RJ45, 1 m	
	Shield component sets	
8SCS001.0000-00	ACOPOSmulti shield component set: 1x shield plate 4x type 1; 1x hose clamp, B 9 mm, D 12-22 mm	
8SCS002.0000-00	ACOPOSmulti shield component set: 1x clamping plate; 2x clamps D 4-13.5 mm; 4x screws	
8SCS003.0000-00	ACOPOSmulti shield component set: 1x shield mounting plate 4x 45°; 8x screws	
8SCS004.0000-00	ACOPOSmulti shield component set: 1x shield plate 4x type 0; 2x hose clamps, B 9 mm, D 32-50 mm	
8SCS010.0000-00	ACOPOSmulti shield component set: 1x ACOPOSmulti holding plate SK14-20; 1x shield terminal SK20	
	Terminal blocks	

Table 72: 8BVI1650HCSS.000-1 - Order data

Model number	Short description	Figure
8TB2104.203L-00	Screw clamp 4-pin, single row, spacing: 5.08 mm, label 3: T- T + B- B+, L keying: 1010	
8TB2108.2010-00	Screw clamp 8-pin, single row, spacing: 5.08 mm, label 1: numbered serially	

Table 72: 8BVI1650HCSS.000-1 - Order data

Information:

Only 8BCM motor cables from B&R are permitted to be connected to the motor connectors.

ACOPOSmulti SafeMOTION EnDat 2.2

Information:

Only 8BCF EnDat 2.2 cables from B&R or 8BCH hybrid motor cables from B&R are permitted to be connected to the encoder interfaces.

For details, see 1.2 "Safe power transmission system " on page 167.

3.7.1.3 Technical data

Product ID	8BVI1650HCSS.000-1
General information	
B&R ID code	0xB878
Cooling and mounting method	Cold plate or feed-through mounting
Slots for plug-in modules	2 [1)]
Certification	
CE	Yes
cULus	Yes
KC	Yes
FSC	Yes
DC bus connection	
Voltage	
Nominal	750 VDC
Continuous power consumption [2)]	121.8 kW
Power loss depending on the switching frequency [3)]	
Switching frequency 5 kHz	[0.001 * I_M^2 + 9.9 * I_M+ 165] W
Switching frequency 10 kHz	[0.17 * I_M^2 + 10.8 * I_M + 320] W
Switching frequency 20 kHz	In preparation
DC bus capacitance	3630 µF
Design	ACOPOSmulti backplane
24 VDC supply	
Input voltage	25 VDC ±1.6%
Input capacitance	32.9 µF
Max. power consumption	43 W + P_{SMC1} + P_{SLOT2} + $P_{24\ V\ Out}$ + $P_{HoldingBrake}$ + 4 * $P_{Fan8B0M...}$ [4)]
Design	ACOPOSmulti backplane
24 VDC output	
Quantity	2
Output voltage	
DC bus voltage (U_{DC}): 260 to 315 VDC	25 VDC * (U_{DC}/315)
DC bus voltage (U_{DC}): 315 to 800 VDC	24 VDC ±6%
Protection	250 mA (slow-blow) electronic, automatic reset
Motor connection [5)]	
Quantity	1
Continuous power per motor connection [2)]	120 kW
Continuous current per motor connection [2)]	165 A_{eff}
Reduction of continuous current depending on the switching frequency and mounting method [6)]	
Switching frequency 5 kHz	
Cold plate mounting [7)]	3.1 A/K (from 53°C) [8)]
Feed-through mounting	2.82 A/K (from 40°C) [8)]
Switching frequency 10 kHz	
Cold plate mounting [7)]	1.8 A/K (from 17°C) [9)]
Feed-through mounting	1.5 A/K (from -13°C) [10)]
Switching frequency 20 kHz	
Cold plate mounting [7)]	1.2 A/K (from -60°C) [9)]
Feed-through mounting	0.72 A/K (from 141°C) [10)]
Reduction of continuous current depending on the installation elevation	
Starting at 500 m above sea level	16.5 A_{eff} per 1000 m
Peak current	330 A_{eff}
Nominal switching frequency	5 kHz

Table 73: 8BVI1650HCSS.000-1 - Technical data

Product ID	8BVI1650HCSS.000-1
Possible switching frequencies [11]	5/10/20 kHz
Electrical stress of the connected motor in accordance with IEC TS 60034-25 [12]	Limit value curve A
Protective measures	
Overload protection	Yes
Short circuit and ground fault protection	Yes
Max. output frequency	598 Hz [13]
Design	
U, V, W, PE	M8 threaded bolt
Shield connection	Yes
Connection cross section range	
Flexible and fine wire lines	6 to 95 mm² [14]
Approbation data	
UL/C-UL-US	In preparation
CSA	In preparation
Terminal cable cross section dimension of shield connection	12 to 50 mm [15]
Max. motor line length depending on the switching frequency	
Switching frequency 5 kHz	25 m
Switching frequency 10 kHz	25 m
Switching frequency 20 kHz	25 m
Motor holding brake connection	
Quantity	1
Output voltage [16]	24 VDC +5.8% / -0.5% [17]
Continuous current	4.2 A
Max. internal resistance	0.15 Ω
Extinction potential	Approx. 30 V
Max. extinction energy per switching operation	3 Ws
Max. switching frequency	0.5 Hz
Protective measures	
Overload and short circuit protection	Yes
Open line monitoring	Yes
Undervoltage monitoring	Yes
Response threshold for open line monitoring	Approx. 0.5 A
Response threshold for undervoltage monitoring	24 VDC -2% / -4%
Encoder interfaces [18]	
Quantity	1
Type	EnDat 2.2 [19]
Connections	9-pin female DSUB connector
Status indicators	UP/DN LEDs
Electrical isolation	
Encoder - ACOPOSmulti	No
Encoder monitoring	Yes
Max. encoder cable length	100 m Depends on the cross section of the encoder's supply wires [20]
Encoder supply	
Output voltage	Typ. 12.5 V
Load capability	350 mA
Protective measures	
Short circuit protection	Yes
Overload protection	Yes
Synchronous serial interface	
Signal transmission	RS485
Data transfer rate	6.25 Mbit/s
Max. power consumption per encoder interface	P_{SMC}[W] = 19 V * $I_{Encoder}$[A] [21]
Trigger inputs	
Quantity	2
Wiring	Sink
Electrical isolation	
Input - Inverter module	Yes
Input - Input	Yes
Input voltage	
Nominal	24 VDC
Maximum	30 VDC
Switching threshold	
Low	<5 V
High	>15 V
Input current at nominal voltage	Approx. 10 mA
Switching delay	
Rising edge	52 µs ±0.5 µs (digitally filtered)
Falling edge	53 µs ±0.5 µs (digitally filtered)
Modulation compared to ground potential	Max. ±38 V
Electrical characteristics	
Discharge capacitance	0.9 µF

Table 73: 8BVI1650HCSS.000-1 - Technical data

Product ID	8BVI1650HCSS.000-1
Operating conditions	
Permitted mounting orientations	
Hanging vertically	Yes
Lying horizontally	Yes
Standing horizontally	No
Installation at elevations above sea level	
Nominal	0 to 500 m
Maximum [22]	4000 m
Degree of pollution in accordance with EN 60664-1	2 (non-conductive pollution)
Overvoltage category in accordance with IEC 60364-4-443:1999	III
EN 60529 protection	IP20 [23]
Environmental conditions	
Temperature	
Operation	
Nominal	5 to 40°C
Maximum [24]	55°C
Storage	-25 to 55°C
Transport	-25 to 70°C
Relative humidity	
Operation	5 to 85%
Storage	5 to 95%
Transport	Max. 95% at 40°C
Mechanical characteristics	
Dimensions [25]	
Width	427.5 mm
Height	317 mm
Depth	
Cold plate	212 mm
Feed-through mounting	209 mm
Weight	Approx. 19.5 kg
Module width	8

Table 73: 8BVI1650HCSS.000-1 - Technical data

1) SLOT 2 is not occupied. SLOT 1 of the ACOPOSmulti module is occupied by the SafeMOTION module.
2) Valid in the following conditions: 750 VDC DC bus voltage, 5 kHz switching frequency, 40°C ambient temperature, installation elevation <500 m above sea level, no derating due to cooling type.
3) I_M... Current on the motor connection [A].
4) P_{SMC1} ... Max. power consumption P_{SMC} [W] of the SafeMOTION module in SLOT1 (see the "Encoder interfaces" section).
P_{SLOT2} ... Max. power consumption P_{8BAC} [W] of the plug-in module in SLOT2 (see the technical data for the respective plug-in module).
$P_{24\ V\ Out}$... Power [W] that is output to the connections X2/+24 V Out 1 and X2/+24 V Out 2 on the module (max. 10 W).
$P_{Fan8B0M...}$... Portion of the power [W] that is used by the fan modules in the mounting plate or the 8B0M0040HFF0.000-1 fan module (see the technical data for the respective 8B0M... mounting plate / 8B0M0040HFF0.000-1 fan module).
5) Only 8BCM motor cables from B&R are permitted to be connected to the motor connectors.
6) Valid in the following conditions: 750 VDC DC bus voltage, minimum permissible coolant flow volume (3 l/min).
7) The temperature specifications refer to the return temperature of the cold plate mounting plate.
8) Value for the nominal switching frequency.
9) The module cannot supply the full continuous current at this switching frequency. This unusual value for the return temperature, at which derating of the continuous current must be taken into account, ensures that the derating of the continuous current can be determined in the same manner as at other switching frequencies.
Caution! Condensation can occur at low flow temperatures and return temperatures.
10) The module cannot supply the full continuous current at this switching frequency. This unusual value for the ambient temperature, at which derating of the continuous current must be taken into account, ensures that the derating of the continuous current can be determined in the same manner as at other switching frequencies.
11) B&R recommends operating the module at its nominal switching frequency. Operating the module at a higher switching frequency for application-specific reasons reduces the continuous current and increases the CPU load.
12) If necessary, the stress of the motor isolation system can be reduced by an additional externally wired dU/dt choke. For example, the RWK 305 three-phase du/dt choke from Schaffner (www.schaffner.com) can be used. Important: Even when using a dU/dt choke, it is necessary to ensure that an EMC-compatible, low inductance shield connection is used!
13) The module's electrical output frequency (SCTRL_SPEED_ACT * MOTOR_POLEPAIRS) is monitored to protect against dual use in accordance with EC regulation 428/2009 | 3A225. If the electrical output frequency of the module exceeds the limit value of 598 Hz uninterrupted for more than 0.5 s, then the current movement is aborted and error 6060 is output (Power element: Limit speed exceeded).
14) The connection is made with cable lugs using an M8 threaded bolt. The rated cross section of the cable lug must match the wire cross section of the cable that is to be connected.
15) The maximum diameter that can be clamped depends on the shield component set.
16) During project development, it is necessary to check if the minimum voltage can be maintained on the holding brake with the specified wiring. The operating voltage range of the holding brake can be found in the user's manual for the respective motor.
17) The specified value is only valid under the following conditions:
- The 24 VDC supply for the module is provided by an 8B0C auxiliary supply module installed on the same mounting plate.
- Connection between S1 and S2 (activation of the external holding brake) using a jumper with a max. length of 10 cm.
If the 24 VDC supply for the module is applied to the mounting plate using an 8BVE expansion module, then the output voltage is reduced because of voltage drops on the expansion cable. In this case, undervoltage monitoring must be disabled.
If jumpers longer than 10 cm are used to connect S1 and S2, then the output voltage is reduced because of voltage drops on the jumpers.
18) Only 8BCF EnDat 2.2 cables from B&R are permitted to be connected to the encoder interfaces.
19) An EnDat 2.2 functional safety encoder is required when using ACOPOSmulti SafeMOTION inverter modules! With standard EnDat 2.2 encoders, only the STO, SBC and SS1 functions are monitored with respect to timing!

20) The maximum encoder cable length l_{max} can be calculated as follows (the maximum permissible encoder cable length of 100 m must not be exceeded):

$l_{max} = 7.9 / I_G * A * 1/(2*\rho)$

I_G ... Max. current consumption of the encoder [A].
A ... Cross section of the supply wire [mm²].
ρ ... Specific resistance [Ω mm²/m] (e.g. for copper: ρ = 0.0178).

21) $I_{Encoder}$ ... Max. power consumption of the connected encoder [A].

22) Continuous operation at elevations ranging from 500 m to 4000 m above sea level is possible (taking the specified continuous current reductions into consideration).

23) This value only applies in its delivered state (SLOT2 of the module is sealed by a slot cover / shield plate). If SLOT2 on the module is not sealed, then the level of protection is reduced to IP10. It is important to note that a 8SCS005.0000-00 shield set (slot cover / shield plate) or plug-in module must always be inserted!

24) Continuous operation at ambient temperatures ranging from 40°C to max. 55°C is possible (taking the specified continuous current reductions into consideration), but this will result in a shorter service life.

25) These dimensions refer to the actual device dimensions including the respective mounting plate. Make sure to leave additional space above and below the devices for mounting, connections and air circulation.

3.7.1.4 Wiring

For details, see 3.7.2 "Wiring: Safe 8x width inverter modules (single-axis modules)" on page 135.

For general information, see 6 "Wiring" on page 142.

3.7.2 Wiring: Safe 8x width inverter modules (single-axis modules)

3.7.2.1 Pinout overview

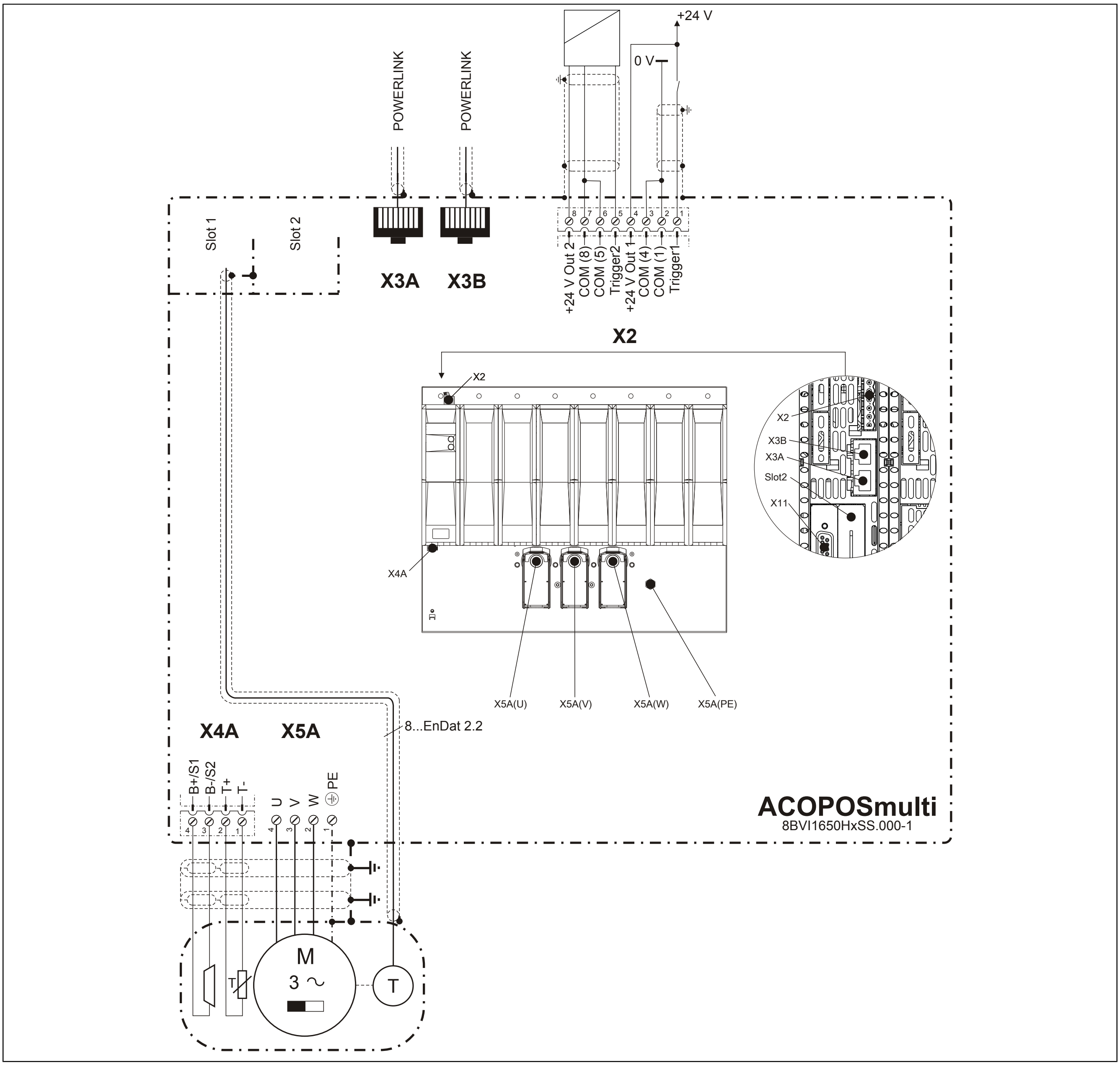


Figure 15: Pinout overview

3.7.2.2 X2 connector - Pinout

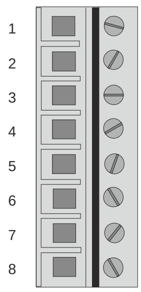
X2	Pin	Name	Function
	1	Trigger 1	Trigger 1
	2	COM (1)	Trigger 1 0 V
	3	COM (2)	+24 V output 1 0 V
	4	+24 V Out 1	+24 V output 1
	5	Trigger 2	Trigger 2
	6	COM (5)	Trigger 2 0 V
	7	COM (8)	+24 V output 2 0 V
	8	+24 V Out 2	+24 V output 2

Table 74: X2 connector - Pinout

3.7.2.3 X3A, X3B connectors - Pinout

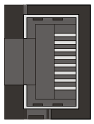
X3A, X3B	Pin	Name	Function
	1	RXD	Receive signal
	2	RXD\	Receive signal inverted
	3	TXD	Transmit signal
	4	Shield	Shield
	5	Shield	Shield
	6	TXD\	Transmit signal inverted
	7	Shield	Shield
	8	Shield	Shield

Table 75: X3A, X3B connectors - Pinout

3.7.2.4 X4A connector - Pinout

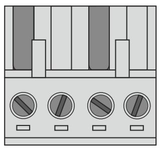
X4A	Name	Function
	T-	Axis 1: Temperature sensor -
	T+	Axis 1: Temperature sensor +
	B- [1)]	Axis 1: Brake -
	B+ [1)]	Axis 1: Brake +

Table 76: X4A connector - Pinout

1) Wiring is not permitted to exceed a total length of 3 m.

Danger!

The FUNCTIONAL FAIL SAFE state is activated if the SBC output B+ is shorted to 24 V (i.e. safe pulse disabling is activated). The brake always remains on/released, however, due to the short circuit to 24 V! This can lead to dangerous situations because the motor holding brake cannot brake or prevent the spin-out movement (or the unrestrained lowering in the case of hanging loads)!
Appropriate wiring measures must be implemented to ensure that the SBC output B+ is not shorted to 24 V!

Danger!

The SBC output

- **is not permitted to be wired to multiple modules!**
- **is not permitted to be wired as an open emitter!**
- **is not permitted to be wired as an open collector!**

Danger!

Only an output voltage of ≤5 V can be ensured for the safe motor holding brake output when shut off. When selecting a motor holding brake, the user must ensure that the required braking torque is reached at a voltage of 5 V.

Information:

The transistors of the SBC output stage are tested cyclically. When the output channels are active, this test emits low pulses on the output with a maximum length of 600 µs.

This must be taken into consideration when choosing the motor holding brake!

Danger!

The connections for the motor temperature sensors and the motor holding brake are safely isolated circuits. These connections are therefore only permitted to be connected to devices or components that have sufficient isolation in accordance with IEC 60364-4-41 or EN 61800-5-1.

Caution!

If B+ and B- are swapped when connecting the permanent magnet holding brakes, then the brakes cannot be opened! ACOPOSmulti inverter modules cannot determine if a holding brake is connected with reverse polarity!

Warning!

Temperature sensors are only permitted to be connected to the X4A/T+ and X4A/T- connectors on an ACOPOSmulti module under the following conditions:

- **There is no ACOPOSmulti plug-in module in SLOT1 on the ACOPOSmulti module with a temperature sensor connected to T+ and T-**

Otherwise, the temperature monitoring functions on the ACOPOSmulti module may become ineffective, which in extreme cases can cause the hardware (e.g. motors) connected to the ACOPOSmulti module to be destroyed!

3.7.2.5 X5A - Pinout

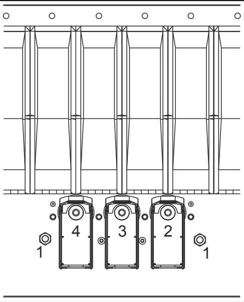
X5A	Pin	Name	Function
	1	PE	Axis 1: Protective ground conductor
	2	W	Axis 1: Motor connection W
	3	V	Axis 1: Motor connection V
	4	U	Axis 1: Motor connection U
	Holding torque for the M8 nuts: 12 Nm		

Table 77: X5A - Pinout

Information:

Only 8BCM motor cables from B&R are permitted to be connected to the motor connectors.

Motor connections U, V, W - Cable installation

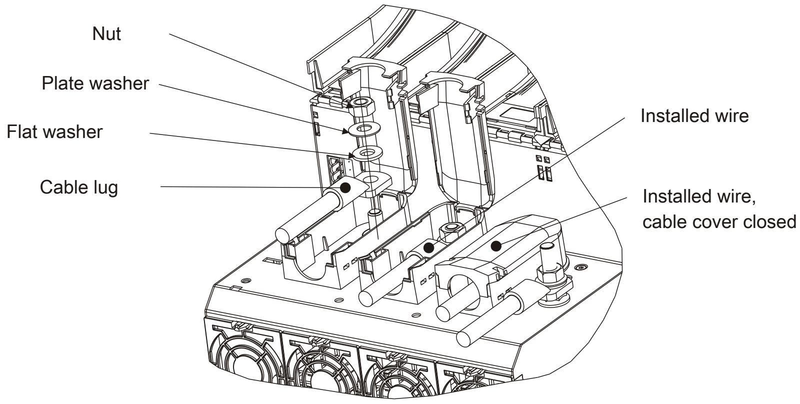


Figure 16: X5A - Cable installation

PE connection (1-wire) - Cable installation

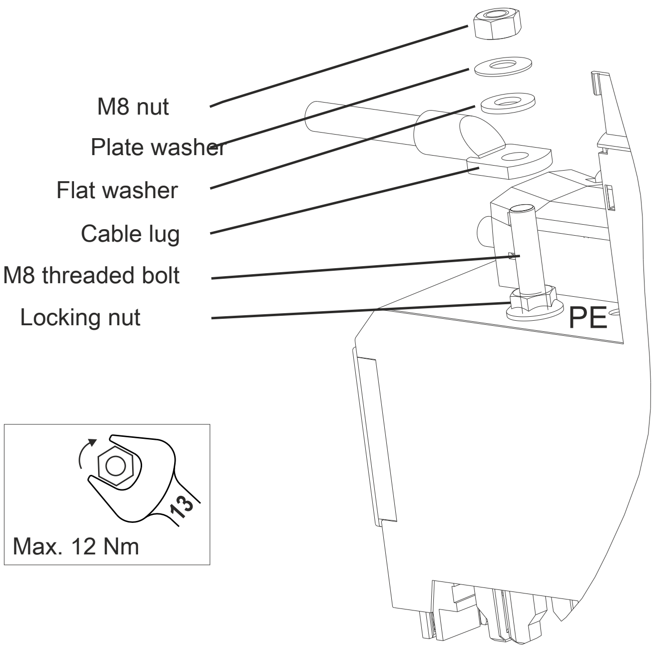
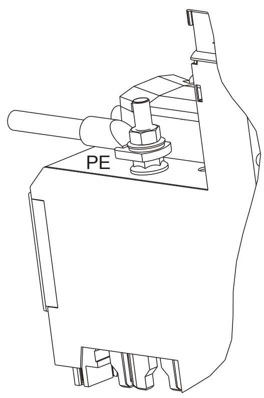
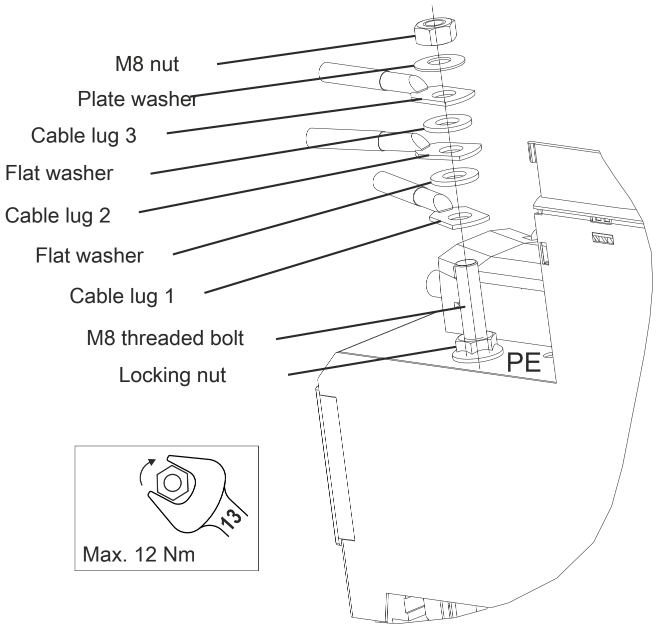
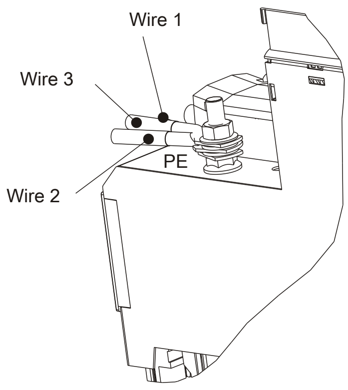
	
PE connection (1-wire) - Overview of installation material	Installed wire

Table 78: PE connection (1-wire) - Cable installation

PE connection (3-wire) - Cable installation



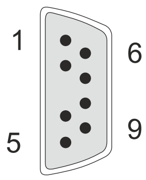
PE connection (3-wire) - Overview of installation material



Installed wire

Table 79: PE connection (3-wire) - Cable installation

3.7.2.6 SafeMOTION EnDat 2.2 module - Pinout

Figure	X11 (X12)	Pin	Name	Function
		1	U+	Encoder supply +12.5 V
		2	---	---
		3	---	---
		4	D	Data input
		5	T	Clock output
		6	COM (1)	Encoder supply 0 V
		7	---	---
		8	D\	Data input inverted
		9	T\	Clock output inverted

Information:

Only 8BCF EnDat 2.2 cables from B&R or 8BCH hybrid motor cables from B&R are permitted to be connected to the encoder interfaces.

Information:

SafeMOTION modules cannot be replaced! SafeMOTION modules and the corresponding inverter module form a single unit. In the event of an error, the entire inverter module must be replaced.

4 Installation

See the ACOPOSmulti user's manual MAACPM-ENG, chapter "Installation".

5 Dimensioning

See the ACOPOSmulti user's manual MAACPM-ENG, chapter "Dimensioning".

6 Wiring

6.1 General information

6.1.1 EMC-compatible installation

General information

If the directives for electromagnetic compatibility of the installation are followed, the ACOPOSmulti drive system meets the EMC directive 2004/108/EC and low-voltage directives 2006/95/CE. It also meets the requirements for harmonized EMC product standard IEC 61800-3:2004 for industry (second environment).

Additional EMC measures must be implemented by the machine or system manufacturer in the event that the product standard for the machine includes lower limit values or the machine conforms to the IEC 61000-6-4 basic standard. Proof of conformity to required limit values must be provided by the manufacturer or distributor of the machine or system in accordance with the guidelines for implementing the EMC directive.

Additional EMC measures are required when operating ACOPOSmulti drive systems in a residential area or when connecting ACOPOSmulti drive systems to a low voltage system that also supplies buildings in a residential area (first environment) without an intermediate transformer.

Installation notes

1. The control cabinet or system must be constructed properly.
2. To prevent the effects of disturbances, the following lines must be properly shielded:
    - Motor cables
    - Encoder cables
    - Control cables
    - Data cables
3. Inductive switching elements such as contactors or relays must be equipped with corresponding suppressor elements such as varistors, RC elements or damping diodes.
4. All electrical connections must be kept as short as possible.
5. Cable shields must be attached to designated shield terminals and the connector housing.
6. Shielded cables with copper braiding or tinned copper braiding must be used. Twisting the braided shield or extending it with single conductors is not permitted.
7. Unused cable conductors must be grounded on both sides whenever possible.

6.1.2 Overview

Passive power supply

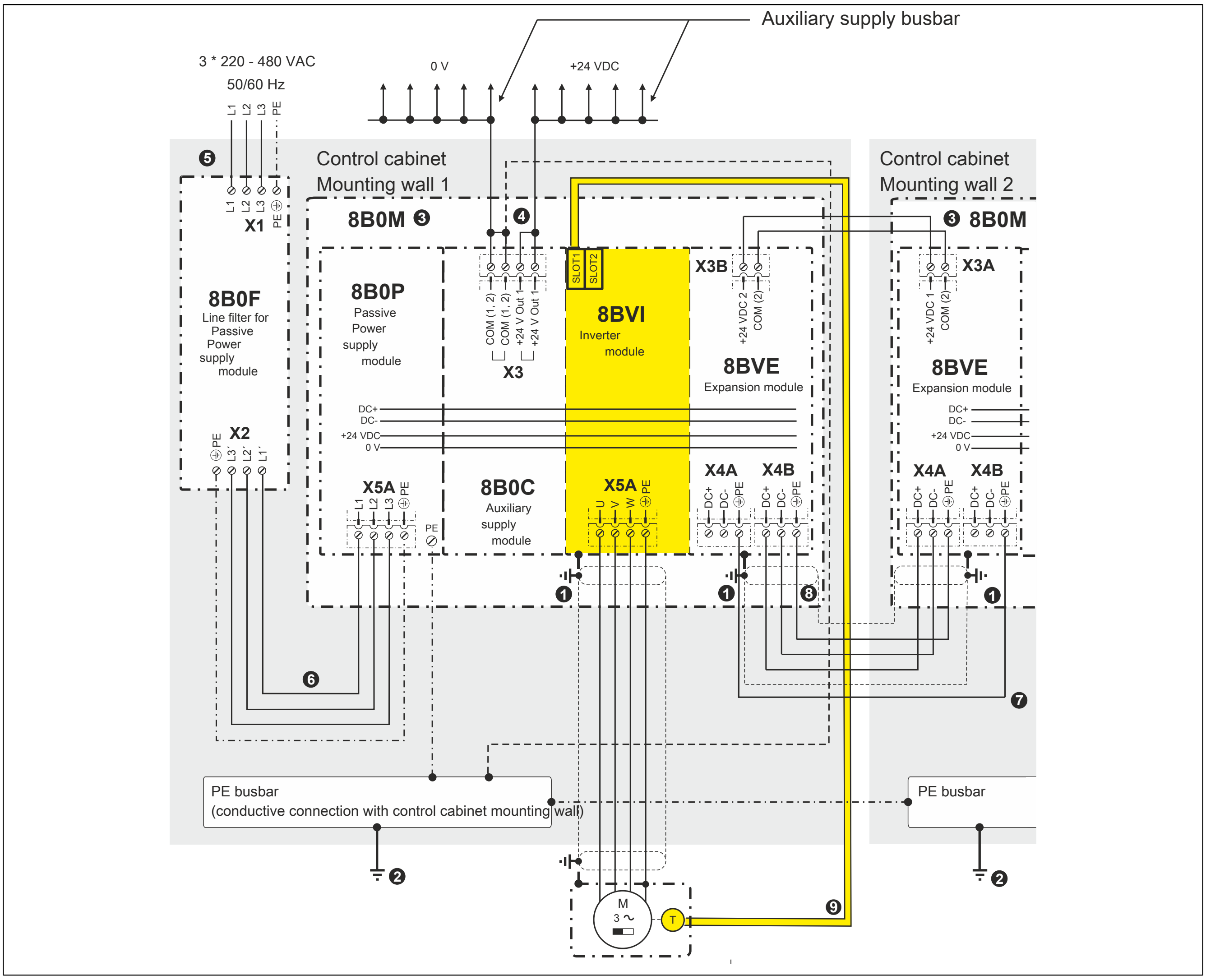


Figure 17: Overview of ground/shield for ACOPOSmulti drive system (passive power supply)

1 Shielding connection via module-specific shield component set.
2 Central grounding point.
3 8B0M mounting plate, large-surface conductive connection with control cabinet mounting wall.
4 One of the two COM connections (1, 2) on the X3 connector must be grounded to achieve a defined relationship between the signal ground and ground potential. Otherwise, the Safe Brake Control (SBC) safety function could fail if an error occurs (ground fault).
5 The power mains line inside the control cabinet must be kept as short as possible.
6 The connection between the line filter and power supply module is never shielded. To prevent disturbances on the power mains (❺), they cannot be routed parallel to the connection between the line filter and power supply module.
7 An additional PE connection must be made between two 8BVE expansion modules in order to meet the conditions necessary for the ACOPOSmulti drive systems power mains connection on all 8B0M mounting plates that are connected using 8BVE expansion modules. This additional PE connection must be made with the same wire cross section as the PE wire routed in the expansion cable (at least 2.5 mm² with protected wiring or 4 mm² with unprotected wiring).
9 ACOPOSmulti SafeMOTION EnDat 2.2: Only 8BCF EnDat 2.2 cables from B&R are permitted to be connected to the encoder interfaces.

Active power supply

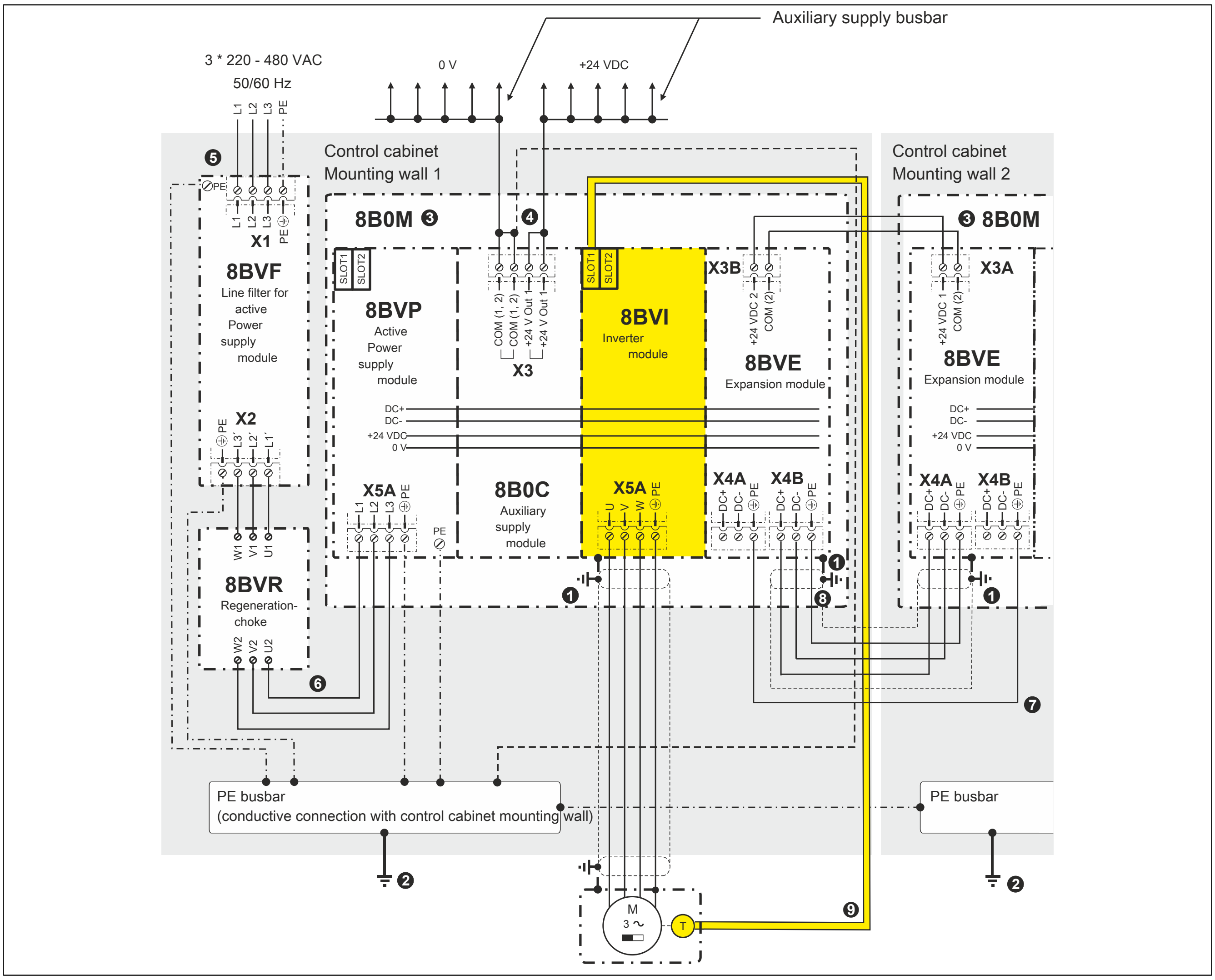


Figure 18: Overview of ground/shield for ACOPOSmulti drive system (active power supply)

1 Shielding connection via module-specific shield component set.
2 Central grounding point.
3 8B0M mounting plate, large-surface conductive connection with control cabinet mounting wall.
4 One of the two COM connections (1, 2) on the X3 connector must be grounded to achieve a defined relationship between the signal ground and ground potential. Otherwise, the Safe Brake Control (SBC) safety function could fail if an error occurs (ground fault).
5 The power mains line inside the control cabinet must be kept as short as possible.
6 The connection between the line filter and power supply module is never shielded. To prevent disturbances on the power mains (❺), they cannot be routed parallel to the connection between the line filter and power supply module.
7 An additional PE connection must be made between two 8BVE expansion modules in order to meet the conditions necessary for the ACOPOSmulti drive systems power mains connection on all 8B0M mounting plates that are connected using 8BVE expansion modules. This additional PE connection must be made with the same wire cross section as the PE wire routed in the expansion cable (at least 2.5 mm² with protected wiring or 4 mm² with unprotected wiring).
9 ACOPOSmulti SafeMOTION EnDat 2.2: Only 8BCF EnDat 2.2 cables from B&R are permitted to be connected to the encoder interfaces.

Danger!

One of the two COM connections (1, 2) on the X3 connector must be grounded to achieve a defined relationship between the signal ground and ground potential. Otherwise, the Safe Brake Control (SBC) safety function could fail if an error occurs (ground fault).

Caution!

No additional consumers/components are permitted to be connected between the 8BVF line filter, 8BVR regeneration choke and 8BVP power supply module!

Warning!

ACOPOSmulti drive systems are only permitted to be used with specially designed line filters. Third-party line filters are not permitted to be used; it is possible that they will be destroyed!

6.1.2.1 Additional PE connection on 8BVE expansion modules

When connecting two or more 8BVE expansion modules, the PE connection must always be made between the first and last 8BVE expansion module.

Connection between two 8BVE expansion modules

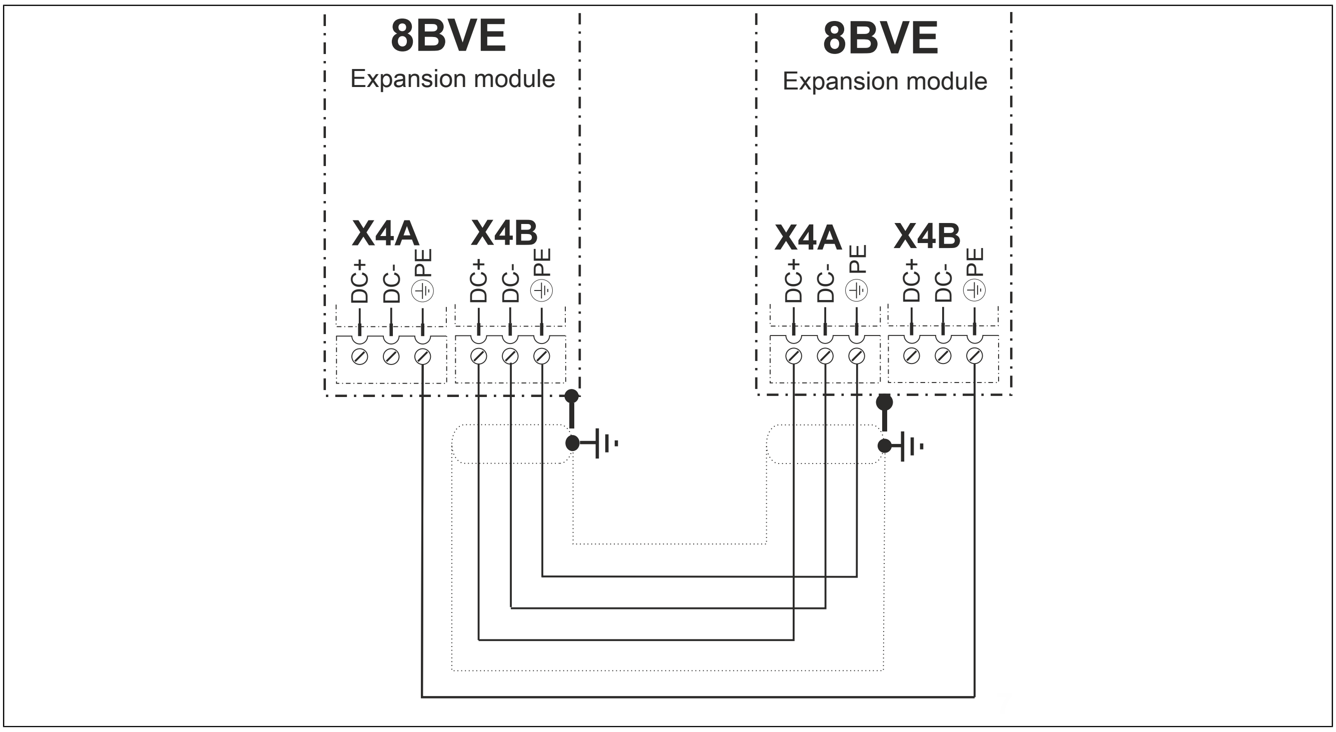


Figure 19: Connection between two 8BVE expansion modules

Connection between multiple 8BVE expansion modules

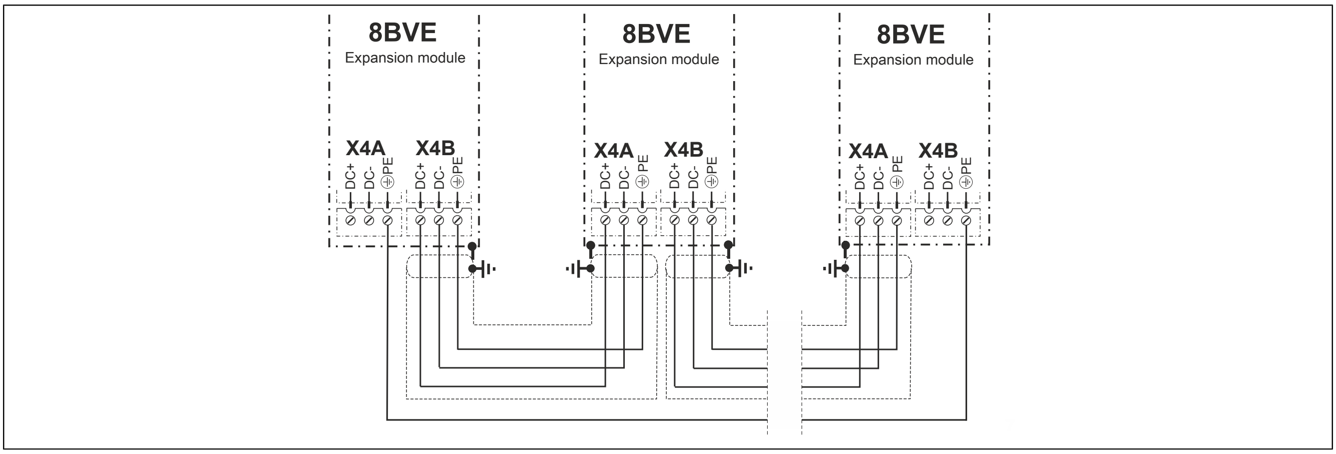


Figure 20: Connection between multiple 8BVE expansion modules

Connection between two 8BVE expansion modules in combination with 8CVI inverter modules

Variant 1: 8CVI inverter modules to both 8BVE expansion modules

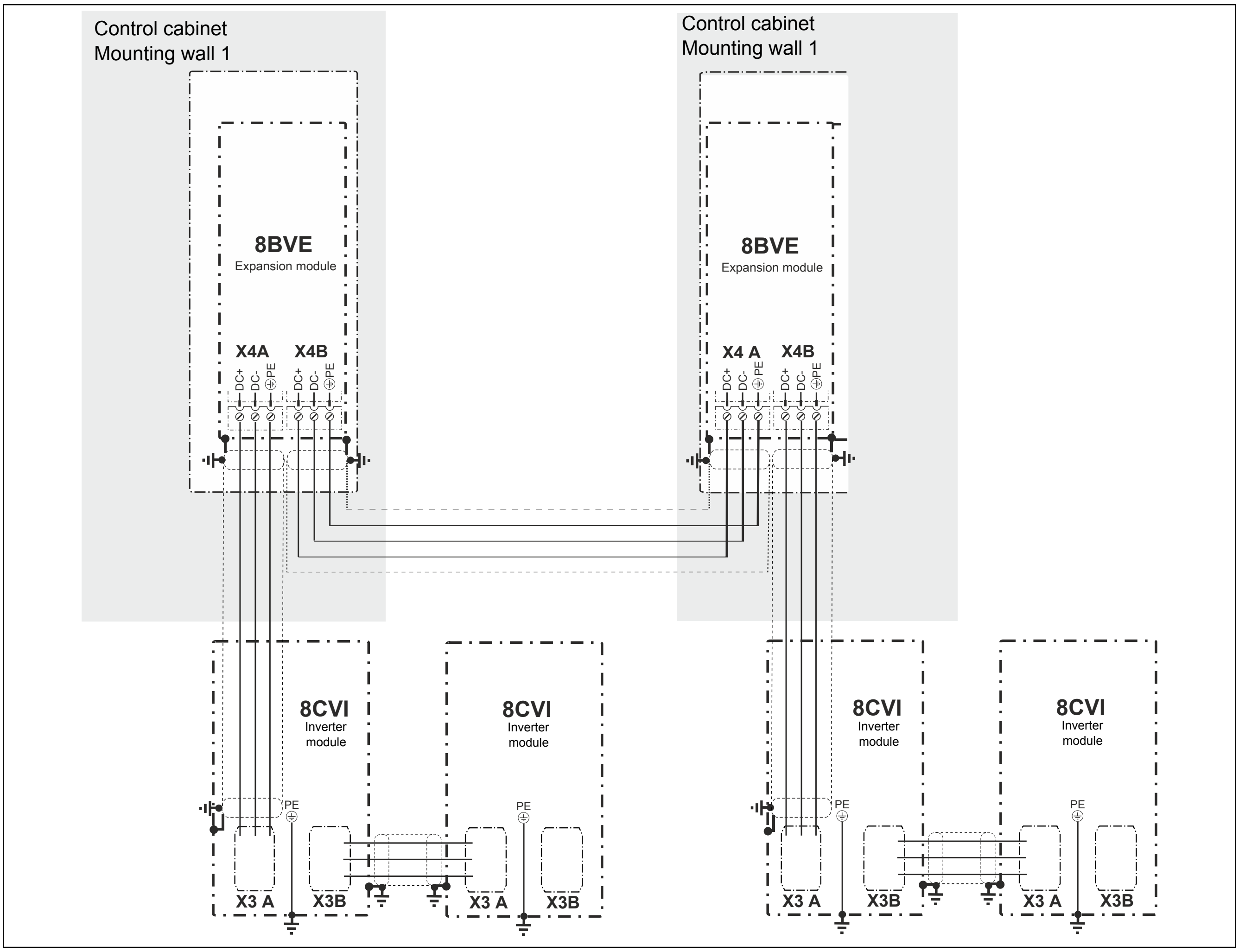


Figure 21: 8CVI inverter module to both 8BVE expansion modules

Variant 2: 8CVI inverter modules to the last 8BVE expansion module

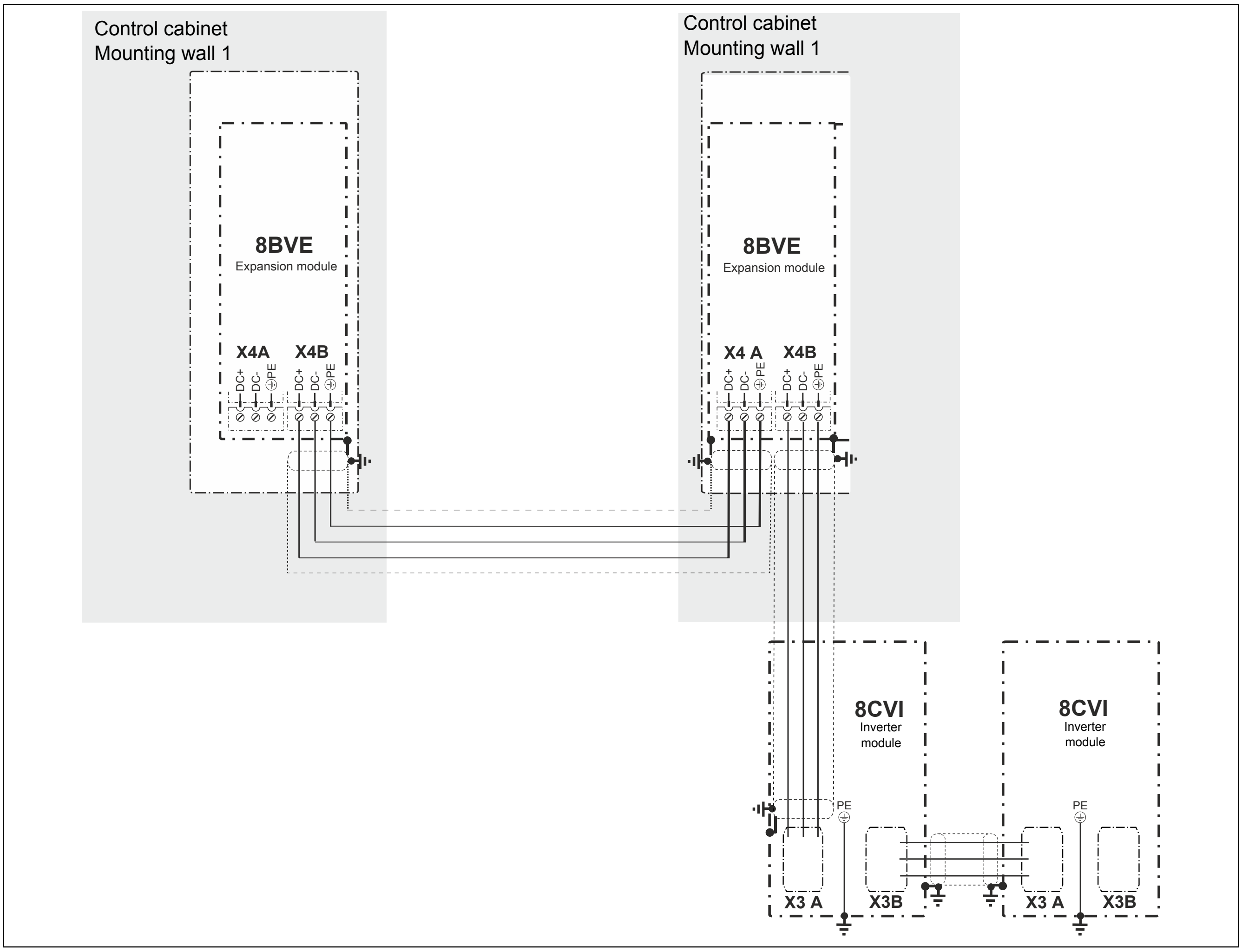


Figure 22: 8CVI inverter modules to the last 8BVE expansion module

6.1.3 Ground and shield connection diagrams

6.1.3.1 8BVI SafeMOTION inverter modules (single-axis modules)

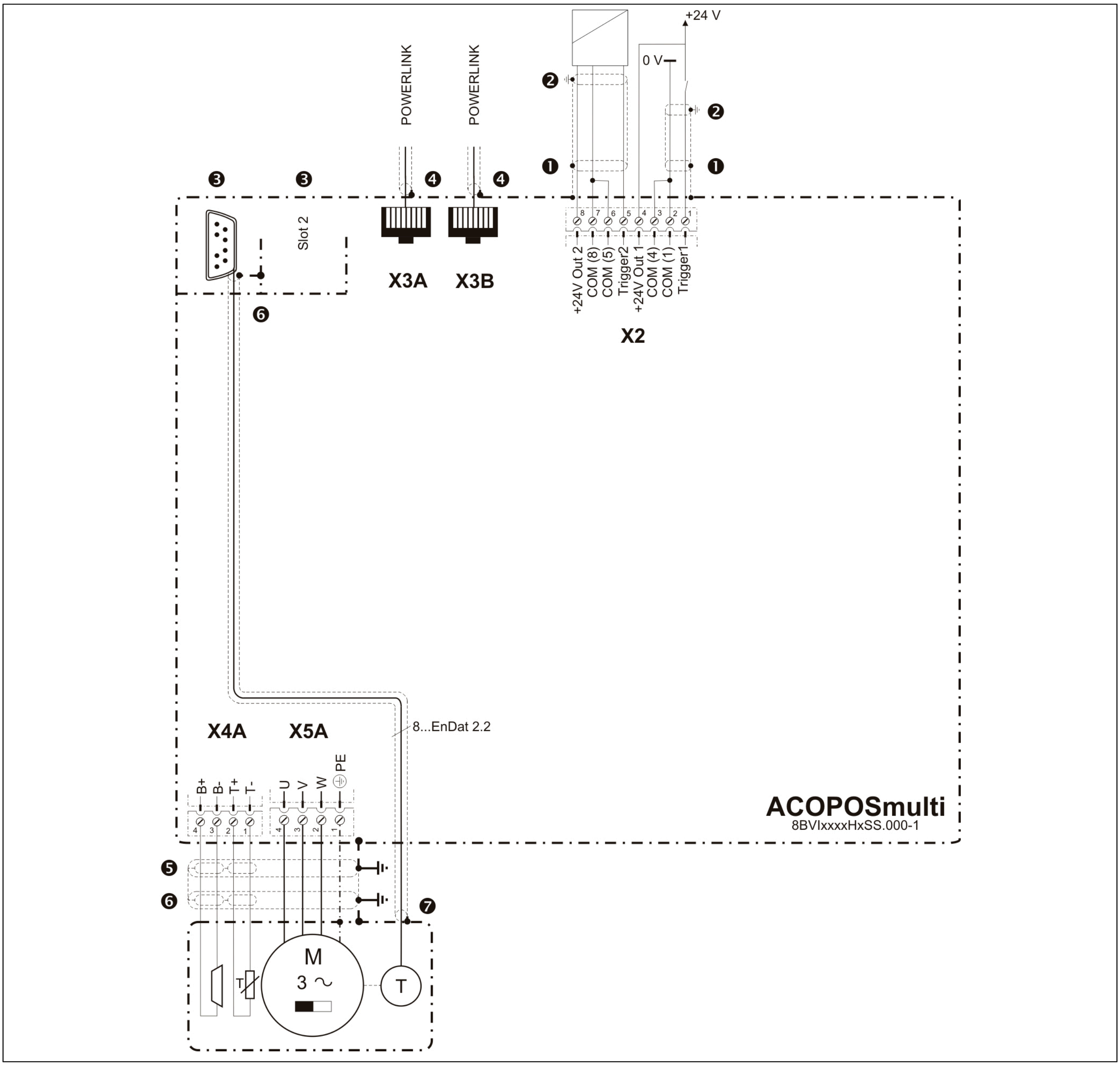


Figure 23: Ground connections and shield connections for SafeMOTION 8BVI EnDat 2.2 inverter modules

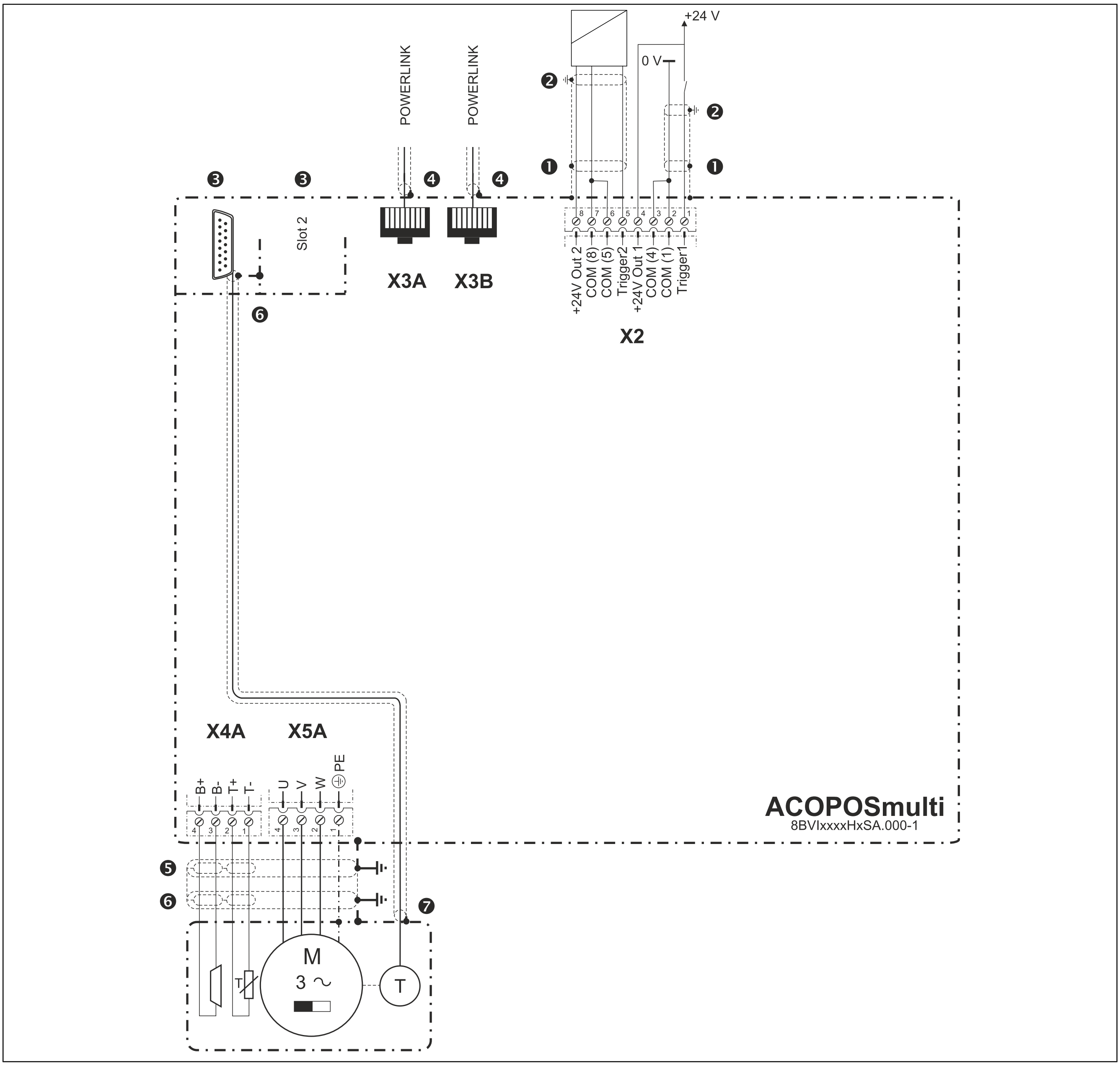
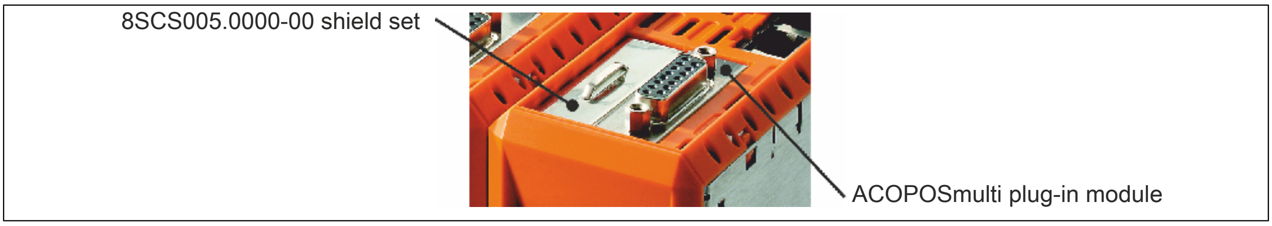


Figure 24: Ground connections and shield connections for SafeMOTION 8BVI SinCos inverter modules

1. Both trigger inputs are only filtered internally with approx. 50 µs. Make sure the cable shield is grounded properly. The optional 8SCS002.0000-00 shield set can be used for this.
2. The cable shield must be attached to the shield connector.
3. ACOPOSmulti plug-in modules automatically come in contact with the housing when inserted in the module slot:



Open module slots on ACOPOSmulti modules can be closed with the optional 8SCS005.0000-00 shield set available from B&R. The standard shield set for closing open module slots on ACOPOSmulti SafeMOTION inverter modules is the 8SCS005.0000-00.

4. <u>Male DSUB cable connection:</u>
   The cable shield must be sufficiently connected using the designated clamp in the metallic or metal-plated male DSUB housing. The fastening screws on the DSUB housing must be tightened.

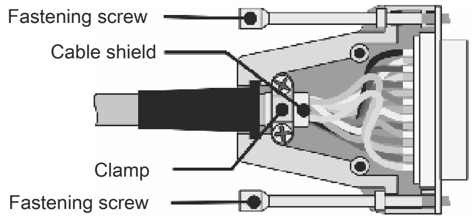


Figure 25: Cable shield in DSUB housing

   <u>Terminal cable connection:</u>
   The cable shield must be connected to the ACOPOSmulti module housing using the optional 8SCS002.0000-00 shield set.

   <u>Male RJ45 cable connection:</u>
   Grounding the cable shield also provides improved EMC properties. Grounding should take place on both sides, over a large area and near the connector. The optional 8SCS002.0000-00 shield set, available from B&R, can be used on the ACOPOSmulti module for this.

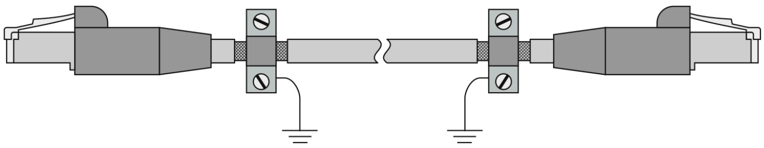


Figure 26: Male RJ45 connector - Grounding the cable shield

Information:

When cabling POWERLINK networks with B&R POWERLINK cables, no additional grounding of the cable shield is required to ensure resistance to disturbances in accordance with EN 61800-3!

5. The cable shield can be connected to the ACOPOSmulti module housing using the optional shield sets available from B&R.
6. On the motor side, the cable shield of the motor line is connected to the motor housing via the motor connector and connected to ground via the machine.
7. On the motor side, the encoder cable shield must be connected to the motor housing using the encoder connector and connected to ground via the machine.

   For external encoders, the cable shield of the encoder cable must be connected (on the encoder side) to the machine and therefore to ground via the encoder connector.

6.1.4 Insulation and high voltage testing

6.1.4.1 Insulation resistance testing in accordance with EN 60204

In accordance with EN 60204, the insulation resistance of electrical equipment is measured with 500 VDC between the main circuit conductors and the protective ground conductor system and is not permitted to fall below a value of 1 MΩ. Testing individual sections of the system is permitted.

Motor connectors on ACOPOSmulti inverter modules (X5A / X5B)

Warning!

An insulation test is not permitted to be carried out on the motor connectors (X5A / X5B) of ACOPOSmulti inverter modules since this would destroy the ACOPOSmulti inverter modules!

The motor cable must be disconnected from the motor connector (X5A / X5B) of the ACOPOSmulti inverter module before insulation resistance is measured!

B&R motors and B&R motor cables

In principle, insulation resistance measurement can be carried out on B&R motor cables and B&R motors. The insulation resistance can be lower than 1 MΩ, however, depending on the motor that is connected. The 50 kΩ minimum value required as specified in EN 60204, Section 18.3 is exceeded in any case.

Warning!

An insulation test is not permitted to be carried out on the motor connectors (X5A / X5B) of ACOPOSmulti inverter modules since this would destroy the ACOPOSmulti inverter modules!

The motor cable must be disconnected from the motor connector (X5A / X5B) of the ACOPOSmulti inverter module before insulation resistance is measured!

6.1.4.2 High voltage testing

In accordance with EN 60204, the electrical equipment must be able to withstand a test voltage connected between the conductors of all circuits and the protective ground conductor system for at least 1 s (exception: all circuits with a voltage < PELV voltage). The test voltage must be twice the rated voltage for the equipment, but at least 1000 VAC (50/60 Hz). Components that cannot handle this test voltage must be disconnected before carrying out the high voltage test.

Motor connectors on ACOPOSmulti inverter modules (X5A / X5B)

Warning!

A high voltage test is not permitted to be carried out on the motor connection (X5A / X5B) of ACOPOSmulti inverter modules since this would destroy the ACOPOSmulti inverter modules!

B&R motors and B&R motor cables

In principle, high voltage testing can be carried out on B&R motor cables and B&R motors. Depending on the size of the motor and length of the motor cable, increased measurement currents can occur because of capacitive coupling.

Warning!

A high voltage test is not permitted to be carried out on the motor connection (X5A / X5B) of ACOPOSmulti inverter modules since this would destroy the ACOPOSmulti inverter modules!

The motor cable must be removed from the motor connection (X5A / X5B) of the ACOPOSmulti inverter module before the high voltage measurement is made!

6.1.4.3 Typical procedure

Isolation test

a) Disconnect the motor cable from the X5A / X5B connector on the ACOPOSmulti inverter module.
b) Perform the insulation test on the X1 power mains connection (mains side) of the ACOPOSmulti line filter.
c) Perform the insulation test on the B&R motor.

High voltage testing

a) Disconnect the connection cable between the X2 connector of the ACOPOSmulti line filter and the U1 / V1 / W1 connectors of the ACOPOSmulti regeneration choke on the X2 connector of the ACOPOSmulti line filter.
b) Disconnect the connection cable between the X5A connector on the ACOPOSmulti power supply module and the U2 / V2 / W2 connections of the ACOPOSmulti regeneration choke on the X5A connector of the ACOPOSmulti power supply module.
c) Perform the high voltage test on the U1 / V1 / W1 connectors of the ACOPOSmulti regeneration choke.
d) Disconnect the motor cable from the X5A / X5B connector on the ACOPOSmulti inverter module.
e) Perform the high voltage test on the B&R motor.

Chapter 3 • System features

1 SafeMOTION module

1.1 General information

The SafeMOTION module is an integrated component of the safe ACOPOSmulti SafeMOTION concept.
One SafeMOTION module is integrated in the safe drive for each safe axis. A safe single-axis module has one integrated SafeMOTION module, and a safe dual-axis module has two integrated SafeMOTION modules.

A SafeMOTION module is the equivalent of a safe node and performs the safety functions on the drive.

Only single-axis modules are available for ACOPOSmulti SafeMOTION SinCos inverter modules.

Information:

A safe dual-axis module includes two SafeMOTION modules. It is therefore the equivalent of one POWERLINK node and two safe nodes. This should be taken into consideration when designing the system.

Information:

The user is not able to connect or disconnect the SafeMOTION module! This means that a standard ACOPOSmulti axis cannot be retrofitted!

1.2 Safety functions

The following safety functions are supported by the SafeMOTION module:

Safety function	ACOPOSmulti SafeMOTION		EN ISO 13849-1		EN 61508 / EN 62061		Safety Encoder evaluation necessary?
	EnDat 2.2	SinCos	EnDat 2.2	SinCos	EnDat 2.2	SinCos	
	Starting in Safety Release						
Safe Torque Off (STO)	R 1.3	R 1.4	PLe / CAT 4	PLe / CAT 4	SIL 3	SIL 3	No
Safe Torque Off One Channel (STO1)	R 1.3	R 1.4	PLd / CAT 3	PLd / CAT 3	SIL 2	SIL 2	No
Safe Operation Stop (SOS)	R 1.3	R 1.4	PLd / CAT 3	Max. PLe / CAT 4, depends on the encoder used	SIL 2	Max. SIL 3, depends on the encoder used	Yes
Safe Stop 1 (SS1)	R 1.3	R 1.4	Time-based monitoring: PLe / CAT 4 Ramp-based monitoring: PLd / CAT 3	Time-based monitoring: PLe / CAT 4 Ramp-based monitoring: Max. PLe / CAT 4, depends on the encoder used	Time-based monitoring: SIL 3 Ramp-based monitoring: SIL 2	Time-based monitoring: SIL 3 Ramp-based monitoring: Max. SIL 3, depends on the encoder used	Time-based monitoring: No Ramp-based monitoring: Yes
Safe Stop 2 (SS2)	R 1.3	R 1.4	PLd / CAT 3	Max. PLe / CAT 4, depends on the encoder used	SIL 2	Max. SIL 3, depends on the encoder used	Yes
Safely Limited Speed (SLS)	R 1.3	R 1.4	PLd / CAT 3	Max. PLe / CAT 4, depends on the encoder used	SIL 2	Max. SIL 3, depends on the encoder used	Yes
Safe Maximum Speed (SMS)	R 1.3	R 1.4	PLd / CAT 3	Max. PLe / CAT 4, depends on the encoder used	SIL 2	Max. SIL 3, depends on the encoder used	Yes
Safe Direction (SDI)	R 1.3	R 1.4	PLd / CAT 3	Max. PLe / CAT 4, depends on the encoder used	SIL 2	Max. SIL 3, depends on the encoder used	Yes
Safely Limited Increment (SLI)	R 1.3	R 1.4	PLd / CAT 3	Max. PLe / CAT 4, depends on the encoder used	SIL 2	Max. SIL 3, depends on the encoder used	Yes
Safely Limited Acceleration (SLA)	R 1.9	R 1.9	PLd / CAT 3	Max. PLe / CAT 4, depends on the encoder used	SIL 2	Max. SIL 3, depends on the encoder used	Yes
Safe Brake Control (SBC)	R 1.3	R 1.4	PLd / CAT 3	PLd / CAT 3	SIL 2	SIL 2	No
Safely Limited Position (SLP)	R 1.4	R 1.4	PLd / CAT 3	Max. PLe / CAT 4, depends on the encoder used	SIL 2	Max. SIL 3, depends on the encoder used	Yes
Safe Maximum Position (SMP)	R 1.4	R 1.4	PLd / CAT 3	Max. PLe / CAT 4, depends on the encoder used	SIL 2	Max. SIL 3, depends on the encoder used	Yes
Safe Homing	R 1.4	R 1.4	PLd / CAT 3	Max. PLe / CAT 4, depends on the encoder used	SIL 2	Max. SIL 3, depends on the encoder used	Yes
Safe Brake Test (SBT)	-	R 1.7	-	Max. PLd / CAT 3, depends on the encoder used	-	Max. SIL 2, depends on the encoder used	Yes
Remanent Safe Position (RSP)	R 1.9	-	PLd / CAT 3	-	SIL 2	-	Yes

Table 80: ACOPOSmulti SafeMOTION: Safety functions and corresponding safety levels

Details about the individual safety functions can be found in section 4 "Safety technology" on page 166.

2 Integrated safety technology

Seamless integration of safety technology in the standard application is a reality with B&R's safety technology products. This allows fixed wiring to be replaced by safe data transfer via the existing machine bus system. Flexibly configured or programmed safety behavior can be adapted optimally to various safety situations. Complete diagnostic information about safety components accessible via the machine bus system provides detailed data about the state of the machine.

Insufficient protection from manipulation and the inadequacy of existing safety solutions provide some justification for dangerous behavior when it comes to operating the machine. The possibilities provided by the latest safety technology allow considerable potential for improvement here. In the pursuit of improving machine safety, safety technology guidelines are continually updated according to the current technological situation. Consequently, improvements become mandatory. B&R's integrated safety technology is state-of-the-art and meets both current and expected future demands on safety components.

Safety shutdowns do not always have to involve a full machine stop. When opening a protective cover, it is often sufficient to reduce the speed. Smart, safe reactions to various situations provide safety without having to stop the production process. The machine does not need to be emptied and set up again, and manipulation is not necessary. This results in real advantages for the user that can be implemented with programmable safety behavior.

Integrated safety technology products are certified for use in safety applications up to:

- EN ISO 13849, PLe / CAT 4
- IEC 62061, SIL 3
- IEC 61508, SIL 3
- IEC 61511, SIL 3

The actual level of safety achieved depends on the respective safety function and the components being used!

A cycle time of 200 µs for SIL 3 safety applications is a new feature for safety communication. Response times decrease by a factor of 10, and the advantages of hard-wired solutions are combined with the possibilities of advanced, integrated and intelligent safety bus technology. POWERLINK and openSAFETY accomplish all this using only standard Ethernet mechanisms. As a result, these protocols can be combined with all conventional and, more important, newer Ethernet profiles. openSAFETY is the fastest and most flexible real-time safety bus system on the market.

The reduction to a single cable allows safety-related data to be transferred using the existing infrastructure. Additional cabling of a safe line is not necessary. Transparent and non-reactive access of secure data is an integral part of functional machine control. Complicated communication mechanisms between the safe application and standard application are also no longer necessary. Smart, safe reactions instead of hard machine stops provide advantages for processes, help to avoid manipulation and therefore increase the value of machines.

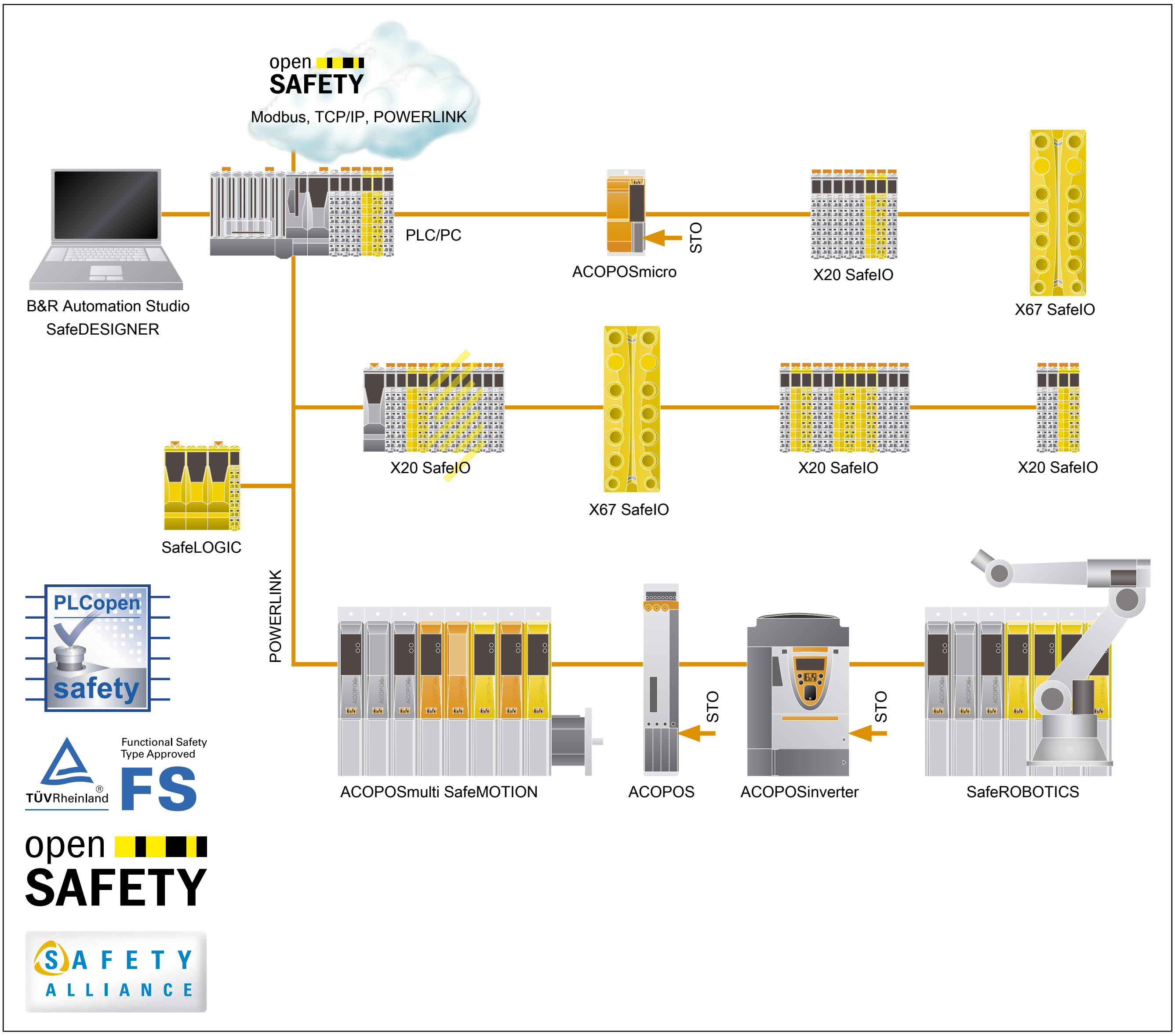


Figure 27: Integrated safety technology - Topology

3 System requirements

Integrated safety technology requires the use of the following software and hardware:

- POWERLINK V2
- Automation Studio V3.0.80 or higher
- Automation Runtime V3.00 or higher
- ACP10 V2.180 software or higher (ACOPOSmulti SafeMOTION EnDat 2.2 Safety Release R1.3)
- ACP10 V2.250 software or higher (ACOPOSmulti SafeMOTION EnDat 2.2 Safety Release R1.4 or higher)
- ACP10 V2.391 software or higher (ACOPOSmulti SafeMOTION SinCos Safety Release R1.4 or higher)
- ACP10 V2.480 software or higher (ACOPOSmulti SafeMOTION Safety Release R1.9 or higher)
- SG4 CPUs

4 System limits

The following limitations exist when using SafeMOTION modules:

- One SafeMOTION module corresponds to one safe node. A single-axis inverter module has one integrated SafeMOTION module, i.e. **one safe node**. A dual-axis inverter module has two integrated SafeMOTION modules, i.e. **two safe nodes**. Additionally, each inverter module equates to **one POWERLINK node**.
- A SafeMOTION module can only communicate safely with one SafeLOGIC controller with SafeMOTION support (see SafeLOGIC data sheets X20SL80xx, X20SL81xx and X20SLXx10 under www.br-automation.com). It is not possible for a SafeMOTION module to communicate safely with multiple SafeLOGIC controllers or with other safe modules (other SafeIO, SafeMOTION, etc.).
- The output-side payload data size of the SafeLOGIC controller is limited to 1490 bytes. Among other things, this limitation reduces the resulting number of usable SafeIO or SafeMOTION modules during SafeLOGIC-to-SafeLOGIC communication.
- The safe state is always initiated in B&R safety modules by cutting off the output. This is a design feature of the modules and cannot be changed.
  This is particularly important for SafeMOTION modules since the safe state cuts off the torque on the motor!

Danger!

Situations involving external forces (e.g. hanging loads) can result in dangerous movements!
If this poses a safety risk, then the user must implement the necessary equipment to eliminate the risk (e.g. mechanical brakes)! This equipment must correspond to the required safety level!

5 Safety response time

The safety response time is the time between the arrival of the signal on the input channel and the output of the cutoff signal on the output.

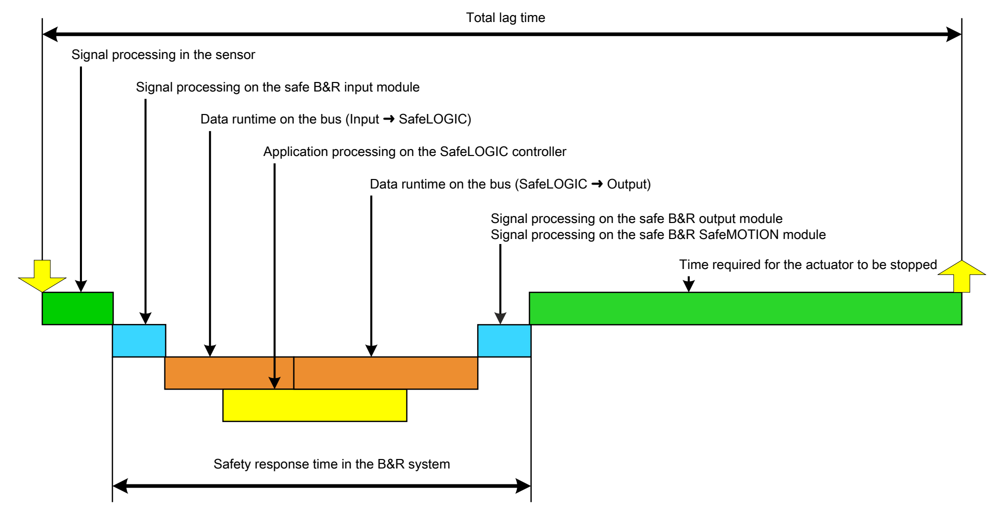


Figure 28: Total lag time

As illustrated in the figure, the safety response time in the B&R system is composed of the following partial response times:

- Signal processing on the safe B&R input module
- Data runtime on the bus (Input → SafeLOGIC)
- Data runtime on the bus (SafeLOGIC → Output)
- Signal processing on the safe B&R output module

Danger!

The following sections are dedicated exclusively to the safety response time in the B&R system. To observe the complete safety response time, the user must include signal processing in the sensor as well as the time until the actuator comes to a standstill.

Be sure to validate the total lag time on the system!

5.1 Signal processing on the safe B&R input module

For signal processing on the safe B&R input module, the following values must be added:

- The filter value of the switch-off filter
- 5000 μs when "Pulse_Mode = external" is configured
- When using safe analog input channels or safe temperature inputs, see the table "Max. safety response time" in the "I/O update time" section for the respective module.
- "Timebase" parameter + I/O update time for safe counter channels

5.2 Data runtime on the bus

The following relationship must be taken into consideration for the data runtime on the bus:

- The time needed to transfer data from the input to the SafeLOGIC controller or to the output depends on the sum of the cycle times and CPU copy times in effect on the transfer line.
- POWERLINK MN (managing node, standard CPU) settings are important for the actual timing on the bus, but they cannot be used from a safety standpoint since the values can be changed at any time in the course of modifications made outside of the safety application.
- In the SafeLOGIC controller, data runtimes are monitored on the bus using openSAFETY services. The time needed to process the application on the SafeLOGIC controller is taken into account in this test (system-dependent). Monitoring is defined in SafeDESIGNER using the parameters in the "Safety_Response_Time" parameter group.
- The total max. data runtime on the bus is calculated by adding the "Worst_Case_Response_Time_us" parameter for the safe input module and the "Worst_Case_Response_Time_us" parameter for the safe output module. When doing this, be sure to check the "Manual_Configuration" parameter. If the "Manual_Configuration" parameter is set to "No", the value specified for the "Default_Worst_Case_Response_Time_us" parameter is used.
- **Special case: Local inputs on the module:**
  The total max. data runtime on the bus is calculated by adding "Cycle_Time_max_us" parameter + 2000 µs and the "Worst_Case_Response_Time_us" parameter for the safe output module. When doing this, be sure to check the "Manual_Configuration" parameter. If the "Manual_Configuration" parameter is set to "No", the value specified for the "Default_Worst_Case_Response_Time_us" parameter is used.

Information:

The safety components located in this network segment could be cut off by the SafeLOGIC controller if modified parameters on the POWERLINK MN alter the data runtimes on the bus so that they lie outside of the SafeDESIGNER parameters defined in the parameter group "Safety_Response_Time".

Information:

The safety components located in this network segment could be cut off by the SafeLOGIC controller if EMC disturbances cause data failures that fall outside of the SafeDESIGNER parameters defined in the parameter group "Safety_Response_Time".

5.3 Signal processing on the safe B&R output module

The duration of signal processing on the safe B&R output module amounts to the following:

- Max. 800 µs with FET (field-effect transistor) technology
- Max. 50 ms with relay channels

5.4 Signal processing on the safe B&R SafeMOTION module

The duration of signal processing in the event of a function request is 800 µs in the SafeMOTION module.

In addition to the signal processing, however, the duration of the communication between the POWERLINK interface and the SafeMOTION module must also be taken into account. In the worst case, this can be 1600 µs.

Safe error response time

In addition to the signal processing duration in functional situations, the safe error response time is also relevant when setting up safety equipment.

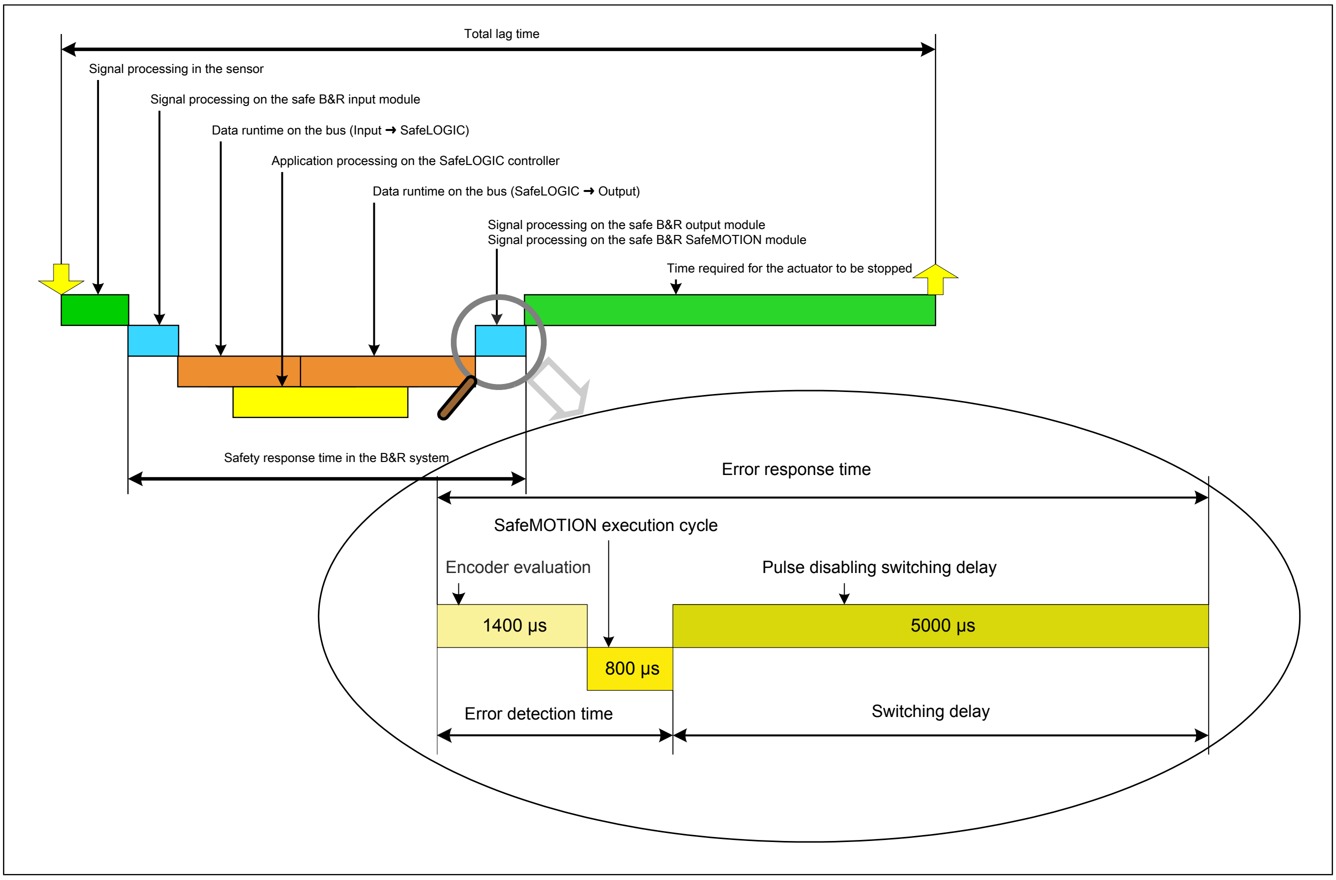


Figure 29: Safe error response time

The safe error response time plays a role if the currently monitored limit is exceeded when a safety function is activated on the SafeMOTION module.

The safe error response time includes:

- Error detection time (encoder evaluation + processing time on the SafeMOTION module)
- Switching delay

Danger!

In the worst case, the safe error response time on the SafeMOTION module is 7200 µs.

When setting up the safety measures, the assumption must be that the drive will accelerate to its maximum within this amount of time.

This speed must be considered together with the speed when the safety function is violated in order to determine the maximum possible speed when coasting to a stop!

In addition, the error response time for determining the residual distance must be used when an error occurs in order to determine the maximum distance by which a monitored position limit can be exceeded!

5.5 Calculating the safety response time

The safety response time can be calculated using the Response Time Calculator. This tool can be opened with "Project → Response Time Calculator".

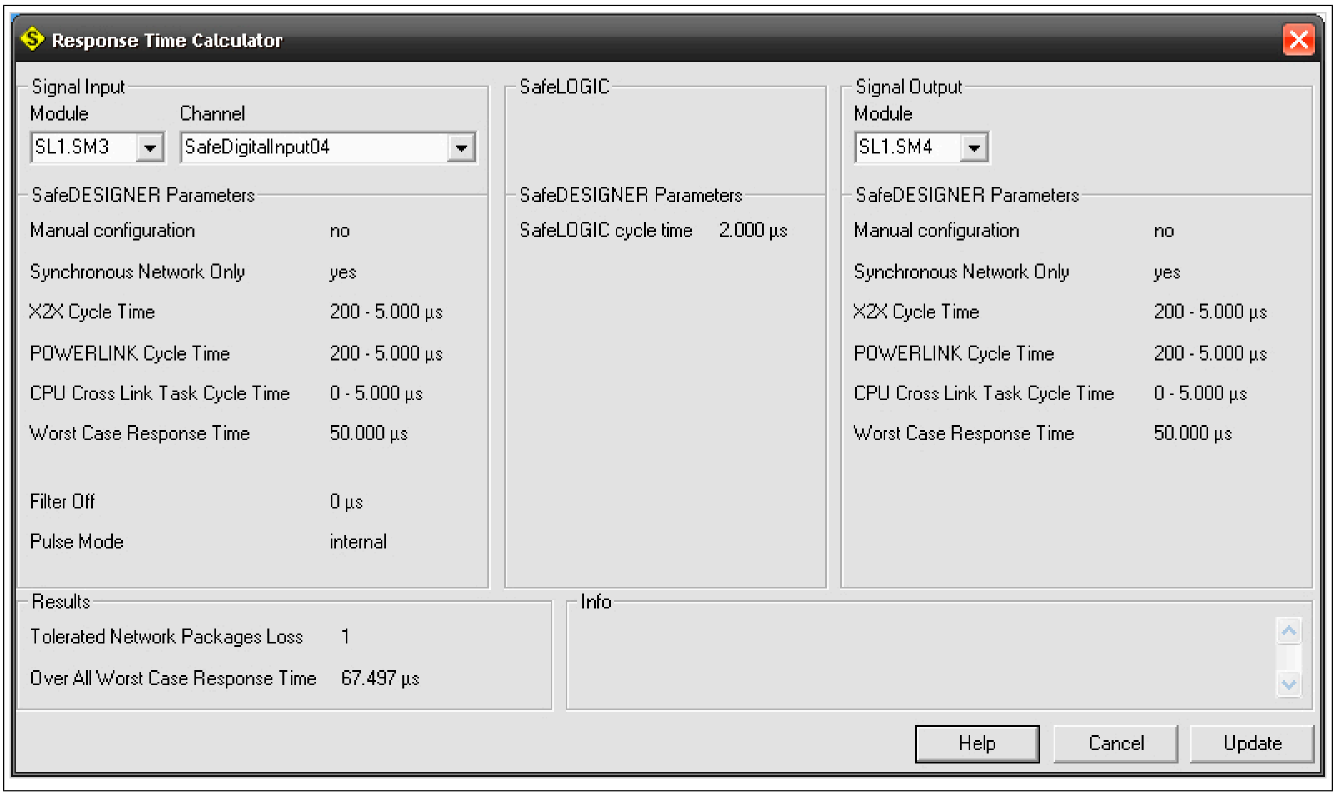


Figure 30: Response Time Calculator

This tool takes the values set in SafeDESIGNER and uses them to calculate the total response time and the tolerated packet loss on the network.

The modules relevant for the calculation can be selected in the "Signal input" and "Signal output" section. The values that are set accordingly are automatically shown in SafeDESIGNER and the total response time is calculated.

If the values set in SafeDESIGNER for the response time calculation result in a longer maximum response time than is set in SafeDESIGNER, the calculation is canceled and the error is shown in the "Info" field.

SafeDESIGNER parameters can also be changed with the dialog box window open. The values are applied either after changing which inputs/outputs are selected or after updating using the "Refresh" button.

Input fields:

Input field	Value	Function	Corresponding SafeDESIGNER parameters
Synchronous network only	Yes	All networks involved in data transfer are synchronous.	Synchronous_Network_Only = Yes
	No	At least one of the networks involved in data transfer is not synchronous.	Synchronous_Network_Only = No
X2X cycle time	200-30,000 µs	X2X cycle time entry for checking the data runtime on the SafeLOGIC controller	Min_X2X_CycleTime_us Max_X2X_CycleTime_us
POWERLINK cycle time	200-30,000 µs	POWERLINK cycle time entry for checking the data runtime on the SafeLOGIC controller	Min_Powerlink_CycleTime_us - Max_Powerlink_CycleTime_us
CPU cross link task cycle time	0-30,000 µs	Cycle time entry of the CPU cross link task for checking the data runtime in the SafeLOGIC controller. See the table below.	Min_CPU_CrossLinkTask_CycleTime_us - Max_CPU_CrossLinkTask_CycleTime_us
Response time	3000-500,000 µs	Limit value for monitoring the data runtime on the bus	Worst_Case_Response_Time_us
Filter off	0	A switch-off filter is not being used on the input module.	Filter_Off_us
	1-500,000 µs	A switch-off filter is being used on the input module.	
Pulse mode	External	"External clock signals" mode is being used on the input module.	Pulse_Mode = External
	Internal	"External clock signals" mode is being used on the input module.	Pulse_Mode = Internal
	None	"External clock signals" mode is not being used on the input module.	Pulse_Mode = No clock
SafeLOGIC cycle time	800-20,000 µs	SafeLOGIC cycle time parameter "Cycle_Time_us" from SafeDESIGNER in µs.	Cycle_Time_us

Table 81: Fields in the "Response Time Calculator"

If the SafeLOGIC controller is on a different POWERLINK interface than the SafeIO modules, then the data must be copied to the CPU on its way from the SafeIO modules to the SafeLOGIC controller. An internal system task (CPU_CrossLinkTask) handles this copy procedure. The cycle time of this task is automatically assigned by the system.

It is important to know the configuration options of CPU_CrossLinkTask for monitoring data runtime on the SafeLOGIC controller:

Min. CPU cross link task	Max. CPU cross link task	Description
Value > 0	Value > 0	Data is always copied via the CPU. Application situations where data is not copied are detected by the SafeLOGIC controller and registered as errors due to the very short runtime.
Value > 0	0	Not a valid combination
No	Value > 0	Runtime monitoring in the SafeLOGIC controller accepts application situations where data is copied as well as application situations where it is not.
0	0	Data is never copied via the CPU. Application situations where data is copied are detected by the SafeLOGIC controller and registered as errors due to the very long runtime.

Table 82: Meaning of "Min./Max. CPU" parameters

Output fields:

Output field	Value	Function	Corresponding SafeDESIGNER parameters
Tolerated network packages loss	0-10	Number of lost packets that are tolerated without cutting off the safety function	-
Total response time	- -	Resulting safety response time in the B&R system.	-

Table 83: Output fields in the "Response time calculator"

5.6 Parameters for the safety response time in SafeDESIGNER

The parameters for the safety response time are generally configured in the same way for all stations involved in the application. For this reason, these parameters are configured for the SafeLOGIC controller in SafeDESIGNER.

For application situations in which individual safety functions require optimal response time behavior, the parameters for the safety response time can be configured individually on the respective module.

The parameters and their limits for the SafeMOTION module are described below for each specific module.

<table>
<tr><th>Parameter</th><th>Description</th><th>Default value</th><th>Unit</th></tr>
<tr><td rowspan="2">Manual_Configuration</td><td>The parameters for the safety response time are generally configured in the same way for all stations involved in the application. For this reason, these parameters are configured for the SafeLOGIC controller in SafeDESIGNER. For application situations in which individual safety functions require optimal response time behavior, the parameters for the safety response time can be configured individually on the respective module.</td><td>No</td><td>-</td></tr>
<tr><td colspan="3"><table>
<tr><th>Parameter value</th><th>Description</th></tr>
<tr><td>Yes</td><td>The individual data from the "Safety_Response_Time" group on the module is used to calculate the safety response time for the module's signals.</td></tr>
<tr><td>No</td><td>The generally configured parameters for the safety response time from the 'Safety_Response_Time' group on the SafeLOGIC controller are valid for the module.</td></tr>
</table></td></tr>
<tr><td rowspan="2">Synchronous_Network_Only</td><td>This parameter determines the synchronization characteristics of the network being used.</td><td>Yes</td><td>-</td></tr>
<tr><td colspan="3"><table>
<tr><th>Parameter value</th><th>Description</th></tr>
<tr><td>Yes</td><td>In order to calculate the safety response time, networks must be synchronous and their cycle times must either be the same or an integer ratio of the cycle times.</td></tr>
<tr><td>No</td><td>No requirement for synchronization of the networks</td></tr>
</table></td></tr>
<tr><td>Max_X2X_CycleTime_us</td><td>This parameter corresponds to the maximum duration of communication between the SafeMOTION module and the POWERLINK interface.
• Permissible values: 200 - 30,000 µs</td><td>1600</td><td>µs</td></tr>
<tr><td>Max_Powerlink_Cycle-Time_us</td><td>This parameter specifies the maximum POWERLINK cycle time used to calculate the safety response time.
• Permissible values: 200 - 30,000 µs</td><td>5000</td><td>µs</td></tr>
<tr><td>Max_CPU_CrossLink-Task_CycleTime_us</td><td>This parameter specifies the maximum cycle time for the copy task on the CPU used to calculate the safety response time. A value of 0 indicates that a copy task is not included for the response time.
• Permissible values: 0 - 30,000 µs</td><td>5000</td><td>µs</td></tr>
<tr><td>Min_X2X_CycleTime_us</td><td>This parameter corresponds to the minimum duration of communication between the SafeMOTION module and the POWERLINK interface.
• Permissible values: 200 - 30,000 µs</td><td>600</td><td>µs</td></tr>
<tr><td>Min_Powerlink_CycleTime_us</td><td>This parameter specifies the minimum POWERLINK cycle time used to calculate the safety response time.
• Permissible values: 200 - 30,000 µs</td><td>200</td><td>µs</td></tr>
<tr><td>Min_CPU_CrossLinkTask_CycleTime_us</td><td>This parameter specifies the minimum cycle time for the copy task on the CPU used to calculate the safety response time. A value of 0 indicates that configurations without copy tasks are also included for the response time.
• Permissible values: 0 - 30,000 µs</td><td>0</td><td>µs</td></tr>
<tr><td>Worst_Case_Response_Time_us</td><td>This parameter specifies the limit value for monitoring the safety response time.
• Permissible values: 3000 - 500,000 µs</td><td>50000</td><td>µs</td></tr>
</table>

Table 84: Parameters for the safety response time in SafeDESIGNER

5.7 Minimum signal lengths

The "Worst_Case_Response_Time_us" parameter in SafeDESIGNER influences the maximum number of data packets that can fail without triggering a safety response. This parameter therefore acts like a switch-off filter. If several data packets are lost within the tolerated amount, safety signals may not be detected if their low phase is shorter than the configured "Worst_Case_Response_Time_us".

Danger!

Lost signals can result in serious safety errors. Check all signals to determine the smallest possible pulse length and make sure that it is larger than the value configured for the "Worst_Case_Response_Time_us".

Possible solution:

- The switch-on filter can be used to extend the low phase of a signal on the input module.
- Low phases of signals from the SafeLOGIC controller can be lengthened with restart inhibit functions or timer function blocks.

6 Detecting errors within the module

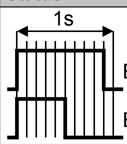
The red "SE" LED makes it possible to evaluate the following error states:

- Module error, e.g. defective RAM, defective CPU, etc.
- Overtemperature/Undertemperature
- Overvoltage/Undervoltage
- Incompatible firmware version
- Incorrect configuration

Errors that occur within the module are detected with the diagnostic coverage (DC) specified in the respective safety function in accordance with the requirements of the standards listed in the certificate. After this occurs, the module reverts back to a safe state within the safe error response time.

The internal module tests needed for this are only performed, however, if the module's firmware has been booted and the module is in either the PREOPERATIONAL state or the OPERATIONAL state. If this state is not achieved (for example, because the module has not been configured in the application), then the module will remain in the boot state.

The boot state is clearly indicated by the following SE LED blink sequences:

LED	Color	Status
SE	Red	 Boot phase or defective processor Boot phase, Firmware error

Danger!

Operating the safety module in boot mode is not permitted.

Danger!

A safety-related output channel is only permitted to be switched off for a maximum of 24 hours. The channel must be switched on by the end of this period so that the module's internal channel test can be performed.

Chapter 4 • Safety technology

1 Integrated safety technology - ACOPOSmulti SafeMOTION

1.1 General information

The safety functions integrated in the drive open up entirely new possibilities for guaranteeing the safety of personnel while maintaining maximum machine availability.
The inverter modules with integrated safety technology - "ACOPOSmulti SafeMOTION" - round off the B&R safety concept and make it possible to design an entire safety application using state-of-the-art products from B&R.

Information:

Due to the internal cycle time of 800 μs on the SafeMOTION module, the POWERLINK cycle time on the ACOPOSmulti SafeMOTION must be set to 800 μs or a whole-number multiple of 800 μs.

The products are intended for use worldwide, in the following areas for example:

- Automotive industry
- Electrical industry
- Beverages industry
- Food industry
- Glass and cement building materials industry
- Handling robotics industry
- Metal industry
- Packaging industry
- Paper printing industry
- Pharmaceutical industry
- Plastics industry
- Textile industry
- Transport systems
- Wood handling and processing industry

This list shows typical areas of application but is by no means complete.

Danger!

B&R drive systems and servo motors have been designed, developed and manufactured for conventional use in industrial environments. They were not designed, developed and manufactured for any use involving serious risks or hazards that could lead to death, injury, serious physical damage or loss of any kind without the implementation of exceptionally stringent safety precautions.

In particular, such risks and hazards include the use of these devices to monitor nuclear reactions in nuclear power plants, their use in flight control or flight safety systems as well as in the control of mass transportation systems, medical life support systems or weapons systems.

1.2 Safe power transmission system

The main components of a safe power transmission system are the safe inverter module, the encoder cable, the motor cable and a motor with a position encoder that meets the requirements for use in integrated safety technology.

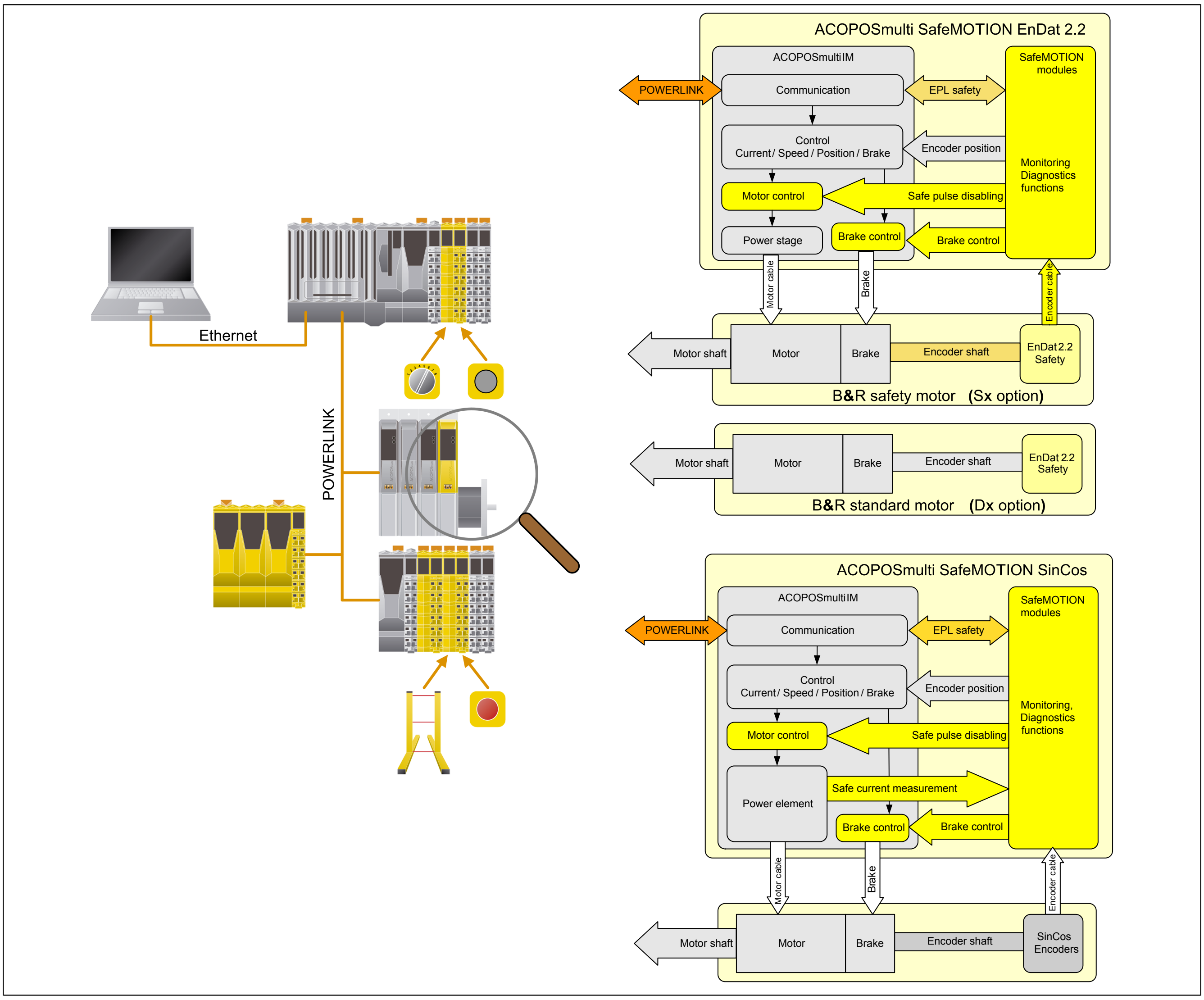


Figure 31: Safe power transmission system

Safe inverter module

The safe inverter module consists of a standard ACOPOSmulti inverter with one additional safe monitoring module – the SafeMOTION module – for each axis.
This means that a safe single-axis module includes one SafeMOTION module and is the equivalent of one POWERLINK node and one safe node.
On the other hand, a dual-axis module contains two SafeMOTION modules and is therefore the equivalent of one POWERLINK node and two safe nodes.

As before, actual control is performed via the standard application and is not safety-related. The addition of the SafeMOTION module provides safety-related monitoring of specific limits based on requirements, however. If these limits are exceeded, the SafeMOTION module activates safe pulse disabling and the motor holding brake output is switched to 0 V.

1.2.1 ACOPOSmulti SafeMOTION EnDat 2.2

Motor with safe position encoder

In order to be able to use all safety functions, the use of an EnDat 2.2 functional safety encoder from Heidenhain is mandatory! With standard EnDat 2.2 encoders, only the STO, SBC, and time-monitored SS1 safety functions are available!

B&R safety motors (Sx encoder option)

For motors with the Sx encoder option, the EnDat 2.2 functional safety encoder is installed in strict accordance with Heidenhain's installation guidelines.
In this way, encoder slippage or encoder shaft breakage can be ruled out as a mechanical error.

Danger!

Encoders used with B&R safety motors (Sx encoder option) are only permitted to be replaced by B&R!

If the encoder is replaced by someone other than B&R, mechanical errors such as encoder slippage or shaft breakage can no longer be ruled out.

B&R standard motors (Dx encoder option)

For motors with the Dx encoder option, the SafeMOTION module can sufficiently detect encoder slippage or encoder shaft breakage in some applications. In this case, the application must meet all requirements specified under 2.3.3.2 "Encoder mounting without proof of fatigue strength - Safe lag error monitoring" on page 186, and all limitations listed in this section must be taken into account. Under these conditions, B&R standard motors can also be used for safety applications!

Combining B&R motors with gearboxes

Danger!

When combining B&R motors with gearboxes, the mechanical connection between the motor and gearbox does not meet "functional safety" requirements. It is not possible to rule out slippage or breakage.

For combinations of B&R motors and gearboxes, only safety functions in which no safe absolute position is monitored are permitted to be used (STO, SBC, SOS, SS1, SS2, SLS, SMS, SLI, SDI, SLA, SBT (only available for ACOPOSmulti SafeMOTION SinCos) and Safe Speed).

The use of B&R motor-gearbox combinations is not permitted with hanging loads and other comparable applications where breakage between the motor and gearbox would result in a dangerous situation!

Encoder cable

The encoder cable is connected to the SafeMOTION module with a male DSUB connector. Please note the instructions in the "Cable connection via male DSUB connector" section under 6.1.3.1 "Wiring / General information / Connection diagrams for ground and shield connections / 8BVI inverter modules with SafeMOTION (single-axis modules)" on page 148.

Information:

Only 8BCF EnDat 2.2 cables from B&R or 8BCH hybrid motor cables from B&R are permitted to be connected to the encoder interfaces.

Motor cable

The motor cable is connected to the safe inverter module with a male motor connector.

Information:

Only 8BCM motor cables from B&R are permitted to be connected to the motor connectors.

1.2.2 ACOPOSmulti SafeMOTION SinCos

Available safety functions

In order to use all of the available safety functions, the encoders used must meet the requirements listed in section 2.3.2.2.1 "Safety requirements for SinCos measuring instruments" on page 178. Note that fault exclusion is required for encoder slippage and encoder shaft breakage and that the encoder installation must therefore be evaluated accordingly.

If encoder slippage or encoder shaft breakage is covered only by the lag error monitoring performed by the SafeMOTION module, then the safety-related use of the Safe Homing, SLP and SMP safety functions is not permitted!

Compatible B&R standard motors (Ex encoder option)

For B&R standard motors, the SafeMOTION module can sufficiently detect encoder slippage or encoder shaft breakage in some safety applications. In this case, the safety application must meet all of the requirements specified under 2.3.3.2 "Encoder mounting without proof of fatigue strength - Safe lag error monitoring" on page 186, and all limitations listed in this section must be taken into consideration. Under these conditions, B&R standard motors can be used for safety applications.

- **Encoder cable and encoder**
  The encoder cable is connected to the SafeMOTION module with a male DSUB connector. Please note the instructions in the "Cable connection via male DSUB connector" section under 6.1.3.1 "Wiring / General information / Connection diagrams for ground and shield connections / 8BVI inverter modules with SafeMOTION (single-axis modules)" on page 148.
  The following encoder types are used with B&R standard motors with encoder options E0/E1, E4/E5 and E6/E7:
  Heidenhain ECN 1313, EQN 1325, ECN 1113, EQN 1125 (for details, see 1.2.3 "B&R motors / List of encoders / SinCos measuring instruments" on page 170)

Information:

Only 8BCS encoder cables from B&R are permitted to be connected to the encoder interfaces.

- **Motor cable**
  The motor cable is connected to the safe inverter module with a male motor connector.

Information:

Only 8BCM motor cables from B&R are permitted to be connected to the motor connectors.

Third-party motors

Note the requirements for encoders and motors listed in section 2.3.2.2 "Sine-Cosine encoders" on page 178. Under these conditions, third-party motors can be used for safety applications.

- **Encoder cables and encoders**
  The encoders used must meet the requirements set forth in 2.3.2.2.1 "Safety requirements for SinCos measuring instruments" on page 178, in particular those listed under "EMC requirements for the SinCos measuring instrument " on page 181.
  In addition, the wiring from the inverter module to the motor and within the motor itself must be comparable to that of B&R cables and B&R motors. If not, it must be subjected to a complete type examination with the increased test levels specified in IEC 61326-3-1!

Information:

If cables from other manufacturers are used, make sure that they have the same wave parameters and the same design as the respective B&R cable. If deviations exist, additional measures are necessary to ensure that EMC directives are met. When using cables from other manufacturers, B&R cannot guarantee adherence to EMC limit values! The connectors on the cables as well as on the motors are part of a properly functioning EMC concept!

For details, see the ACOPOSmulti user's manual (MAACPM-ENG) under "Technical data / Cables".

- **Motor cable**
  The motor cable is connected to the safe inverter module with a male motor connector.

Information:

Only 8BCM motor cables from B&R are permitted to be connected to the motor connectors.

1.2.3 B&R motors / Encoder list

The encoders in this list have been tested and approved by B&R for the safe evaluation of ACOPOSmulti SafeMOTION EnDat 2.2 inverter modules.

EnDat 2.2 FS measuring instruments

Manufacturer	Name	Vendor ID Model number	Description	Product information	B&R Motor option	Achievable Safety level
Heidenhain	**ECN1325**	678919-12 678919-03	EnDat 2.2 single-turn, 2048-line Mounted optical rotary encoder	D596629	**S0/D0**	SIL2
Heidenhain	**EQN1337**	678921-02 677921-03	EnDat 2.2 multi-turn, 2048-line, 4096 revolutions Mounted optical rotary encoder	D596629	**S1/D1**	SIL2
Heidenhain	**ECN1123**	640745-01 743586-01	EnDat 2.2 single-turn, 512-line Mounted optical rotary encoder	D750816	**S4/D4**	SIL2
Heidenhain	**EQN1135**	640746-01 743587-01	EnDat 2.2 multi-turn, 512-line, 4096 revolutions Mounted optical rotary encoder	D750816	**S5/D5**	SIL2
Heidenhain	**ECI1319**	810661-02	EnDat 2.2 single-turn, 16-line Mounted inductive rotary encoder	D1000353	**SA/DA**	SIL2
Heidenhain	**EQI1331**	810662-03 807100-01	EnDat 2.2 multi-turn, 16-line, 4096 revolutions Mounted inductive rotary encoder	D1000353	**SB/DB**	SIL2
Heidenhain	**ECI1119**	826930-01	EnDat 2.2 single-turn, 16-line Mounted inductive rotary encoder	D1087103	**S8/D8**	SIL2
Heidenhain	**EQI1131**	826933-12 826980-01	EnDat 2.2 multi-turn, 16-line, 4096 revolutions Mounted inductive rotary encoder	D1087103	**S9/D9**	SIL2
Heidenhain	**LC415-570**	89674-11	EnDat 2.2 20 µm grating period Encapsulated length measuring systems	D689429	**-**	SIL2
Heidenhain	**RCN 8310**	667601-01	EnDat 2.2 single-turn, Angular measuring instrument Optical	D1079323	**-**	SIL2
Heidenhain	**RCN 8510**	667595-01	EnDat 2.2 single-turn, Angular measuring instrument Optical	D1079323	**-**	SIL2

Table 85: Measuring instruments for safe evaluation of ACOPOSmulti SafeMOTION EnDat 2.2 inverter modules

The following SinCos measuring instruments have been tested with respect to their safety requirements and their suitability for use with ACOPOSmulti SafeMOTION SinCos inverter modules:

SinCos measuring instruments

Manufacturer	Name	Vendor ID Model number	Description	Product information	B&R Motor option	Achievable Safety level
Heidenhain	**ECN1313**	586 640-11 586 640-51	EnDat single-turn, 512-line		**E0 8LS starting with Rev. C3 8JS starting with Rev. C0**	SIL2
Heidenhain	**EQN1325**	586 654-05 586 654-55	EnDat multi-turn, 512-line, 4096 revolutions		**E1 8LS starting with Rev. C3 8JS starting with Rev. C0**	SIL2
Heidenhain	*ECI1317*	*623 042-07 623 042-52*	*EnDat single-turn, (inductive), 32-line*		*E2*	*Not suitable*
Heidenhain	*EQI1329*	*623 079-14 623 079-61*	*EnDat single-turn, (inductive), 32-line, 4096 revolutions*		*E3*	*Not suitable*
Heidenhain	**ECN1113**	606 684-01 606 684-P1	EnDat single-turn, 512-line		**E4 8LS starting with Rev. C3 8JS starting with Rev. C0**	SIL2
Heidenhain	**EQN1125**	606 689-13 606 689-16	EnDat multi-turn, 512-line, 4096 revolutions		**E5 8LS starting with Rev. C3 8JS starting with Rev. C0**	SIL2

Table 86: Measuring instruments for safe evaluation of ACOPOSmulti SafeMOTION EnDat 2.2 inverter modules

Manufacturer	Name	Vendor ID Model number	Description	Product information	B&R Motor option	Achievable Safety level
Heidenhain	**ECN1313**	586 643-03	EnDat single-turn, 2048-line		**E6 8LS starting with Rev. C3 8JS starting with Rev. C0**	SIL2
Heidenhain	**EQN1325**	586 653-06	EnDat multi-turn, 2048-line, 4096 revolutions		**E7 8LS starting with Rev. C3 8JS starting with Rev. C0**	SIL2
Heidenhain	*ECI1118*	622 503-01	*EnDat single-turn, (inductive), 16-line*		*E8*	*Not suitable*
Heidenhain	*EQI1130*	*598 412-03*	*EnDat single-turn, (inductive), 16-line, 4096 revolutions*		*E9*	*Not suitable*
Heidenhain	*ECI1319*	*623 042-04 623 042-54*	*EnDat single-turn, (inductive), 32-line*		*EA*	*Not suitable*
Heidenhain	*EQI1331*	*623 079-08 623 079-58*	*EnDat single-turn, (inductive), 32-line, 4096 revolutions*		*EB*	*Not suitable*
AMO	**LMKA**	LMKA-x3100.x0x-x, x-Sxx	Absolute length measuring system SSI + 1 Vss		**-**	SIL2
Pepperl Fuchs	**RVS58S**	RVS58S-xxxxxxxxZ	SinCos rotary encoder 1 Vss 1024-/2048-line		**-**	SIL3
Kübler	**Sendix 5863 SIL/ 5883 SIL**	8.5863SIL.1xxx.xx2x	Multi-turn rotary encoder SSI/BISS + 1 Vss 2048-line		**-**	SIL3

Table 86: Measuring instruments for safe evaluation of ACOPOSmulti SafeMOTION EnDat 2.2 inverter modules

Information:

The "B&R motors / Encoder list" is current as of the publication of this version of the user's manual.

The latest version of the "B&R motors / Encoder list" can be downloaded from www.br-automation.com.

1.3 The closed-circuit principle

Integrated safety technology in the ACOPOSmulti SafeMOTION inverter module uses the closed-circuit principle. When there is a logical 0 at a controller input or the current is interrupted, the corresponding safety function or error response is executed.
The closed-circuit principle ensures that the system tends toward the safest possible result in case of failure.

This method is an example of the general principle referred to in engineering as "fail-safe".

This is why the only safe function is the cutoff of a drive's energy and torque. The consequences that are described below are a result of the fail-safe principle.

Danger!

Situations involving external forces (e.g. hanging loads) can result in dangerous movements!
If this poses a safety risk, then the user must implement the necessary equipment to eliminate the risk (e.g. mechanical brakes)! This equipment must correspond to the required safety level!

If a failure occurs, torque and force are removed from the drive and no more electrical pulses are transmitted to the motor. This is referred to as activating safe pulse disabling.

Information:

Safe pulse disabling
Torque and power are switched off on the drive. No electrical pulses are transmitted from the drive to the motor.

If the drive is in motion at the time of the error, then it will coast to a stop. The residual movement and remaining time must be considered for the worst-case scenario when making all of the calculations for the machine's safety circuit.

Danger!

An error can result in a forward movement followed by the motor coasting to a stop. When estimating the distance and time that results from the forward movement / coasting to a stop, the worst case scenario (i.e. the current maximum possible speed) must always be assumed.

The maximum possible drive speed is calculated from the maximum possible acceleration and the error response time, plus the actively monitored speed limit.

2 Principle - Implementing safety functions

Danger!

The C standards applicable to applications must be adhered to!

Danger!

Note that an error can result in a forward movement. The maximum angle of rotation φ of the motor shaft during this forward movement depends on the motor being used.

For permanently excited synchronous motors, φ = 360°/2p (for B&R standard motors, p=3 so the angle is 60°). For three-phase induction motors, there is a relatively small angle of rotation (between 5° and 15°).

2.1 Safe pulse disabling

Safe pulse disabling in ACOPOSmulti SafeMOTION inverter modules has the exact same structure as in standard ACOPOSmulti inverter modules.

The difference is that no external wiring is required. Instead, pulse disabling is activated internally by the SafeMOTION module. The function is controlled via two channels and tested by the SafeMOTION module.

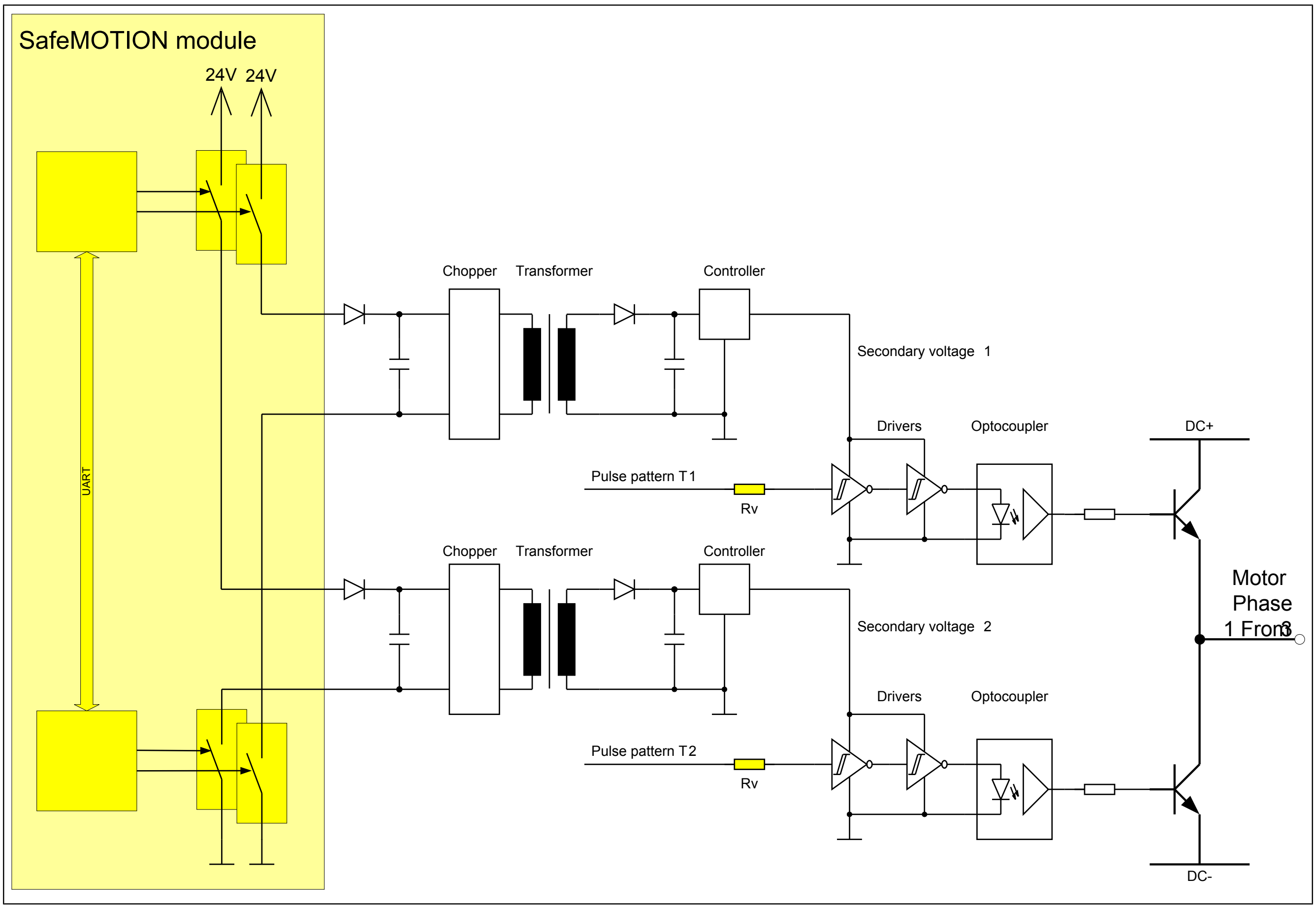


Figure 32: Control of safe pulse disabling

Information:

Safe pulse disabling of the ACOPOSmulti is controlled directly by the SafeMOTION module. External wiring is not possible. This also means it is not necessary to apply fault exclusion to wiring errors!

2.2 Safe motor holding brake output

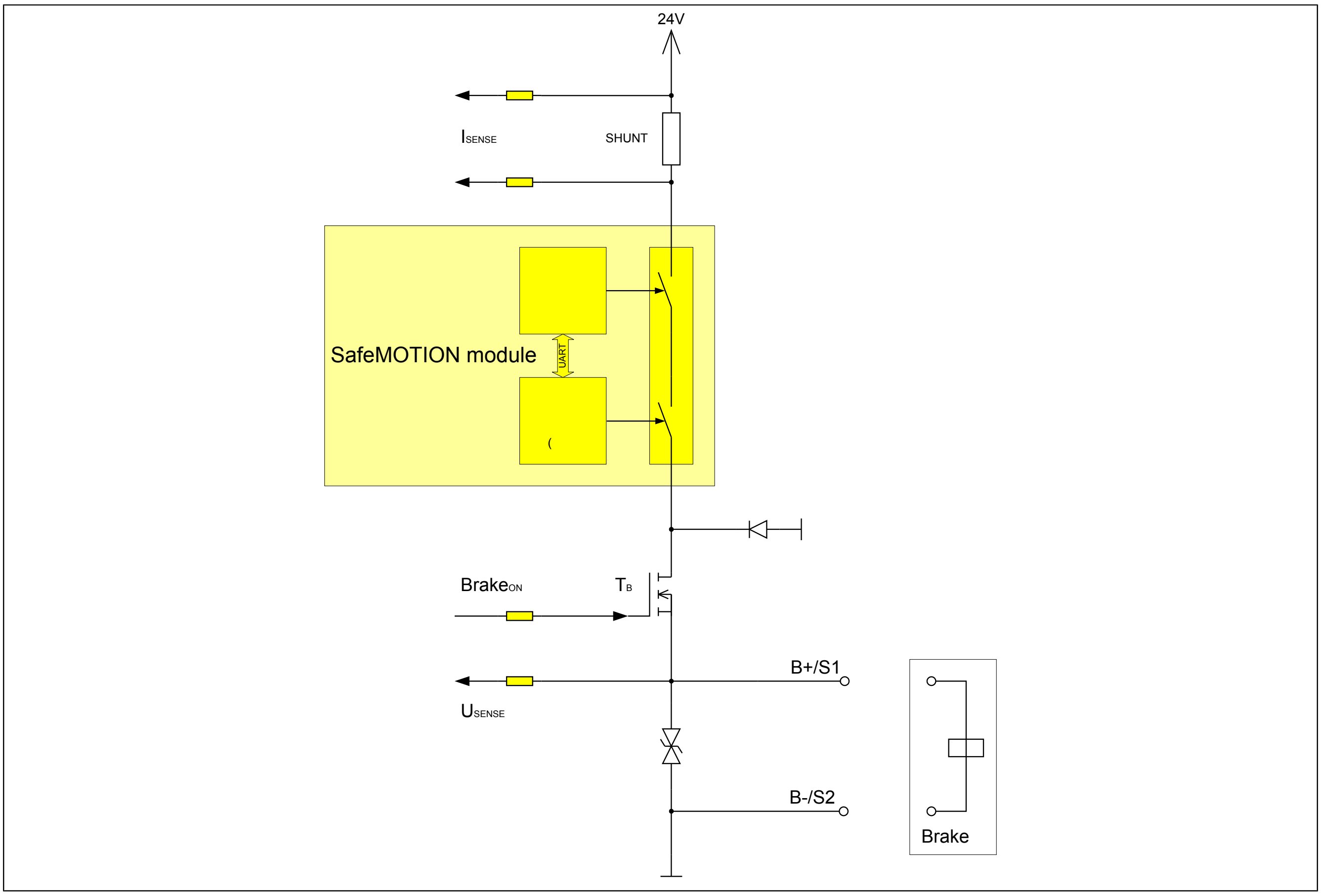


Figure 33: Connection of safe motor holding brake output

A wiring error that causes the output B+ to be shorted to 24 V causes the actuator to remain turned on despite the acknowledgeable FUNCTIONAL FAIL SAFE state being activated.

Error description	Effects	Safety function in accordance with Category 3 / SIL 2 / PL e maintained?
Short circuit: B+ and B-	Error not detected by module-internal testing. However, this is not critical since the motor holding brake is not released in this case (remains engaged).	Yes The motor holding brake output remains in the safe state.
Short circuit between 24 V and B+	Error detected by module-internal testing. The error detection causes the SafeMOTION module to change to the acknowledgeable error state. Safe pulse disabling is activated, and the brake always remains open due to the short circuit to 24 V! **This is a critical error and must therefore be prevented through wiring.**	No Wiring error must be prevented through appropriate wiring!
Short circuit between ground and B+	Error not detected by module-internal testing. However, this is not critical since the motor holding brake is not released in this case (remains engaged).	Yes The motor holding brake output remains in the safe state.

Table 87: Wiring error in safe motor holding brake output

Danger!

The FUNCTIONAL FAIL SAFE state is activated if the SBC output B+ is shorted to 24 V (i.e. safe pulse disabling is activated). The brake always remains on/released, however, due to the short circuit to 24 V! This can lead to dangerous situations because the motor holding brake cannot brake or prevent the spin-out movement (or the unrestrained lowering in the case of hanging loads)!
Appropriate wiring measures must be implemented to ensure that the SBC output B+ is not shorted to 24 V!

Danger!

The SBC output

- **is not permitted to be wired to multiple modules!**
- **is not permitted to be wired as an open emitter!**
- **is not permitted to be wired as an open collector!**

Danger!

Only an output voltage of ≤5 V can be ensured for the safe motor holding brake output when shut off. When selecting a motor holding brake, the user must ensure that the required braking torque is reached at a voltage of 5 V.

Information:

The transistors of the SBC output stage are tested cyclically. When the output channels are active, this test emits low pulses on the output with a maximum length of 600 µs.
Make sure to take this into consideration when selecting the motor holding brake.

2.3 Safe encoder input

2.3.1 Assessing the safety integrity of the overall system

The entire chain, from the encoder to the safety function, must always be taken into consideration when assessing safety integrity.

2.3.1.1 PFH value

To determine the PFH value for the entire safety chain, the PFH value of the current safety function (see 3 "Safety-related characteristic values of integrated safety functions " on page 190) and the PFH value of the encoder must be added:

$$PFH_{Total} = PFH_{Safety\ function} + PFH_{Encoder}$$

2.3.1.2 Category

To determine the category, the category of the respective safety function and the category of the encoder must both be taken into account (encoder manufacturer specifications or determined according to method described).

They must be viewed as a chain, which means the lower of the two categories must be used!

2.3.1.3 Performance level

When determining the performance level of the overall system, all elements that participate in the safety function must be viewed as a chain.

The PL that is achieved for the safety function can then be determined according to "Figure 5" or "Table K.1 – Numerical representation of Figure 5" in EN ISO 13849.

2.3.1.4 SIL

The SIL of the overall system results from the overall PFH value. As a rule of thumb, the drive system (safety function of the ACOPOSmulti SafeMOTION inverter module plus the measuring instrument used) should account for no more then 10% of the SIL limit.

Note that the maximum SIL of the respective safety function (see 3 "Safety-related characteristic values of integrated safety functions " on page 190) cannot be exceeded. This also applies if the PFH value of the chain would be sufficient to achieve a higher SIL!

A maximum of SIL 2 can be reached with a non-certified SinCos encoder.

Safety-related evaluation is not possible for EnDat 2.2 encoders without FS certification, and they therefore cannot be used for safety functions that require safe position evaluation.

2.3.2 Electrical interface

2.3.2.1 EnDat 2.2 functional safety encoder

The conceptual design of the integrated safety functions in the ACOPOSmulti SafeMOTION EnDat 2.2 inverter module includes the use of a Heidenhain EnDat 2.2 functional safety encoder.

The EnDat 2.2 safety encoder must be installed in such a manner as to eliminate the possibility of slippage and encoder shaft breakage. Please follow the installation guidelines from Heidenhain.

In some applications, the SafeMOTION module is able to sufficiently detect encoder slippage or encoder shaft breakage. Mechanical fault exclusion is not necessary for these applications.

> **Danger!**
>
> **Some safety-related measuring instruments can only be used in a closed control loop. This limitation is indicated in the technical data for the respective measuring instrument.**
>
> **These types of safety-related measuring instruments can only be used in combination with an ACOPOSmulti SafeMOTION EnDat 2.2 inverter module!**

Information:

If safety functions are used that require a safe speed and/or position, then a Heidenhain EnDat 2.2 functional safety encoder must be used. Otherwise, the process data from the encoder is set to the FUNCTIONAL FAIL SAFE state.

2.3.2.1.1 Safe encoder counting range

The safe encoder counting range can be found in the data sheet of the respective encoder. On ECN 1325 single-turn and EQN 1337 multi-turn rotary encoders, this range corresponds with the single-turn range. See excerpt from the data sheet:

Technische Kennwerte	**Absolut**	
	ECN 1325 **Singleturn**	**EQN 1337** **Multiturn**
Funktionale Sicherheit für Anwendungen bis	• SIL 2 nach EN 61508 (weitere Prüfgrundlage: EN 61800-5-2) • Kategorie 3 PL d nach EN ISO 13849-1:2008 Sicher im Singleturn-Betrieb	

Information:

The manufacturer's most recent data sheet is the one that is valid. The user is responsible for obtaining this information from the manufacturer.

2.3.2.2 Sine-Cosine encoders

The conceptual design of the ACOPOSmulti SafeMOTION SinCos inverter module includes safe evaluation of analog, sinusoidal incremental signals. For this to be possible, the encoder must meet the requirements specified under 2.3.2.2.1 "Safety requirements for SinCos measuring instruments" on page 178.

2.3.2.2.1 Safety requirements for SinCos measuring instruments

General information

In table D.16, the DIN EN 61800-5-2 standard specifies a general fault model for motion and position sensors that is independent of the construction and design of the motion and position sensors. The following specifications regarding the fault model specified in DIN EN 61800-5-2 refer only to the purely analog 1 V_{ss} signals of a measuring instrument.

Technical data for the encoder interface

The measuring instrument must be suitable according to the technical data for the encoder interface.

Encoder interfaces [1]	
Encoder supply	
Output voltage	5 V ±5% [2]
Load capability	300 mA [3]
Sense lines	2, compensation of max. 2 x 0.7 V
Protective measures	
Short circuit protection	Yes

Table 88: Encoder interface - Technical data

Encoder interfaces [1]	
Sine/Cosine inputs	
Signal transmission	Differential signals, symmetrical
Differential voltage	
In motion	0.5 to 1.35 V [4]
At standstill	0.8 to 1.35 V [5]
Differential voltage deviation per signal period	±10% [6]
Common-mode voltage	Max. ±7 V
Terminating resistors	120 Ω
Max. input frequency	200 kHz
Signal frequency (-5 dB)	<300 kHz
Signal frequency (-3 dB)	DC up to 200 kHz
ADC resolution	12-bit

Table 88: Encoder interface - Technical data

1) Only shielded cables are permitted to be used.
The stranded wire for the analog interface (Sin, nSin, Cos, nCos, Ref, nRef) and the digital interface (T, nT, D, nD) must be twisted pair with a wave impedance of 120 Ω ±10%.
Additional shielding of the analog interface is recommended.
2) During the power-on procedure for the encoder supply voltage (2 seconds), the monitoring limit for the supply voltage is increased from 5.25 V to 6 V. In this phase, overvoltages up to 6 V are not detected.
A short-term overvoltage of maximum 6 V should not damage the encoder electronics in any way.
An undervoltage on the encoder supply will result in a sine or cosine signal outside the specification.
3) An actual reserve of 12 mA exists for the terminating resistor.
4) The sine-cosine output signals from the measuring instrument are checked by the evaluation circuit using pointer length monitoring.
The pointer length $z = 2\sqrt{(Sin - nSin)^2 + (Cos - nCos)^2}$ is monitored according to the specified limits.
5) The sine-cosine output signals from the measuring instrument are checked by the evaluation circuit using pointer length monitoring.
The pointer length $z = 2\sqrt{(Sin - nSin)^2 + (Cos - nCos)^2}$ is also monitored according to the specified limits from the time the evaluation circuit is switched on until a signal period has passed.
6) The sine-cosine output signals from the measuring instrument are checked by the evaluation circuit using pointer length monitoring.
The pointer length $z = 2\sqrt{(Sin - nSin)^2 + (Cos - nCos)^2}$ is only permitted to vary by maximum ±10% per signal period.

Danger!

During the power-on procedure for the encoder supply voltage (2 seconds), the monitoring limit for the supply voltage is increased from 5.25 V to 6 V. In this phase, overvoltages up to 6 V are not detected.

A short-term overvoltage of maximum 6 V must not damage the encoder electronics in any way.

An undervoltage on the encoder supply will result in a sine or cosine signal outside the specification.

Requirements from the "Error list for movement and position sensors in accordance with EN 61800-5-2:2007", Table D.16

The following requirements from the error list must be assessed and implemented by the manufacturer of the measuring instrument or the machine manufacturer.

No.	Fault description	Fault exclusion	Comment	Requirements that must be met by the measuring instrument manufacturer or machine manufacturer
8	Parts become loose at a standstill: • Sensor housing comes off motor housing • Sensor shaft comes off motor shaft	FMEA and proof of fatigue strength of mechanical attachment	Output signal indicates a speed of zero. If fault exclusion is employed, the fastening mechanism for the sensor housing on the motor housing and the sensor shaft on the motor shaft generally withstands excessive stress up to a factor of approximately 20x and any special maintenance information must be provided.	Fault exclusion based on appropriate mounting must be applied in all cases. Exceptions: In synchronous motors applications where the encoder is integrated in position control, errors can be localized using the safe lag error monitoring function in the SafeMOTION module.

Table 89: Error list for movement and position sensors using the standardized error model in accordance with EN 61800-5-2:2007 (Table D.16)

No.	Fault description	Fault exclusion	Comment	Requirements that must be met by the measuring instrument manufacturer or machine manufacturer
9	Fastening mechanism comes loose during movement: • Sensor housing comes off motor housing • Sensor shaft comes off motor shaft	FMEA and proof of fatigue strength of mechanical attachment	Potential effect: • Static offset of sensor shaft • Dynamic slippage of sensor shaft • Output signal is incorrect / indicates a speed of zero If fault exclusion is employed, the fastening mechanism for the sensor housing on the motor housing and the sensor shaft on the motor shaft generally withstands excessive stress up to a factor of approximately 20x and any special maintenance information must be provided.	Fault exclusion based on appropriate mounting must be applied in all cases. Exceptions: In synchronous motors applications where the encoder is integrated in position control, errors can be localized using the safe lag error monitoring function in the SafeMOTION module.
10	Measuring element comes loose[a)] (e.g. optical encoder disc)	None	Output provides incorrect position information	An error that would lead to a position deviation larger than ±1/2 of a signal period must change the sine-cosine signal enough that pointer length monitoring detects an error. This error must be assessed by the measuring instrument manufacturer.
11	No light in front of sensor diode	None	-	An error that would lead to a position deviation larger than ±1/2 of a signal period must change the sine-cosine signal enough that pointer length monitoring detects an error. This error must be assessed by the measuring instrument manufacturer.
Additional requirements for rotary encoders with sin/cos output signals, analog signal generation				
12	Static signal on inputs and outputs, individual or on multiple signals, amplitude in the voltage supply range	None	-	The output signals (sine and cosine) must be generated independently. If this requirement is met, the error is detected by pointer length monitoring on the SafeMOTION module with a diagnostic coverage (DC) of 99%.
14	Swapping the sine and cosine output signal	Fault exclusion is permitted if no electronic components are used to select an output signal from multiple sources.	-	Fault exclusion is required by the measuring instrument manufacturer.
Additional requirements for encoders [b)] with synthetically generated output signals				
21	Distortion of the output signals in any way	None	-	Synthetically generated output signals are not permitted to be used. Exception: Encoders with safety certification, as long as error detection in the encoder is safety-related.
Additional requirements for linear encoders				
23	Mounting for read head broken	FMEA and proof of fatigue strength of mechanical attachment	If fault exclusion is required, the sensor mounting usually withstands the excessive stress that takes place and specific maintenance information should be specified.	Fault exclusion based on appropriate mounting must be applied in all cases. Exceptions: In synchronous motors applications where the encoder is integrated in position control, errors can be localized using the safe lag error monitoring function in the SafeMOTION module.

Table 89: Error list for movement and position sensors using the standardized error model in accordance with EN 61800-5-2:2007 (Table D.16)

No.	Fault description	Fault exclusion	Comment	Requirements that must be met by the measuring instrument manufacturer or machine manufacturer
24	Static offset of measuring element[a)] (e.g. optical encoder strips)	None	-	An error that would lead to a position deviation larger than ±1/2 of a signal period must change the sine-cosine signal enough that pointer length monitoring detects an error. This error must be assessed by the measuring instrument manufacturer.
25	Damaged measuring element[a)] (e.g. optical encoder strips)	None	Pulse shape changed. Pulses missing on incremental encoders	An error that would lead to a position deviation larger than ±1/2 of a signal period must change the sine-cosine signal enough that pointer length monitoring detects an error. This error must be assessed by the measuring instrument manufacturer.
NOTE: This table was written assuming the use of optical sensors. If other sensors are used (e.g. inductive sensors), then the respective errors apply.				

Table 89: Error list for movement and position sensors using the standardized error model in accordance with EN 61800-5-2:2007 (Table D.16)

a) Does not apply to resolvers.
b) Applies correspondingly to linear encoders.

Items not listed in table D.16 are covered by the safety-related evaluation of the sine and cosine signals on the ACOPOSmulti SafeMOTION SinCos inverter module with a diagnostic coverage of 99%!

EMC requirements for the SinCos measuring instrument

The necessary EMC tests must conform with the higher testing levels in accordance with IEC 61326-3-1. The measuring instrument manufacturer or machine manufacturer must provide proof that the measuring instrument conforms to the higher testing levels!

Safety-related values

The ACOPOSmulti SafeMOTION SinCos inverter module offers the possibility of using certified or non-certified SinCos measuring instruments. When determining the safety-related characteristic values of the overall system, non-certified and certified encoders require different procedures.

Non-certified measuring instruments

In order to asses safety integrity, the measuring instrument manufacturer must provide one of the following characteristics. These values can then be used to calculate the PFH for the encoder via diagnostics and encoder evaluation and therefore assess the safety integrity of the overall system.

Value	Unit	Short name	Description
MTTF	[h]	Mean time to failure (mean time to failure)	The MTTF can be directly used to asses safety concepts in accordance with EN ISO 13849. The MTTF (mean time to failure) can be performed for components by analyzing field data or by predictive analysis. At a constant failure rate, the average of the failure-free operating time MTTF = 1/λ , where λ is the failure rate of the instrument. (Statistically, the assumption can be made that 63.2% of the respective components will experience failure after the MTTF has expired.)
λ λ_D λ_S	[10^{-9} 1/h],[FIT]	Failure rate (Failures In Time) Dangerous failure rate Safe failure rate	To assess the safe failure rate according to DIN EN 61508, the FIT value (reciprocal of the MTTF value) must be used as the failure rate. If no detailed breakdown of failure rates ($\lambda_F = \lambda_{F1} + \lambda_{F2} + \ldots + \lambda_{Fn}$) is specified for the measuring instrument being used, the default rate is equally distributed among the faults taken into account in the error model in table D.16 in DIN EN 61800-5-2. If no detailed breakdown of failure rates ($\lambda_F = \lambda_S + \lambda_D$) is specified for the measuring instrument being used, then 50% of the failures will be assumed dangerous in accordance with EN ISO 13849.

Table 90: Characteristics required for non-certified SinCos measuring instruments

Calculating the relevant characteristic values when using non-certified SinCos measuring instruments

PFH value of the encoder with diagnosis of encoder evaluation

The safety integrity level is determined based on the PFH value. There are two methods for determining the PFH value of the encoder with diagnosis of encoder evaluation:

⇨ **Method 1: Determining from the $MTTF_d$ (mean time to dangerous failure) of the encoder being used**

The probability of failure per hour (PFH) for the safety function is calculated from the $MTTF_d$ of the encoder being used and the DC of the SafeMOTION module.

$$PFH_{Encoder} = \frac{1 - DC}{MTTF_d}$$

In the absence of more detailed information about the failure of the measuring instrument, it is assumed that 50% of errors are dangerous.

$$MTTF_d = 2MTTF$$

⇨ **Method 2: Determining from the λ_D (dangerous failure rate) of the encoder being used**

The probability of failure per hour (PFH) for the safety function is determined from the dangerous failure rate (λ_D) of the encoder and the DC of the SafeMOTION module.

$$PFH_{Encoder} = \lambda_D(1 - DC)$$

The encoder evaluation of the ACOPOSmulti SafeMOTION SinCos inverter module has a DC of 99%.

Category (Cat.) of the encoder with diagnosis of encoder evaluation

Safe encoder evaluation can be assessed at Cat. 3 when using a non-certified measuring instrument. This is because the requirements from EN ISO 13849 for diagnostic coverage (DC) and common cause factor (CCF) are met through the named requirements and through the monitoring of the encoder supply voltage in the evaluation logic.

Performance level (PL) of the encoder with diagnosis of encoder evaluation

The performance level of a system can be determined using the figures or tables provided in EN ISO 13849.

Depending on the $MTTF_d$ and PFH value of the SinCos encoder, up to PLd can be achieved (see Figure 5 in EN ISO 13849).

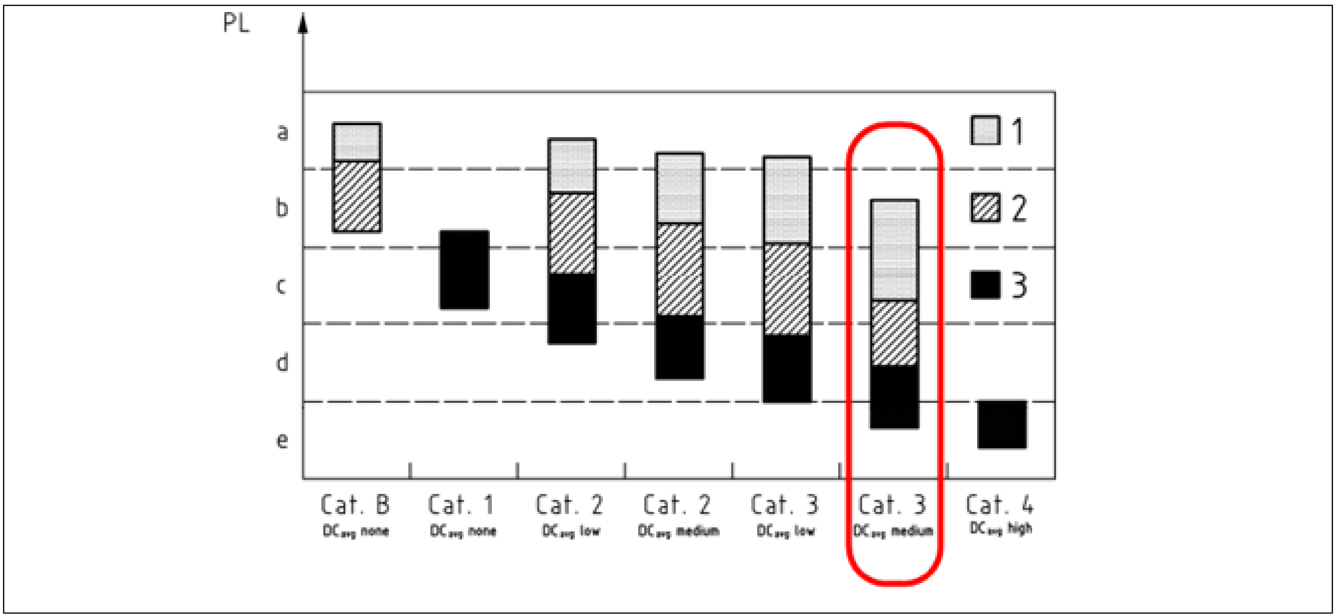


Figure 34: Relationship between DCavg, MTTFd of each channel and PL according to EN ISO 13849-1, Figure 5

Key

1 $MTTF_d$ of each channel = Low
2 $MTTF_d$ of each channel = Medium
3 $MTTF_d$ of each channel = High
PL Performance level

$MTTF_d$	
Name for each channel	**Range for each channel**
Low	3 years ≤ $MTTF_d$ < 10 years
Medium	10 years ≤ $MTTF_d$ < 30 years
High	30 years ≤ $MTTF_d$ ≤ 100 years

Table 91: Mean time to dangerous failure (MTTFd) of each channel in accordance with EN ISO 13849-1, Table 5

SIL capability of the encoder with diagnosis of encoder evaluation

The safety integrity level of a device depends on whether it is operated in a high demand mode of operation or low demand mode of operation.

When operating in a high demand mode of operation, it is assumed that the safety function will be requested continuously or an average of once per hour. For a continuous or high demand mode of operation, the PFH measure is used, which specifies the safety function's probability of failure per hour.

A position measuring instrument is evaluated as a device with a high demand mode of operation.

The maximum possible safety integrity level of a SinCos encoder can be determined as follows.

Safety integrity level (SIL)	Average frequency of dangerous failure of the safety function [h^{-1}] (PFH)
4	$\leq 10^{-9}$ to $< 10^{-8}$
3	$\leq 10^{-8}$ to $< 10^{-7}$
2	$\leq 10^{-7}$ to $< 10^{-6}$
1	$\leq 10^{-6}$ to $< 10^{-5}$

Table 92: Safety integrity levels and target failure measures for a safety function operating in high demand mode of operation or continuous mode of operation in accordance with EN 61508-1:2010, Table 3

The following characteristic values are used to assess the SIL:

- **System type**
  As defined in DIN EN 61508, systems are classified as Type A and Type B. Since a SinCos encoder includes complex components (e.g. OPV), it is considered a Type B system.

- **Hardware fault tolerance (HFT)**
  A hardware fault tolerance of N means that N+1 faults could lead to a failure of the safety function. The hardware fault tolerance is determined based on the MooN architecture used. MooN stands for "M out of N channel architecture" and describes the architecture of a SIL device. For example, "1oo2" refers to an architecture with 2 channels where either of the channels is able to execute the safety function.
  In order to provide single fault tolerance, both signals (sine and cosine) must be generated independently and the safety function (position information) must be contained in both signals. The position information can only be obtained by evaluating both signals, however.
  The SinCos encoder input is to be viewed as single-channel with respect to the position and speed safety functions and can only be assessed as HFT = 0.

- **Safe Failure Fraction (SFF)**
  SFF is the fraction of safe failures. The higher the required SIL rating, the higher the SFF must be. A system's SFF is calculated from the failure rates (λ values) of the individual components.
  To determine the SFF of the SinCos encoder, pointer length monitoring of SinCos signals in the SafeMOTION module is used to increase diagnostic coverage. This additional diagnostics increases the DC level to HIGH.

Safe failure fraction of an element	Hardware fault tolerance		
	0	**1**	**2**
<60%	Not permitted	SIL 1	SIL 2
60% - <90%	SIL 1	SIL 2	SIL 3
90% - <99%	SIL 2	SIL 3	SIL 4
≥99%	SIL 3	SIL 4	SIL 4

Table 93: Maximum allowable safety integrity level for a safety function carried out by a type B safety-related element or subsystem in accordance with EN 61508-2:2010, Table 3

Information:

When a safety-related system executes a safety function over a single channel, the maximum safety integrity level that can be claimed for the safety function under consideration shall be determined by the subsystem with the lowest requirements for hardware safety integrity.

Information:

The overall ACOPOSmulti SafeMOTION SinCos inverter module system is certified for a maximum safety integrity level of SIL 2 for evaluation of non-certified encoders.

Certified measuring instruments

For certified measuring instruments, the manufacturer must specify the necessary safety-related characteristic values.

Verify that all specified diagnostic properties are fulfilled.

Value	Unit	Short name	Description
SIL SIL CL	[ ]	Safety integrity level (Safety Integrity Level) SIL Claim Level	The safety integrity level is one of four discrete levels used to specify the requirement for the safety integrity of the safety functions assigned to the safety-related system, with 4 being the highest level for safety integrity and 1 the lowest. The failure limits for the four safety integrity levels are defined in tables 2 and 3 of IEC 61508-1.
PFH	[10-9 1/h], [FIT]	Probability of safety function failure per hour (Probability of failure per pour)	When operating in a high demand mode of operation, it is assumed that the safety function will be requested continuously or an average of once per hour. For a continuous or high demand mode of operation, the PFH measure is used, which specifies the safety function's probability of failure per hour.
PL	[ ]	Performance level	The ability to operate safety-related parts of control systems or to perform a safety function under foreseeable conditions is assigned a performance level (PL) from a scale of five levels. These performance levels are defined according to the probability of a dangerous failure per hour (see EN ISO 13849-1:2006, Table 3).
Cat.	[ ]	Category	Assesses how well safety-related components in a control system behave when an error occurs.
DC	[%]	Diagnostic coverage (diagnostic coverage)	Partial reduction of the probability of dangerous hardware failures resulting from the use of automatic diagnostic tests Safe evaluation is based solely on the analog Sin/Cos signals. If the measuring instrument contains an internal diagnostics function, then the discovered errors must be reported through a violation of the SinCos interface specification on the subsequent electronics. Only then does it make sense to take into account the level of diagnostic coverage. If a DC is specified, then a provision must also be specified for the diagnostic test interval. Period between online tests to detect faults in a safety-related system with specified diagnostic coverage.
T_m	[years], [a]	Mission time (mission time)	The mission time must be determined by the device manufacturer and specifies the maximum amount of time an encoder can be used. The device must be replaced before the mission time expires!
T_I	[years], [a]	Proof test interval (proof test interval)	Recurring test for fault detection in a safety-related system, which can restore the system to a "like new" condition or as close to it as possible from a practical standpoint. A proof test is normally not possible for electronic devices. The mission time and proof test interval are therefore generally the same.

Table 94: Characteristic values required for certified SinCos measuring instruments

Category (Cat.) of the encoder with diagnosis of encoder evaluation

Danger!

Valid freezing only detected in movement with DC = 99%!

To exclude accumulation of faults at a standstill, movement must take place once a day by at least one signal period of the encoder.

The necessary movement can take place in the course of a functional positioning or homing procedure.

Safe encoder evaluation can be assessed at Cat. 4 when a suitable (certified) measuring instrument is used and the above limitations are taken into account.

Estimation of the achievable safety levels based on the example of a Heidenhain ECN 1313 / EQN 1325

Manufacturer specifications

According to an analysis of the document D662649-01-E-01 from Heidenhain, ECN 1313 and EQN 1325 encoders are deemed suitable for use with the ACOPOSmulti SafeMOTION SinCos inverter module.

The following MTTF / FIT values are specified:

Type	ID number	MTTF [h]	FIT [10^{-9}/h]
ECN 1313	586640-11	>1,666,667	<600
ECN 1313	586643-03	>1,666,667	<600
EQN 1325	586653-06	>1,666,667	<600
EQN 1325	586654-05	>1,666,667	<600

Table 95: MTTF values for Heidenhain ENC 1313 and EQN 1325 encoders according to Heidenhain document D662649-01-E-01

Calculating characteristic values of the encoder with diagnosis of encoder evaluation

Since ECN 1313 and EQN 1225 encoders have the same MTTF values, the following calculations apply to both encoder types.

Characteristic value	ECN 1313 / EQN 1325
MTTF	1,666,667 [h]
$MTTF_d$	3,333,334 [h] = 380 years = high
$PFH_{encoder}$	$3*10^{-9}$ [h^{-1}]
CAT / PL	Cat 3 / PLd
SIL	Max. SIL 2 since the encoder is not certified

Table 96: Calculated characteristic values for Heidenhain ECN 1313 and EQN 1325 with diagnosis of encoder evaluation of the ACOPOSmulti SafeMOTION SinCos inverter module

Calculating the characteristic values of the overall system

The following tables show an example of the safety-related characteristic values for the safety functions of the ACOPOSmulti SafeMOTION SinCos inverter module, performance class XXX, in combination with a Heidenhain ECN 1313 or EQN 1325 encoder:

Safety function	PFH	CAT / PL / SIL
STO	$1*10^{-09}$ [h^{-1}]	CAT 4 / PLe / SIL 3
STO1	$1*10^{-08}$ [h^{-1}]	CAT 3 / PLd / SIL 2
SBC	$1*10^{-08}$ [h^{-1}]	CAT 3 / PLd / SIL 2
SOS **SS1** **SS2** **SLS** **SMS** **SDI** **SLI** **Safe Speed**	$6*10^{-09}$ [h^{-1}] + $3*10^{-09}$ [h^{-1}] = $6*10^{-09}$ [h^{-1}]	CAT 3 / PLd / SIL 2
Safe Homing **SLP** **SMP** **Safe Position**	$6*10^{-09}$ [h^{-1}] + $3*10^{-09}$ [h^{-1}] = $6*10^{-09}$ [h^{-1}] Only with safe encoder mounting (see Table D.16, No. 8 and 9, Fault exclusion)	CAT 3 / PLd / SIL 2 Only with safe encoder mounting (see Table D.16, No. 8 and 9, Fault exclusion)
SBT	$2*10^{-08}$ [h^{-1}] + $3*10^{-09}$ [h^{-1}] = $2.3*10^{-08}$ [h^{-1}]	CAT 3 / PLd / SIL 2

Table 97: Safety-related characteristic values for 8BVIXXXXSA.XXX-X ACOPOSmulti SafeMOTION SinCos inverter modules in combination with a Heidenhain ECN 1313 or EQN 1325 encoder

2.3.3 Mechanical mounting

2.3.3.1 Encoder mounting with proof of fatigue strength

To prevent errors caused by encoder slippage or shaft breakage, the mechanical mounting of the encoder requires proof of fatigue strength.

This proof and the corresponding mounting guidelines can be provided either by the manufacturer of the measuring instrument or by the manufacturer of the machine.

Danger!

To ensure safe operation up to and including the motor shaft, any errors in the connection between the motor shaft and encoder must be identified and prevented.

Danger!

Proof of fatigue strength for the encoder's mechanical mounting is to be dimensioned to the maximum rotor acceleration. This acceleration value must not be exceeded in the worst case. The maximum acceleration is monitored on the SafeMOTION module and can be configured using the "Maximum acceleration" parameter.

Danger!

Mechanical tolerances in the encoder mounting must be taken into account when calculating the residual distance. This residual movement must be taken into account by the safety functions.

Danger!

To ensure safe operation up to and including the motor shaft, any errors in the connection between the motor shaft and encoder must be identified and prevented.
There are specific guidelines that must be followed when installing a functional safety encoder.
The motor manufacturer must ensure that these specifications are adhered to.

Danger!

The frictional connection between the cone-shaped shaft of the rotor and measuring instrument can be dimensioned for maximum rotor acceleration in accordance with the mounting instructions provided by the encoder manufacturer. This acceleration value must not be exceeded in the worst case. The maximum acceleration is monitored on the SafeMOTION module and can be configured using the "*Maximum acceleration*" parameter.

Danger!

If the terminal screw for the coupling ring becomes loose on installed measuring instruments, then the form-fit pin will be the only thing holding the encoder to the motor housing. A movement in accordance with the mounting tolerances is possible. The encoder is not able to register this movement. This residual movement must be taken into account by the safety functions.

2.3.3.2 Encoder mounting without proof of fatigue strength - Safe lag error monitoring

If "Encoder Monitoring" is activated in the SafeMOTION module, in some applications the proof of fatigue strength for the mechanical mounting of the encoder is not required.

The following safety-related restrictions must be taken into account!

Danger!

Only safety functions in which no safe absolute position is monitored are permitted to be used (STO, SBC, SOS, SS1, SS2, SLS, SMS, SLI, SDI, SLA, SBT (only available for ACOPOSmulti SafeMOTION SinCos) and Safe Speed).

Danger!

The application must meet the following requirements for safety-related monitoring of the encoder-motor connection:

- **Encoder connection monitoring can only be used for encoders that are integrated in position control.**
- **Encoder connection monitoring can only be used for drive systems with synchronous motors.**
- **The encoder must be protected against shearing in standstill (e.g. with encasement in the motor housing)!**
- **Monitoring for position lag errors, speed errors and position setpoints change (Alive Testing) must be enabled in the safety application, and sufficiently strict limits must be monitored!**
- **The Safe Position, SLP and/or SMP safety functions must not be used!**
- **Safe monitoring can only be guaranteed when closed-loop control is enabled.**

Danger!

- **An electrical offset of <90° will not be detected sufficiently.**
- **There is no way to monitor the encoder connection if the setpoint remains constant.**
- **An encoder connection error or an error in encoder evaluation is always assumed as the cause for the lag error.**
- **The error reaction in the standard application to a position lag error or speed error is disabled by the SafeMOTION module (overridden). When lag errors occur, only the error responses STO or STO1 with an induction stop are possible.**

Danger!

Note that an error can result in a forward movement. The maximum angle of rotation φ of the motor shaft during this forward movement depends on the motor being used.

For permanently excited synchronous motors, φ = 360°/2p (for B&R standard motors, p=3 so the angle is 60°). For three-phase induction motors, there is a relatively small angle of rotation (between 5° and 15°).

The maximum speed of the forward movement can be calculated as follows:

$$n_{Jolt} = \frac{1}{2\pi}\sqrt{\frac{6a_{max}}{p_z}}\left[\frac{U}{s}\right]$$

with maximum acceleration $a_{max} = \frac{M_{max}}{J}\left[\frac{rad}{s^2}\right]$ **and number of motor pole pairs** p_z

Danger!

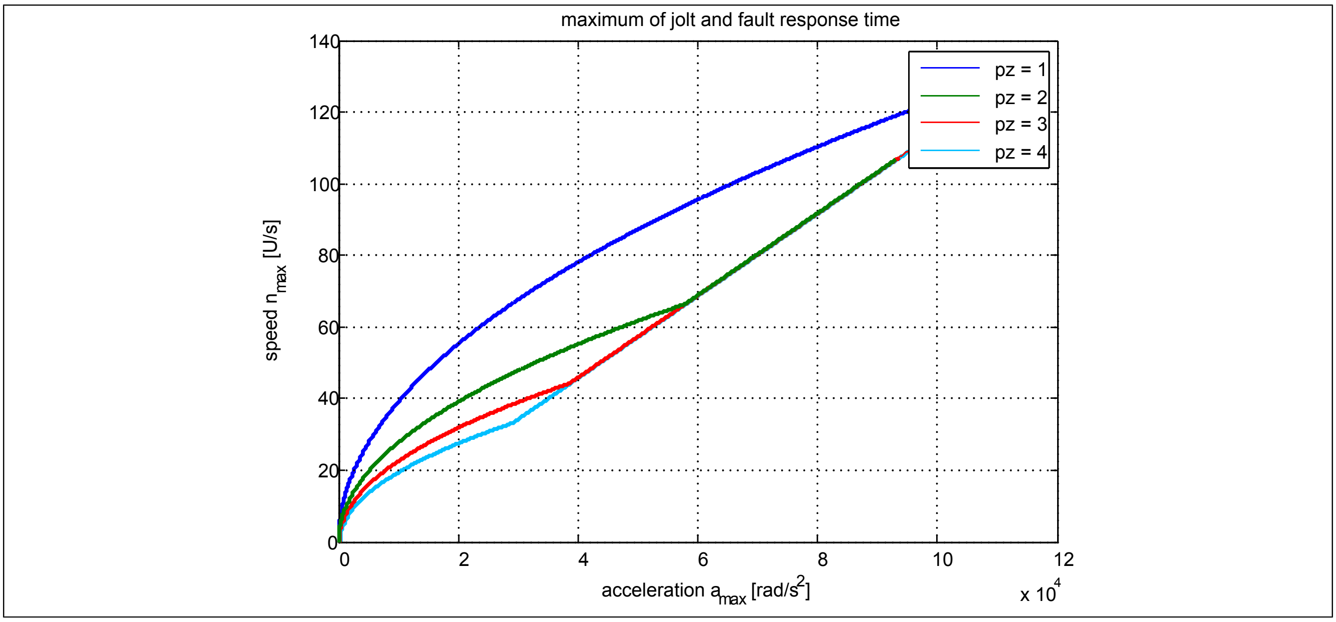
When considering the worst-case scenario for a safety function, the highest value of the maximum speed of the forward movement n_{Jolt} **and the speed must be used as maximum speed due to the maximum error response time** $n_{T_{worstcase}}$.

$$n_{max} = max(n_{Jolt}, n_{T_{worstcase}}) = max\left(\frac{1}{2\pi}\sqrt{\frac{6a_{max}}{p_z}}, \frac{T_{worstcase}}{2\pi} \cdot a_{max}\right)$$

with maximum error response time $T_{worstcase} = 7.2[ms]$

The maximum speed n_{max} **resulting from this must be considered together with the speed when the safety function** n_{LIM} **is violated in order to determine the maximum possible speed** $n_{worstcase}$ **at the time of coasting to a stop!**

$$n_{worstcase} = n_{LIM} + n_{max}$$



Information:

In order to check the plausibility of setpoint selection after each power on, the axis must be moved by at least twice the configured lag error limit before the first request of a safety function, which requires a safe encoder evaluation, or at least within 15 min.
If this is not done, then the SafeMOTION module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state. The S_NotErrFUNC output on the function block is reset, and the drive loses all torque/power and coasts to a stop!
In the event of an error, a synchronous axis will no longer be synchronous.

Danger!

Situations involving external forces (e.g. hanging loads) can result in dangerous movements!
If this poses a safety risk, then the user must implement the necessary equipment to eliminate the risk (e.g. mechanical brakes)! This equipment must correspond to the required safety level!

Information:

A 24-hour timeout begins after successfully checking the plausibility of the setpoint.
The timeout is reset any time the position setpoint changes by more than twice the position lag error tolerance.
If the position setpoint does not change during 24 hours of continuous controller operation, then the SafeMOTION module will switch to the acknowledgeable FUNCTIONAL FAIL SAFE error state. The S_NotErrFUNC output on the function block is reset, and the drive loses all torque/power and coasts to a stop! In the event of an error, a synchronous axis will no longer be synchronous.

The following parameters are relevant for safe monitoring of the encoder-motor shaft connection (Encoder Monitoring):

Parameter	Unit	Description	Default value
Encoder Unit System			
Maximum acceleration [rad/s² or mm/s²]	[rad/s² or mm/s²]	Maximum permissible encoder acceleration	100000
Encoder Monitoring			
Encoder Position Monitoring	Activated/ Deactivated	Activates/Deactivates the monitoring of the position lag error generated on the SafeMOTION module	Activated
Encoder Speed Monitoring	Activated/ Deactivated	Activates/Deactivates the monitoring of the speed error generated on the SafeMOTION module	Activated
Set position alive testing	Activated/ Deactivated	Activates/Deactivates the monitor that detects whether the position setpoint generated on the ACOPOSmulti SafeMOTION inverter module is frozen	Activated
Encoder Monitoring Tolerances			
Encoder Monitoring Position Tolerance	[units]	Position lag error tolerance for shaft breakage monitoring	0
Encoder Monitoring Speed Tolerance	[units/s]	Speed error tolerance for encoder monitoring	0

Table 98: Encoder Monitoring safety function - Parameters

Danger!

The machine manufacturer is responsible for determining whether or not the application is suited for safe encoder connection monitoring if there is no mechanical mechanism for detecting encoder shaft breakage.
The machine manufacturer is responsible for ensuring that the safe encoder monitoring has been configured correctly!

Danger!

Encoder connection monitoring can only be used in a safety-related capacity if the aforementioned requirements for the application have been fulfilled!

2.3.3.2.1 Activating monitoring

The following parameters must be set to "Activated" in SafeDESIGNER in order to enable safe encoder connection monitoring:

- "Encoder Position Monitoring" = Activated
- "Encoder Speed Monitoring" = Activated
- "Set position alive testing" = Activated

Danger!

In order to ensure safety-related monitoring of the encoder/motor connection, all three parameters "Encoder Position Monitoring", "Encoder Speed Monitoring" and "Set Position Alive Testing" must be set to "Activated"!
If this is not the case, then the monitoring system cannot be used for safety purposes and a mechanical solution for detecting errors must be implemented!

2.3.3.2.2 Configuration rule for position lag error tolerance

The position lag error tolerance must be set large enough to ensure availability. This can be done by first measuring the position lag error under the highest influence of disturbance variables and at maximum acceleration and then setting the position lag error tolerance accordingly higher.

Danger!

The position lag error tolerance cannot be higher than half of one pole length!

If the safety function is activated, the size of the position lag error tolerance value affects how long it will take to look for errors and therefore also the error response time and estimation of the residual distance.

This must be taken into account by the machine manufacturer in the risk analysis!

Information:

Due to rounding errors, a reserve of 1 unit should be taken into account with the parameter "Encoder Monitoring Position Tolerance".

2.3.3.2.3 Configuration rule for speed error tolerance

The speed error tolerance must be set large enough to ensure availability.
This can be done by first measuring the speed error under the highest influence of disturbance variables and reference variables (e.g. at maximum acceleration) and then setting the speed error tolerance accordingly higher.

Danger!

When the safety function is enabled, the size of the speed error tolerance value affects how long it will take to look for errors and therefore also the error response time and estimation of the residual distance.

This must be taken into account by the machine manufacturer in the risk analysis!

Information:

Due to rounding errors, a reserve of 1 unit/s should be taken into account with the "Encoder monitoring speed tolerance" parameter.

3 Safety-related characteristic values of integrated safety functions

The safety-related characteristic values have been calculated for the individual safety functions and grouped together in the following blocks:

- Safe Torque Off (STO), Safe Stop 1 (SS1) time-monitored
  → The two safe pulse disabling channels and their activation are included in evaluation.

- Safe Torque Off (STO) single-channel
  → Only one safe pulse disabling channel and its activation are included in evaluation.

- Safe Brake Control (SBC)
  → The safe motor brake output and its activation are included in the evaluation. The brake itself must be taken into account explicitly in the safety chain!

- Safe Operating Stop (SOS), Safe Stop 1 (SS1), Safe Stop 2 (SS2), Safely Limited Speed (SLS), Safe Direction (SDI), Safely Limited Increments (SLI), Safely Limited Acceleration (SLA), Safe Maximum Speed (SMS), Safely Limited Position (SLP), Safe Maximum Position (SMP), Safe Homing
  → The two safe pulse disabling channels and their activation are included in evaluation. Safe evaluation of the encoder, safe position detection and the safe motor holding brake output and its activation are also taken into consideration.
  The safety-related characteristic values of the encoder itself must also be taken into account!
- Safe Brake Test (SBT)
  → The two safe pulse disabling channels and their activation are included in evaluation. Safe evaluation of the encoder, safe position detection, safe current measurement and the safe motor holding brake output and its activation are also taken into consideration.
  The safety-related characteristic values of the encoder itself must also be taken into account!
  The brake itself must be taken into account explicitly in the safety chain.

Danger!

To determine the overall PFH value for safety functions that require safe encoder evaluation, the PFH value of the encoder being used must be taken into account.

For a detailed description, see 2.3.1 "Assessing the safety integrity of the overall system" on page 177!

$\mathbf{PFH_{TOTAL} = PFH_{SOS,SS1,SS2,SLS,SMS,SDI,SLI,SLA,SLP,SMP} + PFH_{Encoder}}$

Danger!

It is the machine manufacturer's responsibility to read and adhere to the technical documentation (product catalog / user's manual) provided for the measuring instrument.

Danger!

If the technical documentation (product catalog / user's manual) for the measuring instrument explicitly specifies that the bit error rate must be verified, then the user needs to implement this verification procedure in the application. This verification is not necessary if using B&R EnDat 2.2 8BCF encoder cables and certain B&R motors.

3.1 Safety-related characteristic values of integrated safety functions ACOPOSmulti SafeMOTION EnDat 2.2

Safety function	Criteria	Characteristic dependent on module width [1]			
		1	2	4	8
Safe Torque Off (STO), Safe Stop 1 (SS1), time-monitored	Maximum safety category in accordance with EN ISO 13849	Cat. 4			
	Maximum performance level in accordance with EN ISO 13849	PLe			
	Maximum safety integrity level in accordance with IEC 62061	SIL 3			
	Maximum safety integrity level in accordance with IEC 61508	SIL 3			
	PFH (probability of dangerous failure per hour)	$<5*10^{-10}$			
	PFD (probability of dangerous failure on demand) with a proof test interval of 20 years	$<9*10^{-05}$			
	PTI (proof test interval) [2]	Max. 20 years			
	DC (diagnostic coverage)	>95%			
	MTTFd (mean time to dangerous failure) [3]	2500 years			

Table 99: Safety-related characteristic values: Safe Torque Off (STO), Safe Stop 1 (SS1) time-monitored

1) ACOPOSmulti inverter modules have different module widths according to their performance class. Different components and/or switching elements are used depending on the performance class / module width, which has a direct effect on the characteristics of safe pulse disabling. The module width is listed in the technical data for the respective ACOPOSmulti inverter module.
2) Corresponds to the mission time of the module.
3) Values determined according to Apfeld, R.; Bömer, T.; Hauke, M.; Huelke, M.; Schaefer, M.: Practical experience with DIN EN ISO 13849-1.openautomation (2009) No. 6, pp. 34-37 (www.dguv.de/ifa/de/pub/grl/pdf/2009_249.pdf).

Safety function	Criteria	Characteristic dependent on module width [1]			
		1	2	4	8
Safe Torque Off, single-channel (STO1)	Maximum safety category in accordance with EN ISO 13849	Cat. 3			
	Maximum performance level in accordance with EN ISO 13849	PLd			
	Maximum safety integrity level in accordance with IEC 62061	SIL 2			
	Maximum safety integrity level in accordance with IEC 61508	SIL 2			
	PFH (probability of dangerous failure per hour)	$<8*10^{-09}$			
	PFD (probability of dangerous failure on demand) with a proof test interval of 20 years	$<1.4*10^{-03}$			
	PTI (proof test interval) [2]	Max. 20 years			
	DC (diagnostic coverage)	>94%			
	MTTFd (mean time to dangerous failure)	>167 years	>157 years	>143 years	>85 years

Table 100: Safety-related characteristic values: Safe Torque Off, single-channel (STO1)

1) ACOPOSmulti inverter modules have different module widths according to their performance class. Different components and/or switching elements are used depending on the performance class / module width, which has a direct effect on the characteristics of safe pulse disabling. The module width is listed in the technical data for the respective ACOPOSmulti inverter module.
2) Corresponds to the mission time of the module.

Safety function	Criteria	Characteristic dependent on module width [1]			
		1	2	4	8
Safe Brake Control (SBC)	Maximum safety category in accordance with EN ISO 13849	Cat. 3			
	Maximum performance level in accordance with EN ISO 13849	PLd			
	Maximum safety integrity level in accordance with IEC 62061	SIL 2			
	Maximum safety integrity level in accordance with IEC 61508	SIL 2			
	PFH (probability of dangerous failure per hour)	$<1*10^{-08}$			
	PFD (probability of dangerous failure on demand) with a proof test interval of 20 years	$<1.75*10^{-03}$			
	PTI (proof test interval) [2]	Max. 20 years			
	DC (diagnostic coverage)	>95%			
	MTTFd (mean time to dangerous failure)	>153 years	>135 years	>117 years	>56 years

Table 101: Safety-related characteristic values: Safe Brake Control (SBC)

1) ACOPOSmulti inverter modules have different module widths according to their performance class. Different components and/or switching elements are used depending on the performance class / module width, which has a direct effect on the characteristics of safe pulse disabling. The module width is listed in the technical data for the respective ACOPOSmulti inverter module.
2) Corresponds to the mission time of the module.

Safety function	Criteria	Characteristic dependent on module width 1)			
		1	2	4	8
Safe Operating Stop (SOS), Safe Stop 1 (SS1), Safe Stop 2 (SS2), Safely Limited Speed (SLS), Safe Direction (SDI), Safely Limited Increments (SLI), Safely Limited Acceleration (SLA), Safe Maximum Speed (SMS), Safely Limited Position (SLP), Safe Maximum Position (SMP), Safe Homing Remanent Safe Position (RSP)	Maximum safety category in accordance with EN ISO 13849	Cat. 3			
	Maximum performance level in accordance with EN ISO 13849	PLd			
	Maximum safety integrity level in accordance with IEC 62061	SIL 2			
	Maximum safety integrity level in accordance with IEC 61508	SIL 2			
	PFH (probability of dangerous failure per hour)	$<5*10^{-9}$			
	PFD (probability of dangerous failure on demand) with a proof test interval of 20 years	Cannot be used since continuous encoder evaluation is required!			
	PTI (proof test interval) 2)	Max. 20 years			
	DC (diagnostic coverage)	>95%			
	MTTFd (mean time to dangerous failure)	>109 years	>100 years	>89 years	>49 years

Table 102: Safety-related characteristic values: Safe Operating Stop (SOS), Safe Stop 1 (SS1), Safe Stop 2 (SS2), Safely Limited Speed (SLS), Safe Direction (SDI), Safely Limited Increments (SLI), Safely Limited Acceleration (SLA), Safe Maximum Speed (SMS), Safely Limited Position (SLP), Safe Maximum Position (SMP), Safe Homing

1) ACOPOSmulti inverter modules have different module widths according to their performance class. Different components and/or switching elements are used depending on the performance class / module width, which has a direct effect on the characteristics of safe pulse disabling. The module width is listed in the technical data for the respective ACOPOSmulti inverter module.

2) Corresponds to the mission time of the module.

3.2 Safety-related characteristic values of integrated safety functions ACOPOSmulti SafeMOTION SinCos

Safety function	Criteria	Characteristic dependent on module width 1)		
		1	2	4
Safe Torque Off (STO), Safe Stop 1 (SS1), time-monitored	Maximum safety category in accordance with EN ISO 13849	Cat. 4		
	Maximum performance level in accordance with EN ISO 13849	PLe		
	Maximum safety integrity level in accordance with IEC 62061	SIL 3		
	Maximum safety integrity level in accordance with IEC 61508	SIL 3		
	PFH (probability of dangerous failure per hour)	$<1*10^{-09}$		
	PFD (probability of dangerous failure on demand) with a proof test interval of 20 years	$<1.5*10^{-04}$		
	PTI (proof test interval) 2)	Max. 20 years		
	DC (diagnostic coverage)	>98%		
	MTTFd (mean time to dangerous failure) 3)	2200 years		

Table 103: Safety-related characteristic values: Safe Torque Off (STO), Safe Stop 1 (SS1) time-monitored

1) ACOPOSmulti inverter modules have different module widths according to their performance class. Different components and/or switching elements are used depending on the performance class / module width, which has a direct effect on the characteristics of safe pulse disabling. The module width is listed in the technical data for the respective ACOPOSmulti inverter module.
2) Corresponds to the mission time of the module.
3) Values determined according to Apfeld, R.; Bömer, T.; Hauke, M.; Huelke, M.; Schaefer, M.: Practical experience with DIN EN ISO 13849-1.openautomation (2009) No. 6, pp. 34-37 (www.dguv.de/ifa/de/pub/grl/pdf/2009_249.pdf).

Safety function	Criteria	Characteristic dependent on module width 1)		
		1	2	4
Safe Torque Off, single-channel (STO1)	Maximum safety category in accordance with EN ISO 13849	Cat. 3		
	Maximum performance level in accordance with EN ISO 13849	PLd		
	Maximum safety integrity level in accordance with IEC 62061	SIL 2		
	Maximum safety integrity level in accordance with IEC 61508	SIL 2		
	PFH (probability of dangerous failure per hour)	$<1*10^{-08}$		
	PFD (probability of dangerous failure on demand) with a proof test interval of 20 years	$<1.5*10^{-03}$		
	PTI (proof test interval) 2)	Max. 20 years		
	DC (diagnostic coverage)	>97%		
	MTTFd (mean time to dangerous failure)	>220 years	>220 years	>180 years

Table 104: Safety-related characteristic values: Safe Torque Off, single-channel (STO1)

1) ACOPOSmulti inverter modules have different module widths according to their performance class. Different components and/or switching elements are used depending on the performance class / module width, which has a direct effect on the characteristics of safe pulse disabling. The module width is listed in the technical data for the respective ACOPOSmulti inverter module.
2) Corresponds to the mission time of the module.

Safety function	Criteria	Characteristic dependent on module width 1)		
		1	2	4
Safe Brake Control (SBC)	Maximum safety category in accordance with EN ISO 13849	Cat. 3		
	Maximum performance level in accordance with EN ISO 13849	PLd		
	Maximum safety integrity level in accordance with IEC 62061	SIL 2		
	Maximum safety integrity level in accordance with IEC 61508	SIL 2		
	PFH (probability of dangerous failure per hour)	$<1*10^{-08}$		
	PFD (probability of dangerous failure on demand) with a proof test interval of 20 years	$<1*10^{-04}$		
	PTI (proof test interval) 2)	Max. 20 years		
	DC (diagnostic coverage)	>97%		
	MTTFd (mean time to dangerous failure)	>300 years	>300 years	>300 years

Table 105: Safety-related characteristic values: Safe Brake Control (SBC)

1) ACOPOSmulti inverter modules have different module widths according to their performance class. Different components and/or switching elements are used depending on the performance class / module width, which has a direct effect on the characteristics of safe pulse disabling. The module width is listed in the technical data for the respective ACOPOSmulti inverter module.
2) Corresponds to the mission time of the module.

Safety function	Criteria	Characteristic dependent on module width [1]		
		1	2	4
Safe Operating Stop (SOS), Safe Stop 1 (SS1), Safe Stop 2 (SS2), Safely Limited Speed (SLS), Safe Direction (SDI), Safely Limited Increments (SLI), Safely Limited Acceleration (SLA), Safe Maximum Speed (SMS), Safely Limited Position (SLP), Safe Maximum Position (SMP), Safe Homing	Maximum safety category in accordance with EN ISO 13849	Max. Cat. 4 with certified measuring instrument Max. Cat. 3 with non-certified measuring instrument		
	Maximum performance level in accordance with EN ISO 13849	Max. PLe with certified measuring instrument Max. PLd with non-certified measuring instrument		
	Maximum safety integrity level in accordance with IEC 62061	Max. SIL 3 with certified measuring instrument Max. SIL 2 with non-certified measuring instrument		
	Maximum safety integrity level in accordance with IEC 61508	Max. SIL 3 with certified measuring instrument Max. SIL 2 with non-certified measuring instrument		
	PFH (probability of dangerous failure per hour)	$<5*10^{-9}$		
	PFD (probability of dangerous failure on demand) with a proof test interval of 20 years	Cannot be used since continuous encoder evaluation is required!		
	PTI (proof test interval) [2]	Max. 20 years		
	DC (diagnostic coverage)	>95%		
	MTTFd (mean time to dangerous failure)	>90 years	>85 years	>80 years

Table 106: Safety-related characteristic values: Safe Operating Stop (SOS), Safe Stop 1 (SS1), Safe Stop 2 (SS2), Safely Limited Speed (SLS), Safe Direction (SDI), Safely Limited Increments (SLI), Safely Limited Acceleration (SLA), Safe Maximum Speed (SMS), Safely Limited Position (SLP), Safe Maximum Position (SMP), Safe Homing

1) ACOPOSmulti inverter modules have different module widths according to their performance class. Different components and/or switching elements are used depending on the performance class / module width, which has a direct effect on the characteristics of safe pulse disabling. The module width is listed in the technical data for the respective ACOPOSmulti inverter module.
2) Corresponds to the mission time of the module.

Safety function	Criteria	Characteristic dependent on module width [1]		
		1	2	4
Safe Brake Test (SBT)	Maximum safety category in accordance with EN ISO 13849	Cat. 3		
	Maximum performance level in accordance with EN ISO 13849	PLd		
	Maximum safety integrity level in accordance with IEC 62061	SIL 2		
	Maximum safety integrity level in accordance with IEC 61508	SIL 2		
	PFH (probability of dangerous failure per hour)	$<1*10^{-08}$		
	PFD (probability of dangerous failure on demand) with a proof test interval of 20 years	Cannot be used since continuous encoder evaluation is required!		
	PTI (proof test interval) [2]	Max. 20 years		
	DC (diagnostic coverage)	>97%		
	MTTFd (mean time to dangerous failure)	>65 years	>55 years	>45 years

Table 107: Safety-related characteristic values: Safe Brake Test (SBT)

1) ACOPOSmulti inverter modules have different module widths according to their performance class. Different components and/or switching elements are used depending on the performance class / module width, which has a direct effect on the characteristics of safe pulse disabling. The module width is listed in the technical data for the respective ACOPOSmulti inverter module.
2) Corresponds to the mission time of the module.

4 Integrated safety functions

Information:

If a safety function is not used in the application, then the respective input must remain open.

The following functions are supported by the SafeMOTION module:

Safety function	ACOPOSmulti SafeMOTION		EN ISO 13849-1		EN 61508 / EN 62061		Safety Encoder evaluation necessary?
	EnDat 2.2	SinCos	EnDat 2.2	SinCos	EnDat 2.2	SinCos	
	Starting in Safety Release						
Safe Torque Off (STO)	R 1.3	R 1.4	PLe / CAT 4	PLe / CAT 4	SIL 3	SIL 3	No
Safe Torque Off One Channel (STO1)	R 1.3	R 1.4	PLd / CAT 3	PLd / CAT 3	SIL 2	SIL 2	No
Safe Operation Stop (SOS)	R 1.3	R 1.4	PLd / CAT 3	Max. PLe / CAT 4, depends on the encoder used	SIL 2	Max. SIL 3, depends on the encoder used	Yes
Safe Stop 1 (SS1)	R 1.3	R 1.4	Time-based monitoring: PLe / CAT 4 Ramp-based monitoring: PLd / CAT 3	Time-based monitoring: PLe / CAT 4 Ramp-based monitoring: Max. PLe / CAT 4, depends on the encoder used	Time-based monitoring: SIL 3 Ramp-based monitoring: SIL 2	Time-based monitoring: SIL 3 Ramp-based monitoring: Max. SIL 3, depends on the encoder used	Time-based monitoring: No Ramp-based monitoring: Yes
Safe Stop 2 (SS2)	R 1.3	R 1.4	PLd / CAT 3	Max. PLe / CAT 4, depends on the encoder used	SIL 2	Max. SIL 3, depends on the encoder used	Yes
Safely Limited Speed (SLS)	R 1.3	R 1.4	PLd / CAT 3	Max. PLe / CAT 4, depends on the encoder used	SIL 2	Max. SIL 3, depends on the encoder used	Yes
Safe Maximum Speed (SMS)	R 1.3	R 1.4	PLd / CAT 3	Max. PLe / CAT 4, depends on the encoder used	SIL 2	Max. SIL 3, depends on the encoder used	Yes
Safe Direction (SDI)	R 1.3	R 1.4	PLd / CAT 3	Max. PLe / CAT 4, depends on the encoder used	SIL 2	Max. SIL 3, depends on the encoder used	Yes
Safely Limited Increment (SLI)	R 1.3	R 1.4	PLd / CAT 3	Max. PLe / CAT 4, depends on the encoder used	SIL 2	Max. SIL 3, depends on the encoder used	Yes
Safely Limited Acceleration (SLA)	R 1.9	R 1.9	PLd / CAT 3	Max. PLe / CAT 4, depends on the encoder used	SIL 2	Max. SIL 3, depends on the encoder used	Yes
Safe Brake Control (SBC)	R 1.3	R 1.4	PLd / CAT 3	PLd / CAT 3	SIL 2	SIL 2	No
Safely Limited Position (SLP)	R 1.4	R 1.4	PLd / CAT 3	Max. PLe / CAT 4, depends on the encoder used	SIL 2	Max. SIL 3, depends on the encoder used	Yes
Safe Maximum Position (SMP)	R 1.4	R 1.4	PLd / CAT 3	Max. PLe / CAT 4, depends on the encoder used	SIL 2	Max. SIL 3, depends on the encoder used	Yes
Safe Homing	R 1.4	R 1.4	PLd / CAT 3	Max. PLe / CAT 4, depends on the encoder used	SIL 2	Max. SIL 3, depends on the encoder used	Yes
Safe Brake Test (SBT)	-	R 1.7	-	Max. PLd / CAT 3, depends on the encoder used	-	Max. SIL 2, depends on the encoder used	Yes
Remanent Safe Position (RSP)	R 1.9	-	PLd / CAT 3	-	SIL 2	-	Yes

Table 108: ACOPOSmulti SafeMOTION: Safety functions and corresponding safety levels

Guidelines for using the integrated safety functions

At least the **Activate** and **S_AxisID** inputs must be connected. Otherwise, the SafeMOTION module will not be operated by the SafeLOGIC controller. As a result, pulse disabling and the motor holding brake output will be permanently set to 0 V, which means that the controller cannot be switched on.

Danger!

All of the safety functions that are being used must be tested.
A function is considered to be "in use" if the corresponding input is connected or the safety function has been configured!

4.1 FAIL SAFE state

4.1.1 Parameters

None

4.1.2 Behavior

If a hardware or firmware error occurs, then the safe inverter module switches to a non-acknowledgeable error state – the FAIL SAFE state. The logbook entry in Automation Studio provides more detailed information about the pending error. This logbook can also be evaluated in the standard application.
If a hardware defect is detected, then the entire inverter module must be replaced.

Information:

SafeMOTION modules cannot be replaced! SafeMOTION modules and the corresponding inverter module form a single unit. In the event of an error, the entire inverter module must be replaced.

An error may also have been caused by a configuration mistake, however. If this is the case, then the safe configuration must be checked and reloaded to the SafeLOGIC controller. This must then be followed by a power off/on cycle to bring the module back to the OPERATIONAL state.

Danger!

Safe pulse disabling is always active in the FAIL SAFE state (i.e. the motor is no longer supplied with power or generating torque). The motor holding brake output is always switched to 0 V in this state!

Danger!

Constantly lit "SE" LEDs indicate a non-acknowledgeable FAIL SAFE state. The cause of this could be a defective module or faulty configuration.
Check the entries in the logbook! If you are able to rule out a faulty configuration, then the module is defective and must be replaced immediately.

It is your responsibility to ensure that all necessary repair measures or corrections to the configuration are initiated after an error occurs since subsequent errors can result in dangerous situations!

Danger!

If connected, the motor holding brake engages in the FAIL SAFE state. The motor holding brake will suffer mechanical wear if the motor is in motion just before the safe state is triggered. This must be taken into account when selecting and dimensioning the motor holding brake (E-stop capability).

4.2 FUNCTIONAL FAIL SAFE state

4.2.1 Parameters

Parameter	Unit	Description	Default value
General settings			
Channel selection for One Channel STO (STO1)	HighSide/LowSide	Selects the HighSide or LowSide IGBT in the one channel STO function	HighSide
Behavior of Functional Fail Safe			
Behavior of Functional Fail Safe	STO / STO1 and STO with time delay	In the FUNCTIONAL FAIL SAFE state, STO (SBC) is activated immediately, or STO1 and then STO (SBC) after a delay.	STO
Delay time for STO in Functional Fail Safe	[µs]	Delay time between STO1 and STO (and SBC) in the FUNCTIONAL FAIL SAFE state	0
Delay time until the brake engages	[µs]	Delay time before the brake engages The second enable channel is activated after this delay time if STO1 and time-delayed STO and SBC are configured for FUNCTIONAL FAIL SAFE.	0

Table 109: Parameters for configuring the FUNCTIONAL FAIL SAFE state

4.2.2 Behavior

If a monitored limit is exceeded or an encoder error occurs during operation – and as long as the safe encoder is required for the safety functions being used – then the SafeMOTION module switches to an acknowledgeable error state – the FUNCTIONAL FAIL SAFE state.
Information about any errors that occur can be found in the logbook entry in Automation Studio. This logbook can also be evaluated in the standard application.

Danger!

The motor holding brake is engaged in the FUNCTIONAL FAIL SAFE state. The motor holding brake will suffer mechanical wear if the motor is in motion just before the safe state is triggered. This must be taken into account when selecting and dimensioning the motor holding brake (E-stop capability).

Danger!

The error response time specified in the manual affects the residual movement in the event of error! This must be taken into account when planning the safety equipment (e.g. distances, monitored limits, etc.)

"Behavior of Functional Fail Safe" = "STO"

Pulse disabling is requested (low and high side) immediately after the error is detected and the safe motor holding brake output is set to 0 V.

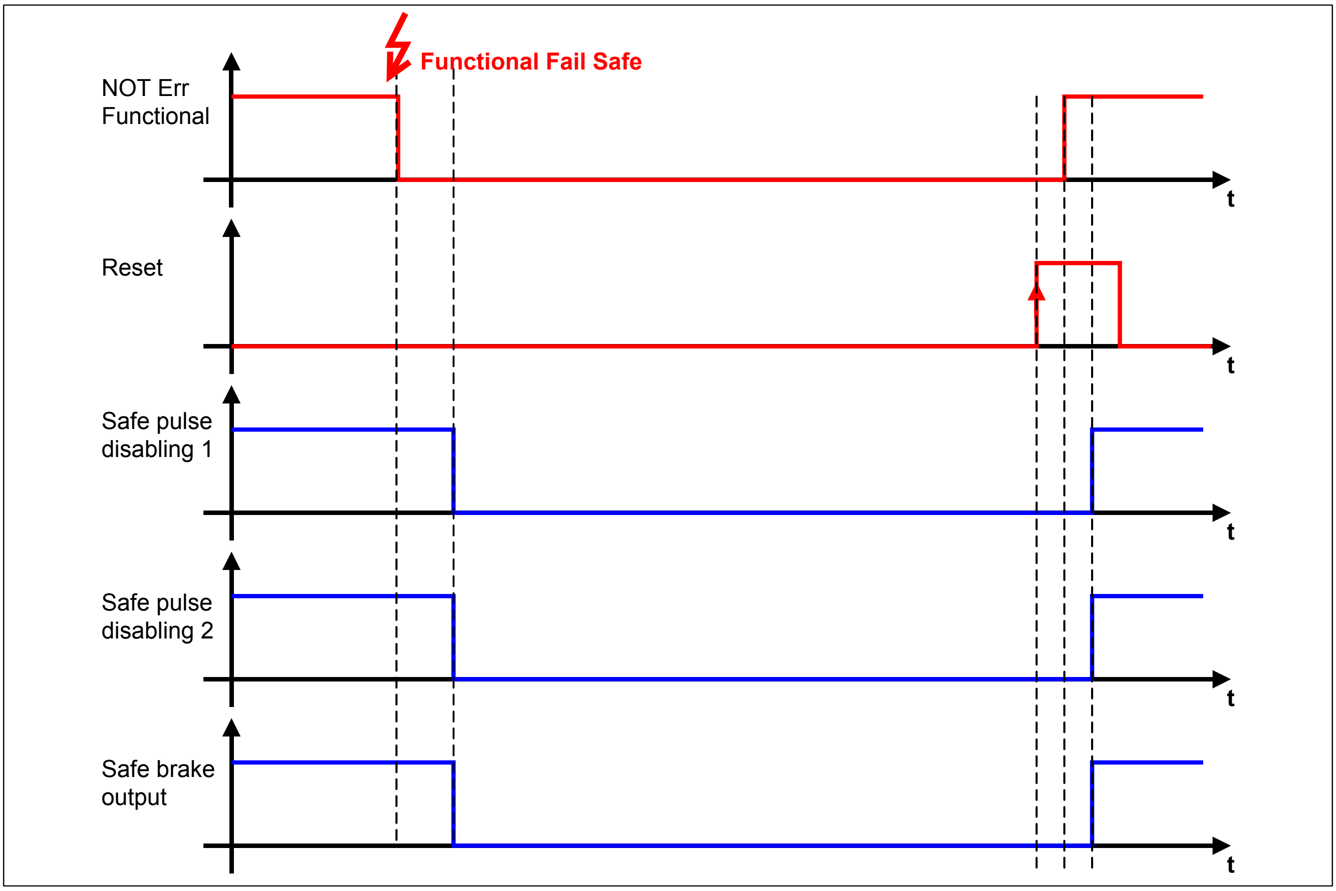


Figure 35: FUNCTIONAL FAIL SAFE - STO configuration

"Behavior of Functional Fail Safe" = "STO1 and STO with time delay"

Either the low or high side of the pulse disabling is switched to 0 V immediately after the error is detected. The safe motor holding brake output is set to 0 V after the time configured for "Delay time for STO in Functional Fail Safe" ($T_{\text{(Delay time for STO in FFS)}}$) has expired.
The second channel of the pulse disabling is also switched to 0 V after the configured time "Delay time until the brake engages" ($T_{\text{(Delay Time until the brake engages)}}$) has expired.

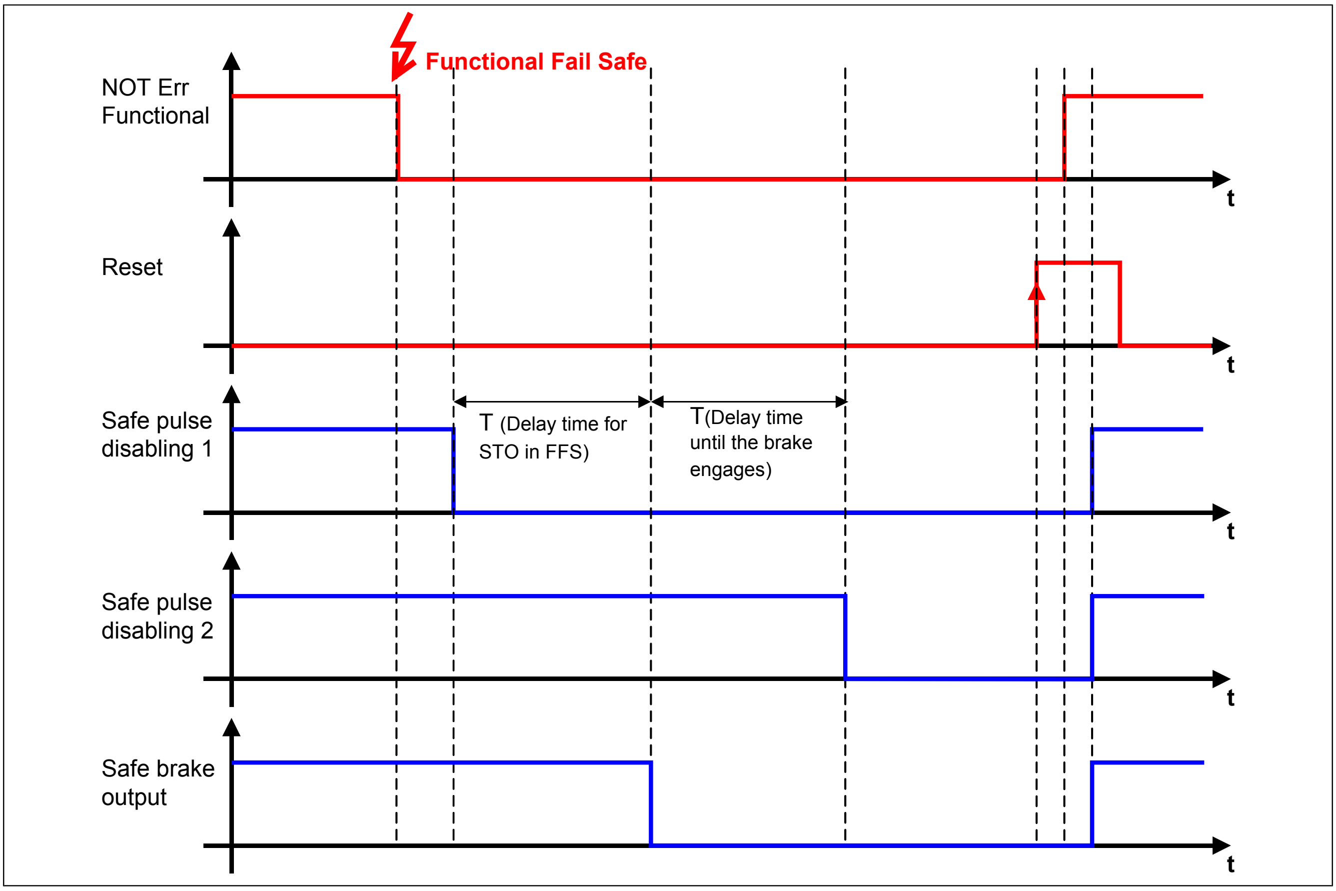


Figure 36: FUNCTIONAL FAIL SAFE - STO1 and STO configuration with time delay

This makes it possible for the drive to be decelerated via the short circuit braking integrated in the ACOPOSmulti system for the amount of time in which just one pulse disabling channel is active.
In this case, the time value $T_{\text{(Delay time until the brake engages)}}$ is used to incorporate this brake engage time. This means that the second pulse disabling channel will only be switched to 0 V after the motor holding brake has actually engaged.

Danger!

Short circuit braking in the ACOPOSmulti system is not suitable for safety purposes and can therefore only be used to protect the machine. If the release of motor energy could result in dangerous situations (e.g. with hanging loads), then a mechanical safeguard must also be installed.

4.3 Safe Position, Safe Speed

4.3.1 Parameters

Parameter	Unit	Description	Default value	Starting in Safety Release
Encoder Type	Rotary encoder / Linear encoder / Encoder used / Encoder not used	Determines the type of encoder used: • ACOPOSmulti SafeMOTION SinCos *(Safety Release 1.7 or higher)* ° Rotary encoder: Rotary encoder ° Linear encoder: Linear encoder ° Encoder not used: No encoder being used • ACOPOSmulti SafeMOTION EnDat 2.2 *(Safety Release 1.9 or higher)* ° Encoder used: Rotary encoder used ° Encoder not used: No encoder being used	Rotary encoder (SinCos) Encoder used (EnDat 2.2)	R 1.7 R 1.9
Number of signal periods	-	Number of signal periods per revolution (rotary encoder) or length of the physical reference system (linear encoder)	1	R 1.7
Count of physical reference system	---	Rotary encoder unit scale: x revolutions Linear encoder unit scale: x reference lengths (reference length = length of the physical reference system) Any unit (mm, 1/100 mm, 1/20 inch, degree of angle, etc.) can be used for positions (and data which can result such as speed and acceleration). For this reason, the relationship between an integer multiple of this unit (units per x revolutions / units per x reference lengths) and a certain number of x revolutions / x reference lengths has to be previously defined.	1	R 1.4
Units per count of physical reference system [units]	[units]	Rotary encoder unit-scale: Units per x revolutions Linear encoder unit scale: Units per x reference lengths Any unit (mm, 1/100 mm, 1/20 inch, degree of angle, etc.) can be used for positions (and data which can result such as speed and acceleration). For this reason, the relationship between an integer multiple of this unit (units per x revolutions / units per x reference lengths) and a certain number of x revolutions / x reference lengths has to be previously defined.	1000	R 1.4
Counting direction	Standard / Inverse	Counting direction of the position or speed **Value** – **Description** Standard – Encoder counting direction is equal to the counting direction of the unit system. Inverse – Encoder counting direction is negative to the counting direction of the unit system.	Standard	R 1.3
Length of physical reference system for linear encoder (nm)	[nm]	For linear measurement systems, the length of a physical reference system is defined here. This value is not used for rotary encoders, where the reference system is a single revolution.	1000000000	R 1.4
Maximum speed to normalize the speed range (units/s)	[units/s]	Maximum speed to which the displayed speed should be normalized	32767	R 1.3
Maximum acceleration (rad/s² or mm/s²)	[rad/s²] or [mm/s²]	Maximum permissible encoder acceleration	100000	R 1.4

Table 110: SafeMOTION parameter group: Encoder Unit System

Information:

The physical drive speed is not permitted to exceed the value set for the "Maximum speed to normalize the speed range (units/s)" parameter; otherwise, the SafeMOTION module will switch to the error state!

Danger!

If the manufacturer of the measuring instrument specifies a limitation of the maximum acceleration, this must be monitored by the SafeMOTION module. The acceleration to be monitored can be configured using the "Maximum acceleration" parameter.

Danger!

Incorrectly configuring the unit system can result in dangerous situations.
When validating the application, the monitored speed limits must be intentionally violated and their physical values tested! The same must also be done for the monitored direction of rotation!

4.3.2 Behavior

These parameters (see 4.3.1 ""Unit system parameters" table" on page 200) can be used to configure the safe unit system.

The safe speed and safe position are transferred in the safety frame. The process data may only be used together with the corresponding status bit. If the respective status bit is FALSE, then the corresponding data is invalid.

Function blocks are available that can link the process data to a specific axis in order to use it in the safety application.

Safe Position

The safe position is transferred in the [units] defined by the configured units system. When homing is completed, the **S_SafePositionValid** status bit is set.

Danger!

If the position signal is not validated, then an invalid position could be used in the safety application. This can result in hazardous situations!

Danger!

The safe encoder evaluation can only detect a transmission or positioning error if:

- **a distance is traversed that is greater than the angular deviation from the safe position that is specified in the product information provided by the manufacturer of the measuring instrument *(applies to ACOPOSmulti SafeMOTION EnDat 2.2)*.**
- **a distance is traversed that is greater than ±½ of the signal period of the SinCos measuring instrument *(applies to ACOPOSmulti SafeMOTION SinCos)*.**

The resulting maximum error in the safe position also depends on the length of the physical reference system (revolutions, length of the scale, etc.).

The error affects the minimum clearance required to prevent pinching/crushing (e.g. of fingers) and must be taken into account when dimensioning the safety function.

Danger!

For a frictionally engaged connection with fault exclusion, there is no additional mechanical offset that would need to be considered for the safe position.

If fault exclusion is fulfilled only by a mechanical stop with backlash, this maximum possible offset must be calculated into the safe position. This is done by adding the values for the measuring instrument and for the mechanical coupling.

Safe Speed

The safe speed is scaled to 2 bytes due to the limited bandwidth available in the safety frame. The scaled speed (v_{Scaled}) is calculated as follows:

$$v_{scaled} = \frac{v_{physical} \cdot 32767}{Maximum\ speed\ to\ normalize\ the\ speed\ range}\left[\frac{scaled\ units}{s}\right]$$

$v_{Physical}$ (physical speed) corresponds to the actual physical value and is calculated in [units/s] using the configured units system.

With the default parameter setting "Maximum speed to normalize the speed range (units/s)" = 32767, the scaled speed equals the physical speed!

The maximum speed is never permitted to exceed the configured value of "Maximum speed to normalize the speed range (units/s)"; otherwise, the module switches to the FUNCTIONAL FAIL SAFE state.

Information:

The speed limits of safety functions are configured in [units/s] of physical speed. The safety functions monitor the scaled speeds [scaled units/s] internally, which can cause scaling errors to occur.

Example

The following configuration results in the speed tolerance for standstill monitoring being scaled internally to 0 [scaled units/s].

Configuration:
"Maximum speed to normalize the speed range (units/s)" = 3,276,700
"Speed Tolerance (unit/s)" = 20

$$Scaled\ Speed\ Tolerance = \frac{Speed\ Tolerance \cdot INT16MAX}{Maximum\ Speed\ to\ normalize\ the\ speed\ range} = \frac{20 \cdot 32767}{3276700} = 0$$

If Safe Operating Stop is activated, a speed tolerance of 0 is monitored internally [scaled units/s]. This can wrongly result in a speed limit violation while at a standstill.

Information:

The configured unit system has a significant impact on the maximum physical speed that is achieved.

When changing the configured unit system, it is important to consider how this will affect the "Maximum speed to normalize the speed range (units/s)" parameter.

Danger!

If the module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state, then the drive loses all torque/power and coasts to a stop! In the event of an error, a synchronous axis will no longer be synchronous. The S_NotErrFUNC output on the function block is reset.

Danger!

Situations involving external forces (e.g. hanging loads) can result in dangerous movements!
If this poses a safety risk, then the user must implement the necessary equipment to eliminate the risk (e.g. mechanical brakes)! This equipment must correspond to the required safety level!

Danger!

If the speed signal is not validated, then an invalid speed value could be used in the safety application. This can result in hazardous situations!

Danger!

The safe encoder evaluation can only detect a transmission or positioning error if:

- **a distance is traversed that is greater than the angular deviation from the safe position that is specified in the product information provided by the manufacturer of the measuring instrument *(applies to ACOPOSmulti SafeMOTION EnDat 2.2)*.**
- **a distance is traversed that is greater than ±½ of the signal period of the SinCos measuring instrument *(applies to ACOPOSmulti SafeMOTION SinCos)*.**

The resulting maximum error in the safe position also depends on the length of the physical reference system (revolutions, length of the scale, etc.).

The error influences the error response time and must be taken into account when dimensioning the safety function.

4.4 Safe Torque Off (STO)

4.4.1 Parameters

None

4.4.2 Behavior

STO is the fundamental safety function of the ACOPOSmulti SafeMOTION inverter module since it represents the "closed-circuit principle".
A request from the STO safety function activates safe pulse disabling and switches off the torque and power to the drive. Activation of safe pulse disabling is performed actively by the SafeMOTION module.

Danger!

A STO request causes synchronized axes to no longer be synchronous.

Danger!

Situations involving external forces (e.g. hanging loads) can result in dangerous movements!
If this poses a safety risk, then the user must implement the necessary equipment to eliminate the risk (e.g. mechanical brakes)! This equipment must correspond to the required safety level!

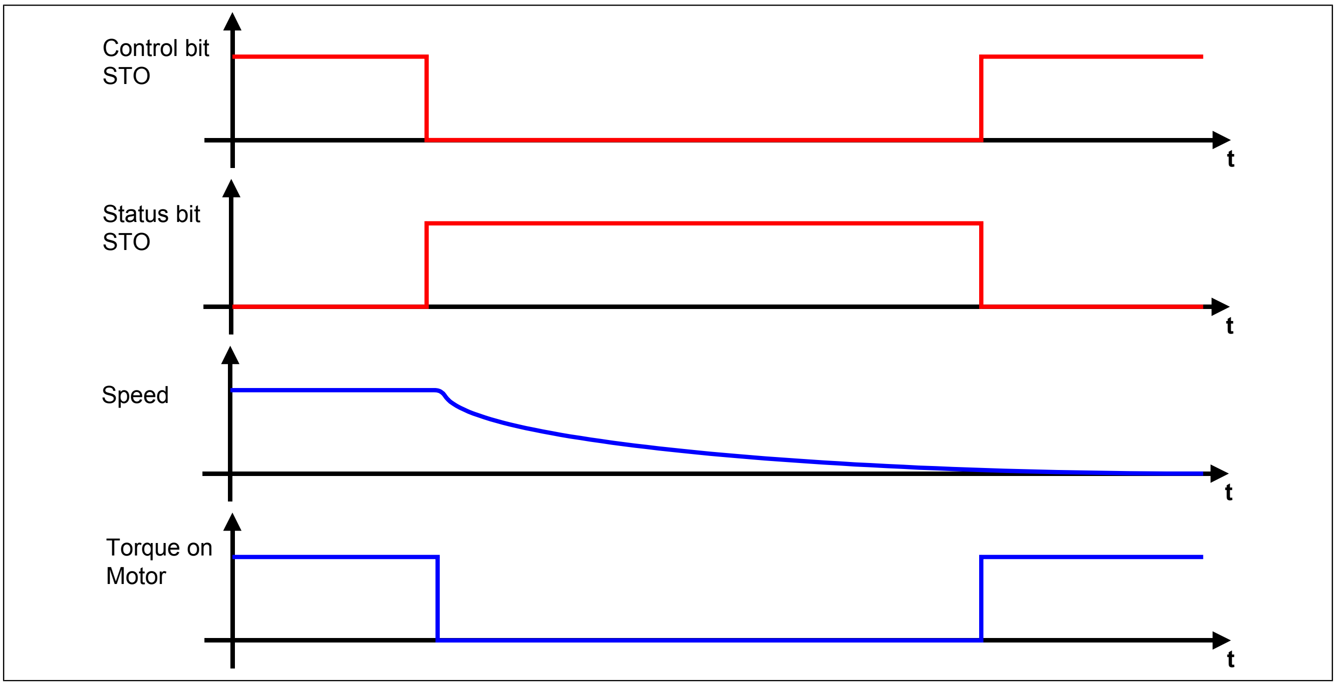


Figure 37: Safe Torque Off (STO)

Information:

The functional safe state of the STO safety function has been achieved when the pulse disabling outputs are switched to 0 V. The respective bit is set when the functional safe state has been achieved.

Danger!

If the drive is in motion at the time STO is requested, it will coast to a stop. The resulting residual movement and time depends on the properties of the machine and must always be considered when dimensioning the safety equipment.
The maximum possible (worst case) movement must be assumed.

The maximum possible speed is determined by the current operating mode. If there is no active safety function, the maximum speed that is physically possible for the motor must be assumed.

Danger!

If the SMS or SLS safety function is active, the assumed maximum speed can be reduced to the currently active configured speed limit plus the maximum possible acceleration during the error response time.

Information:

The resulting residual movement and time determines the clearances that must be observed for the safety features and therefore the overall size of the machine.

Information:

The STO safety function does not require safe encoder evaluation.

Danger!

If the STO safety function is used in the safety application, then it must be tested when commissioning the machine by selecting and deselecting it!

4.5 Safe Torque Off, single-channel (STO1)

4.5.1 Parameters

Parameter	Unit	Description	Default value
General Settings			
Channel selection for One Channel STO (STO1)	HighSide/ LowSide	Selects the HighSide or LowSide IGBT in the STO1 function	HighSide

Table 111: STO1 safety function - Parameters

4.5.2 Behavior

The STO1 safety function works in the same way as STO. The sole difference is that either only the HighSide or only the LowSide IGBTs are switched off depending on the configuration.

Information:

The functional safe state of the STO1 safety function has been achieved when the configured pulse disabling output is switched to 0 V.
The respective bit is set when the functional safe state has been achieved.

Information:

The two-channel aspect is lost because either only the LowSide or only the HighSide of the pulse disabling is activated with the STO1 safety function.
This results in a lower SIL and Performance Level!

Information:

The STO1 safety function does not require safe encoder evaluation.

Danger!

If the safety function STO1 is used in the safety application, then it must be tested when commissioning the machine by selecting and deselecting it!

4.6 Safe Brake Control (SBC)

4.6.1 Parameters

Parameter	Unit	Description	Default value
Safety Additional Parameters			
Delay time to start SBC (us)	[µs]	Delay time between the SBC request and activation of the safety function	0

Table 112: SBC safety function - Parameters

4.6.2 Behavior

The SBC safety function is a safe (time-delayed) output that can be used to safely control a motor holding brake.

Information:

To achieve a defined SIL level, the controlled holding brake must also have at least the same SIL level and errors in the wiring must be ruled out.

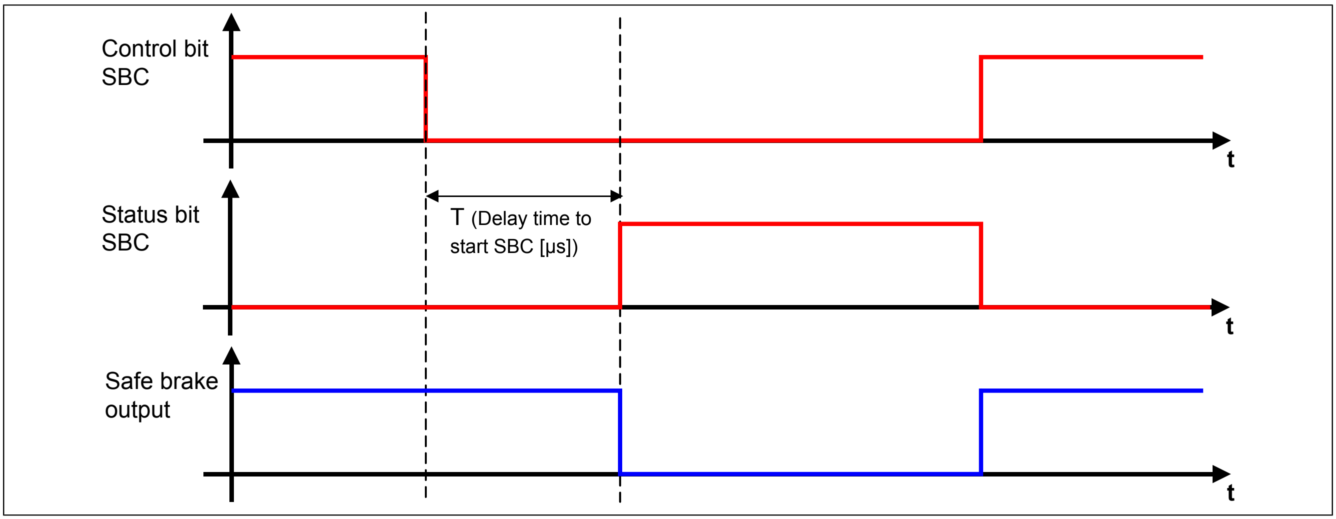


Figure 38: Safe Brake Control (SBC)

Only the actuation of the motor holding brake output by the SafeMOTION module is rated SIL 2.

The SafeMOTION module does not provide safe monitoring of the braking procedure.

Information:

The functional safe state of the SBC safety function has been achieved when the safe motor holding brake output has been switched to 0 V.
The respective bit is set when the functional safe state has been achieved.

The purpose of the delay time T $_{\text{(Delay time to start SBC [µs])}}$ is to compensate for the different runtimes of standard and safety applications.

Information:

The SBC safety function does not require safe encoder evaluation.

Danger!

If the SBC safety function is used in the safety application, then it must be tested when commissioning the machine by selecting and deselecting it!

Information:

Functional errors will occur (e.g. 6029: Holding brake: Control signal on and output status off) if the holding brake is released by the standard application but the motor holding brake output is switched to 0 V by the SafeMOTION module.

4.7 Safe Operating Stop (SOS)

4.7.1 Parameters

Parameter	Unit	Description	Default value
Safety Standstill and Direction Tolerances			
Speed Tolerance	[units/s]	Speed tolerance for standstill monitoring	0
Position Tolerance	[units]	Position tolerance for standstill and direction monitoring	0

Table 113: SOS safety function - Parameters

4.7.2 Behavior

An enabled SOS safety function monitors the drive to ensure that it stops safely. The SafeMOTION module does not control pulse disabling.
The drive can remain active and must be kept at standstill by the standard application.

Information:

The SOS safety function requires safe evaluation of the speed and position.
If the function is programmed in the safety application and if an error is detected in the safe encoder evaluation, then the SafeMOTION module immediately switches to the FUNCTIONAL FAIL SAFE state after the function block is activated!

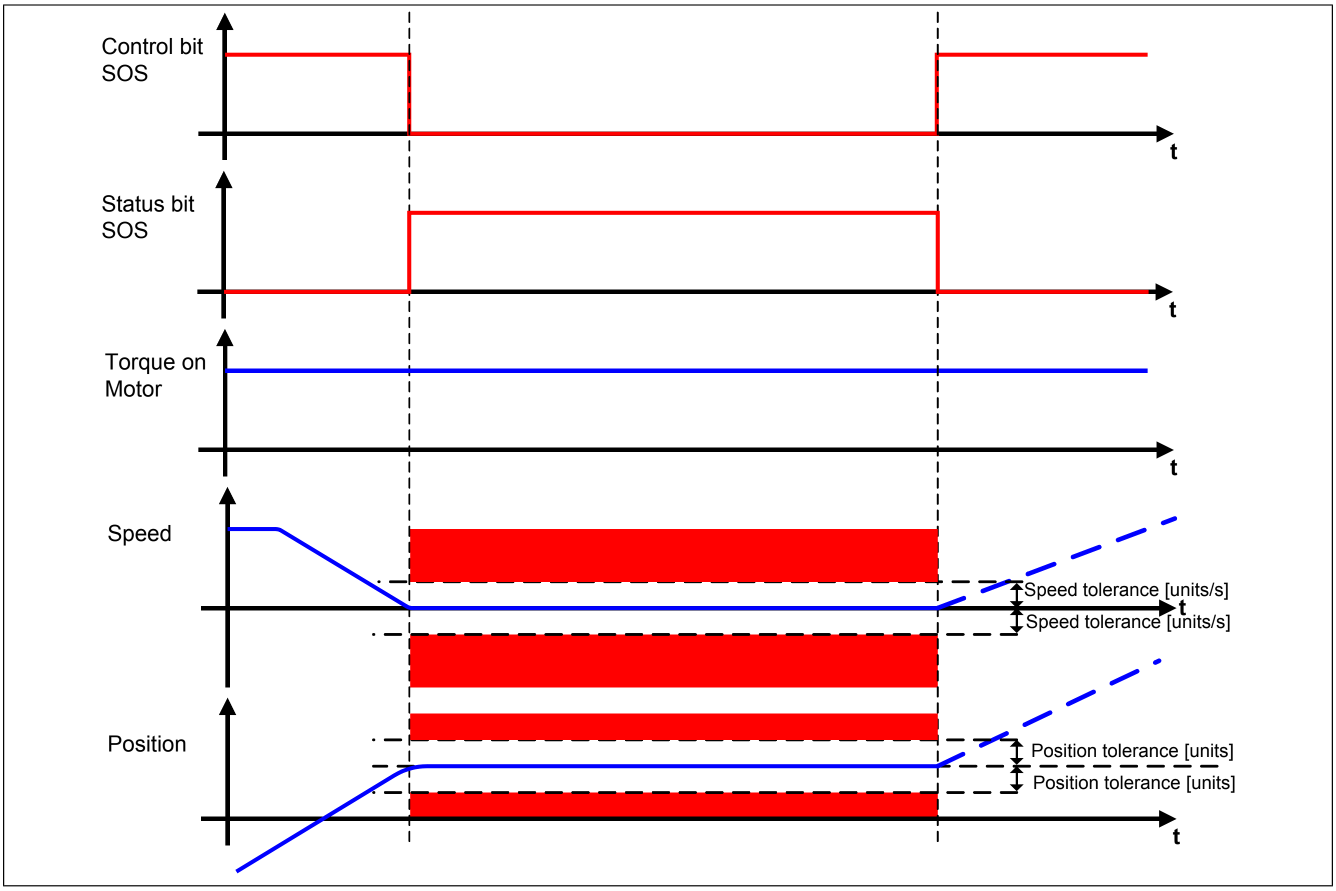


Figure 39: Safe Operating Stop (SOS)

To prevent the axis from drifting, both the speed and position are monitored with standstill tolerance limits. The position window is generated when the safety function is requested. If the request is withdrawn, then monitoring of the standstill tolerance window will also be terminated. The next time a request is made, the standstill tolerance position window is regenerated based on the current position.

Information:

The functional safe state of the SOS safety function has been achieved when the drive is stopped and the standstill is being safety-monitored.
The respective bit is set when the functional safe state has been achieved.

The standstill tolerances can be configured for each axis in SafeDESIGNER.

Danger!

In the event of an error, forward movement can occur during the error response time when monitoring the standstill tolerance window. During this time, the drive can accelerate to its maximum before coasting to a stop.
The speed and position limits being monitored must be set in a manner so that the calculated forward movement does not cause any danger.
The dangerous movement must be determined by a risk analysis.

If the stop monitoring limits are violated, safe pulse disabling is activated and the drive switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state. An error will cause a synchronous axis to no longer be synchronous.

Danger!

If a standstill limit (position or speed) is violated, then the module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state. The drive loses all torque/power and coasts to a stop! In the event of an error, a synchronous axis will no longer be synchronous. The S_NotErrFUNC output on the function block is reset.

Danger!

If the SOS safety function is used in the safety application, then it must be tested when commissioning the machine by selecting and deselecting it!
The configured limits must be violated with the function enabled and the error response must be tested accordingly!

Danger!

Situations involving external forces (e.g. hanging loads) can result in dangerous movements!
If this poses a safety risk, then the user must implement the necessary equipment to eliminate the risk (e.g. mechanical brakes)! This equipment must correspond to the required safety level!

4.8 Safe Stop 1 (SS1)

4.8.1 Parameters

Parameter	Unit	Description	Default value
Safety Deceleration Ramp			
Deceleration Ramp	[units/s²]	Slope of the deceleration ramp to be monitored	1073676289
General Settings			
Rampmonitoring for SS1	Activated/ Deactivated	Activates ramp-based monitoring (in addition to time-based monitoring) when the SS1 function is requested	Activated
Early Limit Monitoring	Activated/ Deactivated	Prematurely terminates monitoring of the deceleration ramp if the value falls below the lower limit for a defined amount of time	Deactivated
Safety Ramp Monitoring Times			
Ramp Monitoring Time for SS1 (us)	[µs]	Deceleration ramp monitoring time for SS1	0
Safety Additional Parameters			
Delay time to start ramp monitoring (us)	[µs]	Delay time between the request for ramp-based monitoring and the start of monitoring	0
Early Limit Monitoring time (us)	[µs]	Time during which the speed must be below the target speed limit in order to prematurely end the deceleration ramp and to assume the safety function's end state	0

Table 114: SS1 safety function - Parameters

4.8.2 Behavior

When requesting the SS1 safety function, the deceleration process of the axis is monitored until standstill after the ramp delay time passes. After decelerating, safe pulse disabling is activated and switches off the torque/power to the drive.

Danger!

Synchronous axes will no longer be synchronous when SS1 is in a safe state.

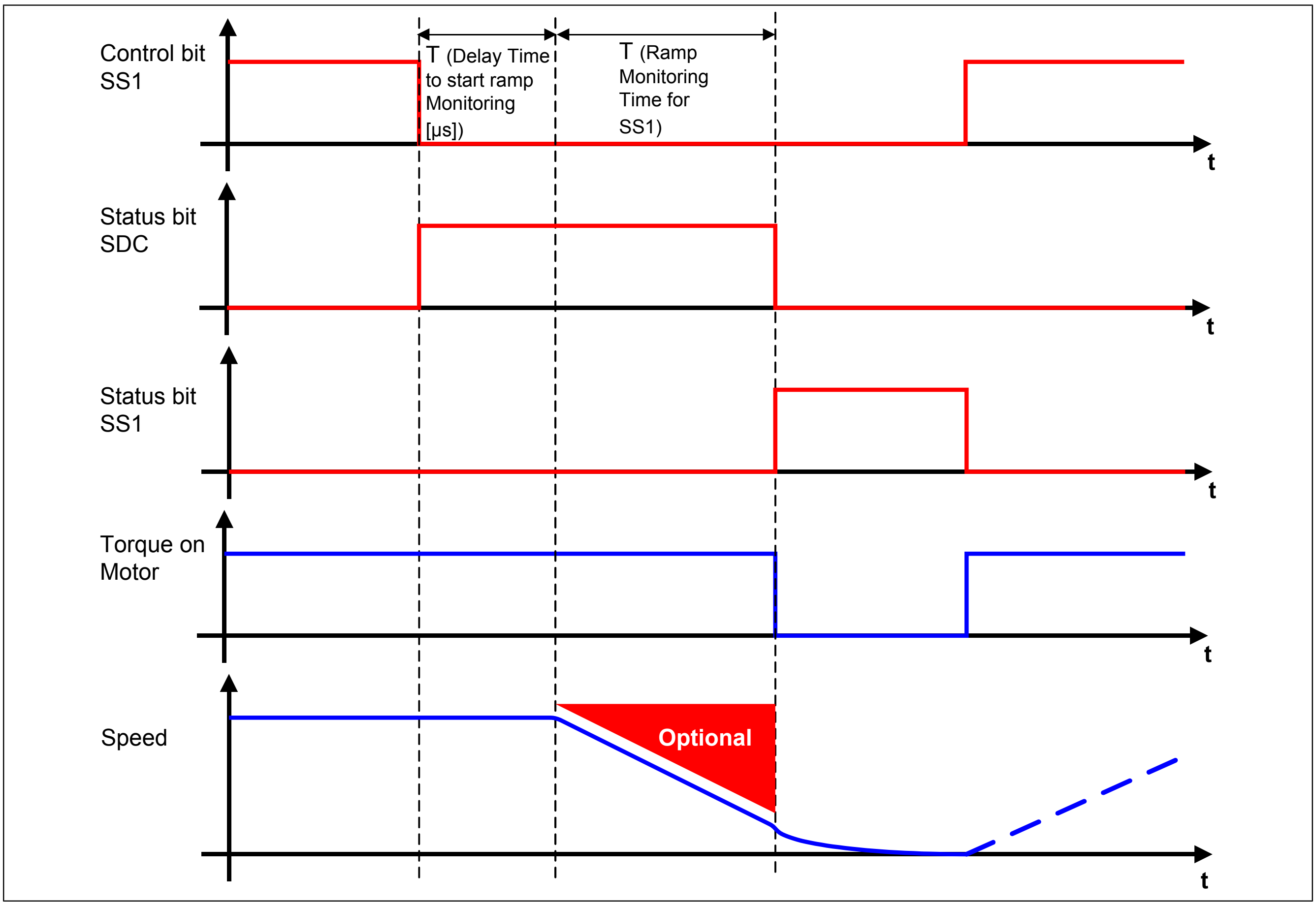


Figure 40: Safe Stop 1 (SS1)

The deceleration itself is controlled by the non-safety-related standard application.

The purpose of the ramp delay time ("Delay time to start ramp monitoring (µs)" parameter) is to compensate for the different runtimes of standard and safety applications.

Information:

The functional safe state of the SS1 safety function has been achieved when the pulse disabling outputs are switched to 0 V. The respective bit is set when the functional safe state has been achieved.

Danger!

Situations involving external forces (e.g. hanging loads) can result in dangerous movements!
If this poses a safety risk, then the user must implement the necessary equipment to eliminate the risk (e.g. mechanical brakes)! This equipment must correspond to the required safety level!

Depending on the requirements for the safety function and its parameter settings, it is possible to monitor either only the deceleration time $T_{\text{(Ramp Monitoring Time for SS1)}}$ or the deceleration ramp as well.
If the monitoring limits are violated during deceleration, then an acknowledgeable error state is entered.

The "Rampmonitoring for SS1" parameter configures the ramp monitoring behavior.

4.8.3 SS1 - Stopping procedure with ramp-based monitoring

"Rampmonitoring for SS1" = Activated

With this setting, the configurable deceleration ramp is monitored in addition to time-based monitoring. In the event of an error, this provides the advantage that a lower maximum speed can be assumed when entering the safe state. During deceleration ramp monitoring, the standard application must ensure that the stopping procedure for a hazardous situation is handled accordingly.

The slope of the monitoring ramp can be set using the "Deceleration Ramp" parameter.

A timer is started when the safety function is requested. After the "Delay time to start ramp monitoring (µs)" has expired, monitoring of the deceleration ramp begins. The monitored ramp always begins at the currently monitored limit and is calculated using the configured slope. If the monitoring ramp reaches the configurable standstill speed limit "Speed Tolerance (units/s)" or the monitoring time "Ramp Monitoring Time for SS1 (µs)" has expired, then safe pulse disabling is activated and torque is switched off on the drive.

The "Early Limit Monitoring" parameter can be used to activate the safe state early. If the setting above has been made, then the safe state of the safety function will be activated when the current speed falls below the standstill speed limit for at least the amount of time defined by "Early Limit Monitoring timer" during deceleration ramp monitoring.

If the active limit is violated during monitoring of the deceleration procedure, then the drive will immediately switch to the acknowledgeable Functional Fail Safe error state.

Information:

If ramp monitoring is configured for the safety function SS1, then the speed must be safely evaluated.
If the function is programmed in the safety application and if an error is detected in the safe encoder evaluation, then the SafeMOTION module immediately switches to the FUNCTIONAL FAIL SAFE state after the function block is activated!

Danger!

If safe pulse disabling is activated (coast to stop) and the safety function is in its functional safe state, the maximum speed at the end of the deceleration ramp must be used to calculate the residual distance.
To determine the maximum possible speed, it must be assumed that in the event of error, the drive will accelerate to its maximum during the error response time starting from the standstill speed limit.
It must be ensured that the spin-out movement and residual distance do not present any danger!

Danger!

If the monitored ramp is exceeded, the residual distance must be calculated based on the error response time, starting with the currently monitored speed limit.
It must be ensured that the spin-out movement and residual distance do not present any danger!

Danger!

If the SS1 safety function with ramp monitoring is used in the safety application, then it must be tested when commissioning the machine by selecting and deselecting it!
The test should include at least one violation of the monitored ramp, and the error response must be tested accordingly!

4.8.4 SS1 - Stopping procedure with time-based monitoring

"Rampmonitoring for SS1" = Deactivated

This configuration provides true time-based monitoring of the deceleration.
A timer is started when the safety function is requested. Within this time frame, the drive must implement a stopping procedure via the standard application that is appropriate for the respective dangerous situation.
After the "Delay time to start ramp monitoring (µs)" plus the "Ramp Monitoring Time for SS1 (µs)" have expired, safe pulse disabling is activated and the drive loses all torque.

Information:

With this configuration of the Safe Stop 1 safety function, only the time frame is monitored.
No speed limit or position window is monitored.
The function can therefore also be used in this configuration without safe encoder evaluation!

Danger!

If safe pulse disabling is activated (coast to stop), the maximum speed after the time frame has expired must be used to calculate the residual distance!
The drive can move at its maximum physical speed during this time window (plus the response time of the safe pulse disabling). If SMS is active, then the speed limit plus the error tolerance can be assumed as the maximum speed.
It must be ensured that the spin-out movement and residual distance do not present any danger!

Danger!

If the SS1 safety function with true time-monitoring is used in the safety application, then it must be tested when commissioning the machine by selecting and deselecting it!
The drive should be accelerated to its maximum during the monitored time frame and the error response tested accordingly!

4.9 Safe Stop 2 (SS2)

4.9.1 Parameters

Parameter	Unit	Description	Default value
Safety Deceleration Ramp			
Deceleration Ramp	[units/s²]	Slope of the deceleration ramp to be monitored	1073676289
General Settings			
Rampmonitoring for SS2	Activated/ Deactivated	Activates ramp monitoring (in addition to time-based monitoring) when the SS2 function is requested	Activated
Early Limit Monitoring	Activated/ Deactivated	Prematurely terminates monitoring of the deceleration ramp if the value falls below the lower limit for a defined amount of time	Deactivated
Safety Standstill and Direction Tolerances			
Speed Tolerance	[units/s]	Speed tolerance for standstill monitoring	0
Position Tolerance	[units]	Position tolerance for standstill and direction monitoring	0
Safety Ramp Monitoring Times			
Ramp Monitoring Time for SS2 (us)	[µs]	Deceleration ramp monitoring time for SS2	0
Safety Additional Parameters			
Delay time to start ramp monitoring (us)	[µs]	Delay time between the request for ramp-based monitoring and the start of monitoring	0
Early Limit Monitoring time (us)	[µs]	Time during which the speed must be below the target speed limit in order to prematurely end the deceleration ramp and to assume the safety function's end state	0

Table 115: SS2 safety function - Parameters

4.9.2 Behavior

With SS2, the deceleration process is monitored until standstill after the ramp delay time passes. The drive must then be kept at standstill by the standard application. As with SOS, this standstill is monitored by the SafeMOTION module according to the configured standstill tolerance window "Speed Tolerance [units/s]" and "Position Tolerance [units]".

The delay itself must be generated by the non-safety-related, standard application by halting the drive in response to the dangerous situation.

Information:

The Safe Stop 2 safety function requires safe evaluation of the speed and position.
If the function is programmed in the safety application and if an error is detected in the safe encoder evaluation, then the SafeMOTION module immediately switches to the FUNCTIONAL FAIL SAFE state after the function block is activated!

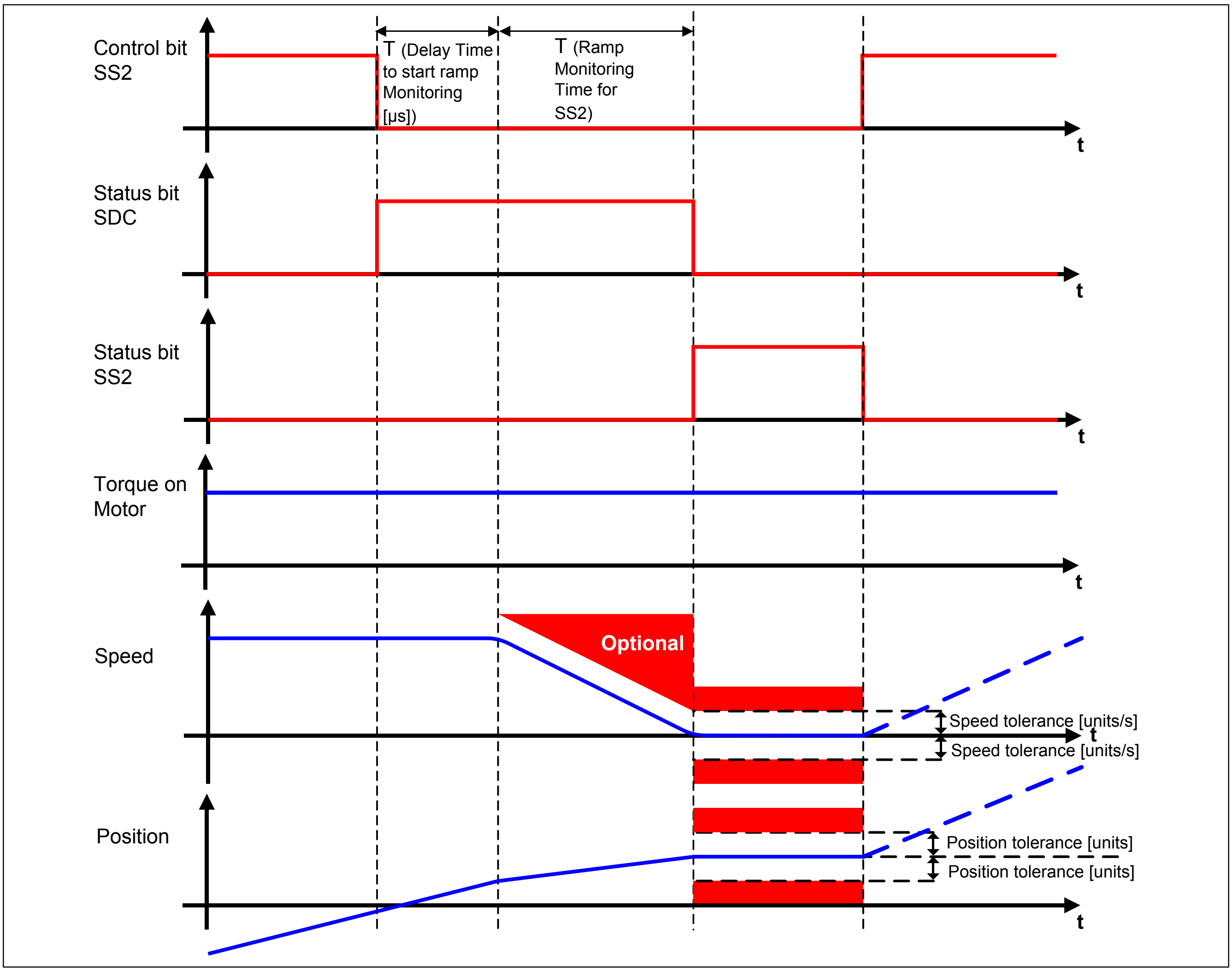


Figure 41: Safe Stop 2 (SS2)

Danger!

If a standstill limit (position or speed) is violated, then the module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state. The drive loses all torque/power and coasts to a stop! In the event of an error, a synchronous axis will no longer be synchronous.
The S_NotErrFUNC output on the function block is reset.

Danger!

Situations involving external forces (e.g. hanging loads) can result in dangerous movements!
If this poses a safety risk, then the user must implement the necessary equipment to eliminate the risk (e.g. mechanical brakes)! This equipment must correspond to the required safety level!

The purpose of the ramp delay time ("Delay time to start ramp monitoring (µs)" parameter) is to compensate for the different runtimes of standard and safety applications.

Information:

The functional safe state of the SS2 function has been achieved when the drive is stopped and the standstill is being safety-monitored.
The respective bit is set when the functional safe state has been achieved.

As with SS1, it is possible to monitor either only the deceleration time or also the deceleration ramp depending on the requirements of the safety function.

The "Rampmonitoring for SS2" parameter configures the ramp monitoring behavior.

4.9.3 SS2 - Stopping procedure with ramp-based monitoring

"Rampmonitoring for SS2" = Activated

With this setting, the configurable deceleration ramp is monitored in addition to time-based monitoring. In the event of an error, this provides the advantage that a lower maximum speed can be assumed when entering the safe state. During deceleration ramp monitoring, the standard application must ensure that the stopping procedure for a hazardous situation is handled accordingly.

The slope of the monitoring ramp can be set using the "Deceleration Ramp" parameter.

A timer is started when the safety function is requested. After the "Delay time to start ramp monitoring (µs)" has expired, monitoring of the deceleration ramp begins. The monitored ramp always begins at the currently monitored limit and is calculated using the configured slope. If the monitoring ramp reaches the configurable standstill speed limit "Speed Tolerance (units/s)" or the monitoring time "Ramp Monitoring Time for SS2 (µs)" has expired, then a position window is established and monitoring of the standstill tolerances is started.

The "Early Limit Monitoring" parameter can be used to activate the safe state early. If the setting above has been made, then the safe state of the safety function will be started when the current speed falls below the standstill speed limit for at least the amount of time defined by "Early Limit Monitoring timer" during deceleration ramp monitoring.

If the active limit or standstill window is violated during monitoring of the deceleration procedure or standstill, then the drive will immediately switch to the acknowledgeable FUNCTIONAL FAIL SAFE error state.

Danger!

When the monitored ramp or standstill tolerance window is exceeded, the residual distance must be calculated based on the error response time, starting with the currently monitored speed limit.
It must be ensured that the spin-out movement and residual distance do not present any danger!

Danger!

In the event of an error, forward movement can occur during the error response time when monitoring the standstill tolerance window. During this time, the drive can accelerate to its maximum before coasting to a stop.
The speed and position limits being monitored must be set in a manner so that the calculated forward movement does not cause any danger.
The dangerous movement must be determined by a risk analysis.

Danger!

If the SS2 safety function with ramp-based monitoring is used in the safety application, then it must be tested when commissioning the machine by selecting and deselecting it!
The test should contain at least one violation of the monitored ramp and standstill tolerance window.
The error response must be tested accordingly!

4.9.4 SS2 - Stopping procedure with time-based monitoring

"Rampmonitoring for SS2" = Deactivated

This configuration provides true time-based monitoring of the deceleration.
A timer is started when the safety function is requested. Within this time frame, the drive must implement a stopping procedure via the standard application that is appropriate for the respective dangerous situation.

After the "Delay time to start ramp monitoring (µs)" and the "Ramp Monitoring Time for SS2 (µs)" have expired, the standstill tolerance window is safety-monitored.

Danger!

If the standstill tolerance window is exceeded, the residual distance must be calculated based on the error response time, starting with the currently monitored speed limit.
It must be ensured that the spin-out movement and residual distance do not present any danger!

Danger!

In the event of an error, forward movement can occur during the error response time when monitoring the standstill tolerance window. During this time, the drive can accelerate to its maximum before coasting to a stop.
The speed and position limits being monitored must be set in a manner so that the calculated forward movement does not cause any danger.
The dangerous movement must be determined by a risk analysis.

Danger!

If the SS2 safety function with time-monitored stopping procedure is used in the safety application, then it must be tested when commissioning the machine by selecting and deselecting it!
The test should contain at least one violation of the standstill tolerance window. The error response must be tested accordingly!

4.10 Safely Limited Speed (SLS)

4.10.1 Parameters

Parameter	Unit	Description	Default value
Safety Deceleration ramp			
Deceleration ramp	[units/s²]	Slope of the deceleration ramp to be monitored	1073676289
General settings			
Ramp monitoring for SLS	Activated/ Deactivated	Activates ramp-based monitoring (in addition to time-based monitoring) when the SLS function is requested	Activated
Early Limit Monitoring	Activated/ Deactivated	Prematurely terminates monitoring of the deceleration ramp if the value falls below the lower limit for a defined amount of time	Deactivated
Speed Limits			
Safe Speedlimit 1 for SLS	[units/s]	Speed limit 1 for SLS	0
Safe Speedlimit 2 for SLS	[units/s]	Speed limit 2 for SLS	0
Safe Speedlimit 3 for SLS	[units/s]	Speed limit 3 for SLS	0
Safe Speedlimit 4 for SLS	[units/s]	Speed limit 4 for SLS	0
Safety Ramp Monitoring Times			
Ramp Monitoring Time for SLS1 (us)	[µs]	Deceleration ramp monitoring time for SLS1	0
Ramp Monitoring Time for SLS2 (us)	[µs]	Deceleration ramp monitoring time for SLS2	0
Ramp Monitoring Time for SLS3 (us)	[µs]	Deceleration ramp monitoring time for SLS3	0
Ramp Monitoring Time for SLS4 (us)	[µs]	Deceleration ramp monitoring time for SLS4	0
Safety Additional Parameters			
Delay time to start ramp monitoring (us)	[µs]	Delay time between the request for ramp-based monitoring and the start of monitoring	0
Early Limit Monitoring time (us)	[µs]	Time during which the speed must be below the target speed limit in order to prematurely end the deceleration ramp and to assume the safety function's end state	0

Table 116: SLS safety function - Parameters

4.10.2 Behavior

The purpose of the SLS safety function is to monitor a specified speed limit: "Safe Speedlimit 1, 2, 3, 4 for SLS (units/s)" parameters. It is also possible to monitor deceleration until the limit is reached if needed by the application.

Four different speed limits can be monitored on the SafeMOTION module. All limits can also be monitored in parallel. If a request is made to monitor multiple speed limits at the same time, then the lowest limit value will always be monitored. To make this possible, the function block includes four different inputs **S_RequestSLSx** (x = 1-4).

The standard (non-safety-related) application must implement a closed-loop control appropriate for the level of danger to decelerate the movement and ensure adherence to the respective speed limit.

Information:

The SLS safety function requires safe evaluation of the speed. If the function is programmed in the safety application and if an error is detected in the safe encoder evaluation, then the SafeMOTION module immediately switches to the FUNCTIONAL FAIL SAFE state after the function block is activated!

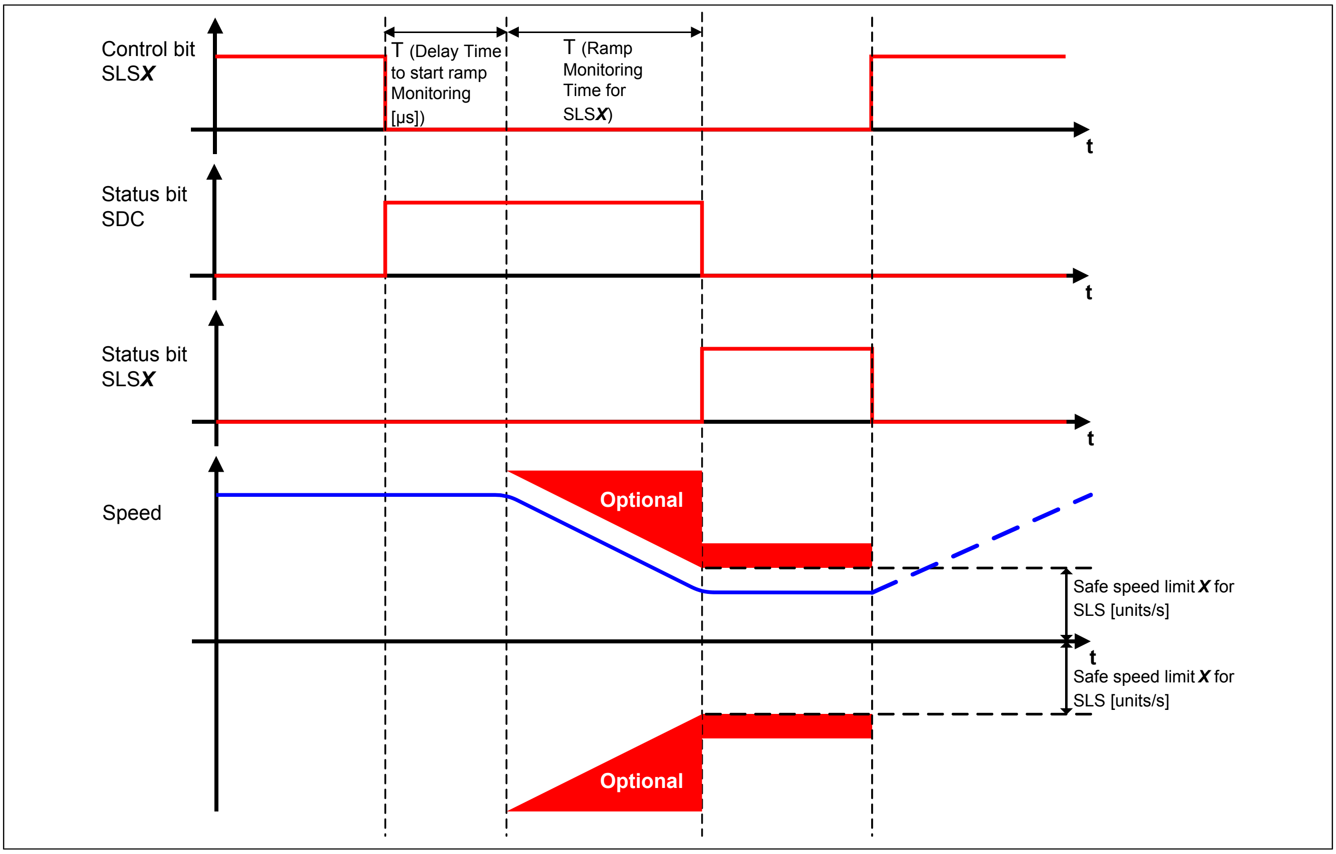


Figure 42: Safely Limited Speed (SLS)

Danger!

Situations involving external forces (e.g. hanging loads) can result in dangerous movements!
If this poses a safety risk, then the user must implement the necessary equipment to eliminate the risk (e.g. mechanical brakes)! This equipment must correspond to the required safety level!

Danger!

If a speed limit is violated, then the module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state.
The drive loses all torque/power and coasts to a stop!
In the event of an error, a synchronous axis will no longer be synchronous. The S_NotErrFUNC output on the function block is reset.

The purpose of the ramp delay time $T_{\text{(Delay time to start ramp monitoring)}}$ is to compensate for the different runtimes of standard and safety applications.

If the delay time ("Ramp monitoring time for SLSX") is set to zero, then the speed limit will be monitored immediately after the request is made for the safety function.

Information:

The functional safe state of the SLS safety function has been achieved if the drive has not exceeded a defined speed limit and this limit is being safety-monitored. The respective bit is set when the functional safe state has been achieved.

As with SS1 and SS2, the deceleration ramp monitoring can be adapted according to requirements so that either only the deceleration time or both the deceleration time and the deceleration ramp are monitored.
The "Rampmonitoring for SLS" parameter configures the deceleration ramp monitoring behavior.

4.10.3 SLS - Stopping procedure with ramp-based monitoring

"Ramp monitoring for SLS" = Activated

With this setting, the configurable deceleration ramp is monitored in addition to time-based monitoring. In the event of an error, this provides the advantage that a lower maximum speed can be assumed when entering the safe state.
During deceleration ramp monitoring, a deceleration procedure must be adjusted to the dangerous situation by the standard application.

The slope of the monitoring ramp can be set using the "Deceleration Ramp" parameter.

A timer is started when the safety function is requested. After the "Delay time to start ramp monitoring (µs)" has expired, monitoring of the deceleration ramp begins. The monitored ramp always begins at the currently monitored limit and is calculated using the configured slope.
If the monitored ramp reaches the corresponding speed limit "Safe Speedlimit 1, 2, 3, 4 for SLS (units/s)" or the "Ramp Monitoring Time for SLS1, 2, 3,4 (µs)" has expired, then the status of the safety function is set and the selected speed limit is monitored.

The "Early Limit Monitoring" parameter can be used to activate the safe state early. If the setting above has been made, then the safe state of the safety function will be started when the current speed falls below the monitored speed limit for at least the amount of time defined by *Early Limit Monitoring timer* during deceleration ramp monitoring.

Danger!

When the monitored ramp or the enabled safe speed is exceeded, the residual distance must be calculated based on the error response time, starting with the currently monitored speed limit. It must be ensured that the spin-out movement and residual distance do not present any danger!

Danger!

In the event of an error when monitoring the safe reduced speed, a dynamic forward movement that goes beyond the monitored limit can occur during the error response time.
During this time, the drive can accelerate to its maximum before coasting to a stop.
The speed limit being monitored must be set in a manner so that the calculated forward movement will not cause any danger. The dangerous movement must be determined by a risk analysis.

Danger!

If the safety function SLS with ramp monitoring is used in the safety application, then it must be tested when commissioning the machine by selecting and deselecting it!
The test should contain at least one violation of the monitored ramp and of each speed limit being used. The error response must be tested accordingly!

4.10.4 SLS - Stopping procedure with time-based monitoring

"Ramp monitoring for SLS" = Deactivated

This configuration provides true time-based monitoring of the deceleration.
A timer is started when the safety function is requested. Within this time frame, the drive must implement a stopping procedure via the standard application that is appropriate for the respective dangerous situation. After the "Delay time to start ramp monitoring (µs)" and the "Ramp Monitoring Time for SLS1, 2, 3,4 (µs)" have expired, the speed limit is safety-monitored.

Danger!

When the speed limit is exceeded, the residual distance must be calculated based on the error response time, starting with the currently monitored speed limit.
It must be ensured that the spin-out movement and residual distance do not present any danger!

Danger!

In the event of an error when monitoring the safe reduced speed, a dynamic forward movement that goes beyond the monitored limit can occur during the error response time.
During this time, the drive can accelerate to its maximum before coasting to a stop.
The speed limit being monitored must be set in a manner so that the calculated forward movement will not cause any danger.
The dangerous movement must be determined by a risk analysis.

Danger!

If the safety function SLS without ramp monitoring is used in the safety application, then it must be tested when commissioning the machine by selecting and deselecting it!
The test should contain at least one violation of each speed limit being used.
The error response must be tested accordingly!

4.11 Safe Maximum Speed (SMS)

4.11.1 Parameters

Parameter	Unit	Description	Default value
General Settings			
Safe Maximum Speed	Used / Not used	SMS safety function activated or deactivated	Used
Speed Limits			
Maximum Speedlimit for SMS	[units/s]	Speed limit of the maximum speed	0

Table 117: SMS safety function - Parameters

4.11.2 Behavior

The difference between SMS and SLS is that SMS cannot be actively requested. It is either activated (parameter "Safe Maximum Speed" = Used) or deactivated (parameter "Safe Maximum Speed" = Not used) in the configuration.

When activated, the current speed is constantly monitored according to a defined limit ("Safe Maximum Speed (units/s)" parameter).

Information:

The SMS safety function requires safe evaluation of the speed.
If the function is programmed in the safety application and if an error is detected in the safe encoder evaluation, then the SafeMOTION module immediately switches to the FUNCTIONAL FAIL SAFE state after the function block is activated!

Danger!

When the monitored speed limit is exceeded, the residual distance must be calculated based on the error response time.
It must be ensured that the spin-out movement and residual distance do not present any danger!

Danger!

In the event of an error when monitoring the safe maximum speed, a dynamic forward movement that goes beyond the monitored limit can occur during the error response time.
During this time, the drive can accelerate to its maximum before coasting to a stop. The speed limit being monitored must be set in a manner so that the calculated forward movement will not cause any danger.
The dangerous movement must be determined by a risk analysis.

Danger!

If the SMS safety function is used in the safety application, then it must be tested when commissioning the machine!
The configured limit must be exceeded! The error response must be tested accordingly!

Danger!

Situations involving external forces (e.g. hanging loads) can result in dangerous movements!
If this poses a safety risk, then the user must implement the necessary equipment to eliminate the risk (e.g. mechanical brakes)! This equipment must correspond to the required safety level!

4.12 Safely Limited Increment (SLI)

4.12.1 Parameters

Parameter	Unit	Description	Default value
Safety Standstill and Direction Tolerances			
Speed Tolerance	[units/s]	Speed tolerance for standstill monitoring	0
Safely Limited Increments			
Safe increments	[units]	Maximum movable increments when SLI is active	0
SLI Off Delay	[μs]	Switch off delay of SLI	0

Table 118: SLI safety function - Parameters

4.12.2 Behavior

With the SLI safety function, the movement is monitored for a defined number of increments ("Safe Increments (units)" parameter).

Information:

The SLI safety function requires safe evaluation of the speed and position.
If the function is programmed in the safety application and if an error is detected in the safe encoder evaluation, then the SafeMOTION module immediately switches to the FUNCTIONAL FAIL SAFE state after the function block is activated!

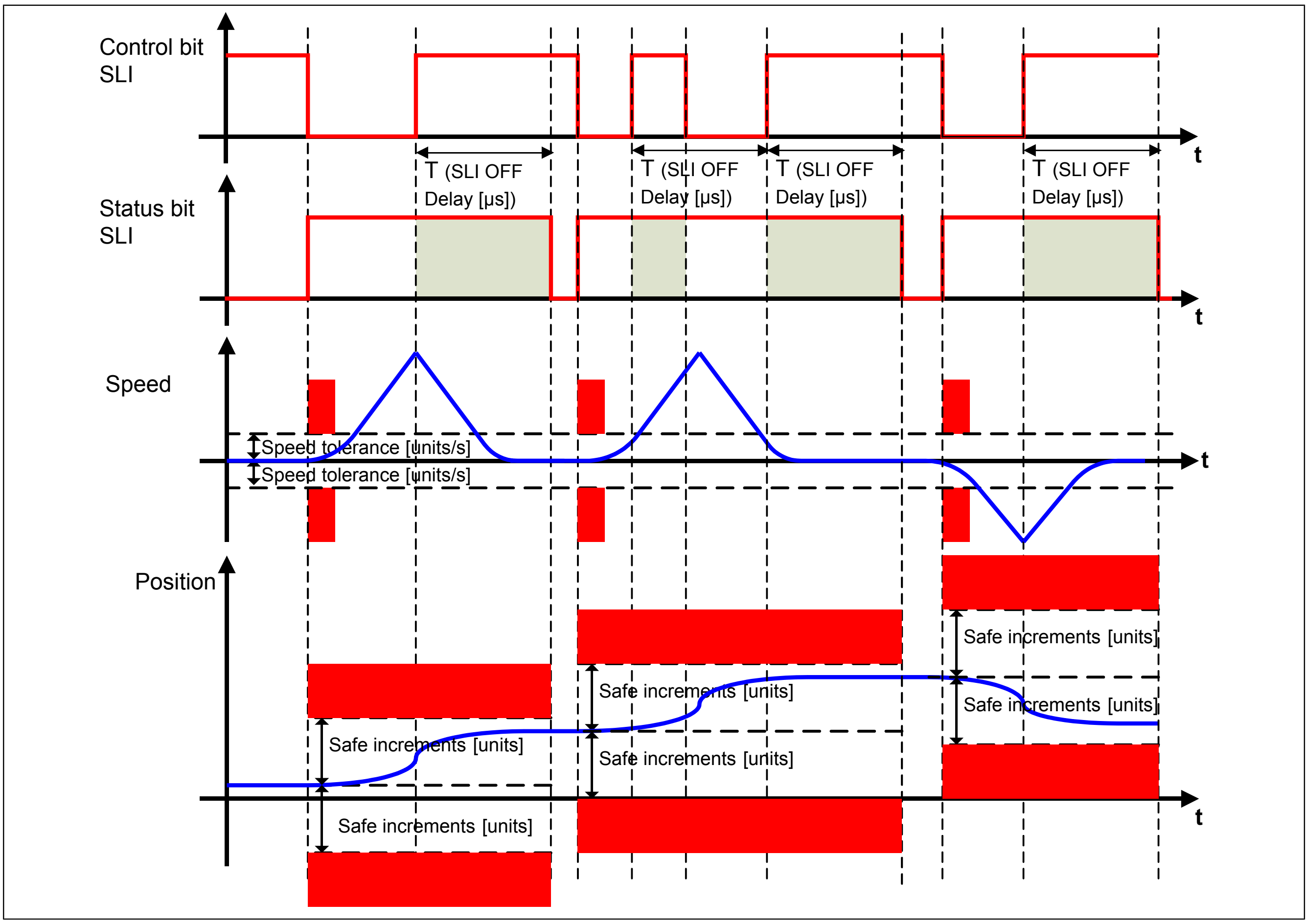


Figure 43: Safely Limited Increment (SLI)

Information:

The SLI safety function is only effective when used in combination with at least a second safety function. The SOS, SS2, or SLS safety functions are possible, for example.

Information:

The functional safe state of the SLI safety function has been achieved if the drive has not exceeded a defined increment size and this limit is being safety-monitored.
The respective bit is set when the functional safe state has been achieved.

The safe axis must be at a standstill when this function is enabled. To do this, the speed is monitored for adhering to the speed standstill tolerance ("Speed Tolerance (units/s)" parameter).

A position window is then generated that is safety-monitored. This position window depends on the configured safe increment size ("Safe Increments (units)" parameter). The standard application must guarantee that this position window is not exceeded.

After the safety function is disabled, monitoring continues for the configured period of time ("SLI OFF Delay (µs)" parameter). This prevents continuous movement caused by constant jogging.

Danger!

If a speed limit for requesting the function or the position window is violated, then the module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state.
The drive loses all torque/power and coasts to a stop! In the event of an error, a synchronous axis will no longer be synchronous.
The S_NotErrFUNC output on the function block is reset.

Danger!

Situations involving external forces (e.g. hanging loads) can result in dangerous movements!
If this poses a safety risk, then the user must implement the necessary equipment to eliminate the risk (e.g. mechanical brakes)! This equipment must correspond to the required safety level!

Danger!

In the event of an error when monitoring the safe increments, a dynamic forward movement that goes beyond the monitored limit can occur during the error response time.
During this time, the drive can accelerate to its maximum before coasting to a stop.
The resulting residual distance must be taken into account when configuring the permissible increments and must not present any danger.
The dangerous movement must be determined by a risk analysis.

Danger!

If the SLI safety function is used in the safety application, then it must be tested when commissioning the machine by selecting and deselecting it!
The test should contain at least one violation of the standstill speed limit when enabled and the permissible increments. The error response must be tested accordingly!

4.13 Safe Direction (SDI)

4.13.1 Parameters

Parameter	Unit	Description	Default value
Safety Standstill and Direction Tolerances			
Position Tolerance	[units]	Position tolerance for standstill and direction monitoring	0
Safety Additional Parameters			
Delay time to start SDI (us)	[µs]	Delay time between the SDI request and activation of the safety function	0

Table 119: SDI safety function - Parameters

4.13.2 Behavior

The SDI safety function monitors the defined direction of movement.

Either the positive or the negative direction can be monitored. The **S_RequestSDIpos** and **S_RequestSDIneg** inputs are available on the function block for this.

Information:

The SDI safety function requires safe evaluation of the position.
If the function is programmed in the safety application and if an error is detected in the safe encoder evaluation, then the SafeMOTION module immediately switches to the FUNCTIONAL FAIL SAFE state after the function block is activated!

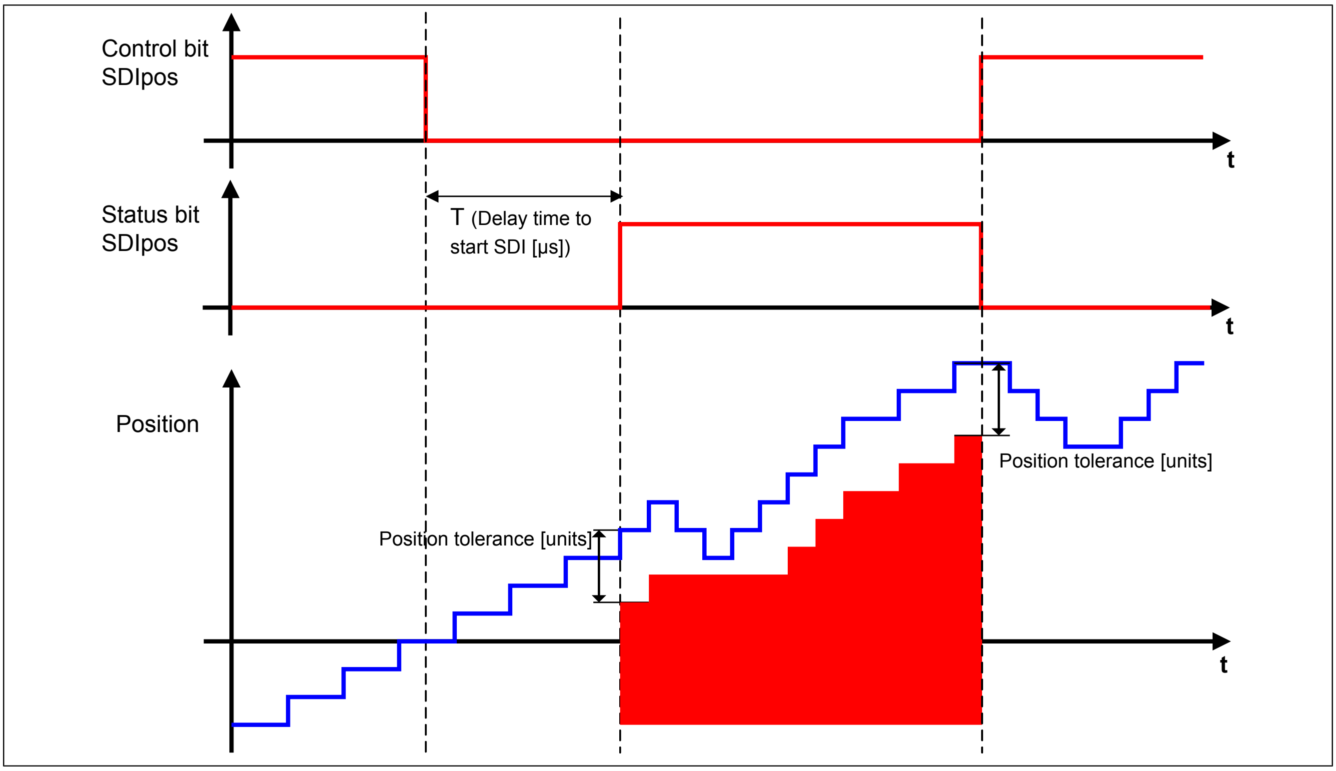


Figure 44: Safe Direction (SDI) - Positive direction of rotation allowed

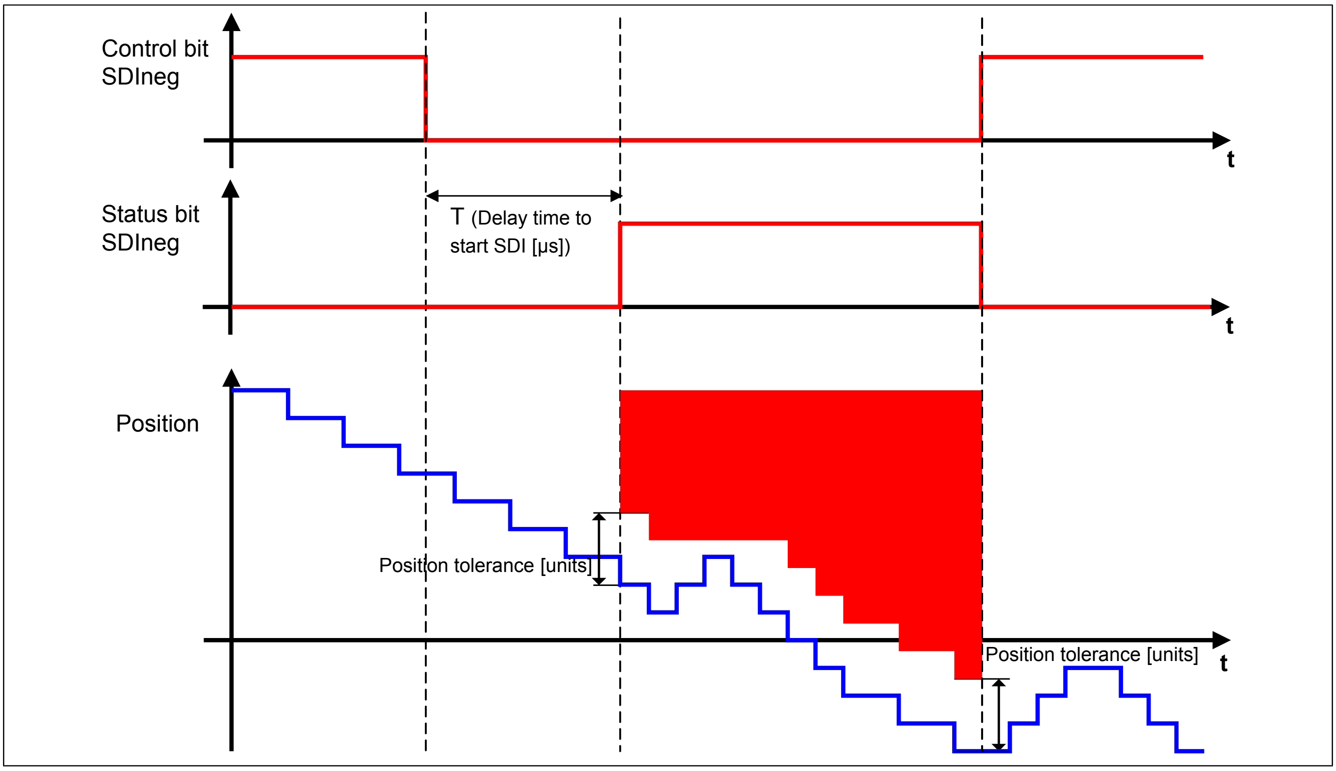


Figure 45: Safe Direction (SDI) - Negative direction of rotation allowed

Information:

The Safe Direction safety function can be activated in parallel with other safety functions. For example, SLS or SLI can be limited to a certain direction.

Information:

The functional safe state of the SDI safety function has been achieved if the drive has not violated a defined direction of movement and this direction of movement is being safety-monitored.
The respective bit is set when the functional safe state has been achieved.

"Delay time to start SDI" can be used to compensate for the different runtimes of standard and safety applications.

When monitoring the direction of movement, then standstill tolerance ("Position Tolerance (units)" parameter) is not permitted to be exceeded in the forbidden direction of movement. When moving in the permitted direction of movement, the position window moves along with it.

Danger!

If the safe direction of movement is violated, then the module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state. The drive loses all torque/power and coasts to a stop!
In the event of an error, a synchronous axis will no longer be synchronous.
The S_NotErrFUNC output on the function block is reset.

Danger!

Situations involving external forces (e.g. hanging loads) can result in dangerous movements!
If this poses a safety risk, then the user must implement the necessary equipment to eliminate the risk (e.g. mechanical brakes)! This equipment must correspond to the required safety level!

Danger!

In the event of an error when monitoring the safe direction of rotation, a dynamic forward movement in the dangerous direction can occur during the error response time.
During this time, the drive can accelerate to its maximum before coasting to a stop. The resulting residual distance must be taken into account when configuring the permissible tolerance limits and must not present any danger.
The dangerous movement must be determined by a risk analysis.

Danger!

If the SDI safety function is used in the safety application, then each of the directions of movement that are being used must be tested by selecting and deselecting it when commissioning the machine!
The test should contain at least one violation of each safe direction of movement that is being used.
The error response must be tested accordingly!

4.14 Safely Limited Acceleration (SLA)

Information:

The Safely Limited Acceleration (SLA) safety function is only available with SafeMOTION Safety Release 1.9 (FW 300) and higher!

4.14.1 Parameters

Parameter	Unit	Description	Default value
Safe acceleration limit for SLA (units/s²) in positive direction	[units/s²]	Limit for acceleration in the positive direction of movement	0
Safe deceleration limit for SLA (units/s²) in positive direction	[units/s²]	Limit for deceleration in the positive direction of movement	0
Safe acceleration limit for SLA (units/s²) in negative direction	[units/s²]	Limit for acceleration in the negative direction of movement	0
Safe deceleration limit for SLA (units/s²) in negative direction	[units/s²]	Limit for deceleration in the negative direction of movement	0
Safety Standstill and Direction Tolerances			
Speed tolerance (unit/s)	[units/s]	Speed tolerance for standstill monitoring	0
Safety Additional Parameters			
Delay time to start SLA (μs)	[μs]	Delay time between the SLA request and activation of the safety function	0

Table 120: SLA safety function - Parameters

4.14.2 Behavior

The SLA safety function is used to monitor the acceleration or deceleration with respect to defined maximum limits.

Information:

The SLA safety function requires safe encoder evaluation.

If the safety function is programmed in the safety application and if an error is detected in the safe encoder evaluation, then the SafeMOTION module immediately switches to the FUNCTIONAL FAIL SAFE state after the function block is activated!

The parameters "Safe acceleration limit for SLA (units/s²) in positive direction" and "Safe deceleration limit for SLA (units/s²) in positive direction" can be used to set the limits for acceleration and deceleration in the positive direction of movement. The parameters "Safe acceleration limit for SLA (units/s²) in negative direction" and "Safe deceleration limit for SLA (units/s²) in negative direction" can be used to set the limits in the negative direction of movement.

Setting the **S_RequestSLA** input to SAFEFALSE requests the SLA safety function.

After the "Delay time to start SLA (μs)" has expired, the configured acceleration and deceleration limits are monitored. The purpose of the delay time is to compensate for the different runtimes of the standard and safety applications.

The **S_SafetyActiveSLA** status bit will be set to SAFETRUE if no errors occur while monitoring is active.

Information:

The SLA safety function can be activated in parallel with other safety functions. This makes it possible, for example, to reduce the expected residual distances in the worst-case calculation.

Information:

The SLA safety function has achieved its safe state when the safety function is selected and no violation is detected during monitoring of the acceleration and deceleration limits.

The respective bit is set when the functional safe state has been achieved.

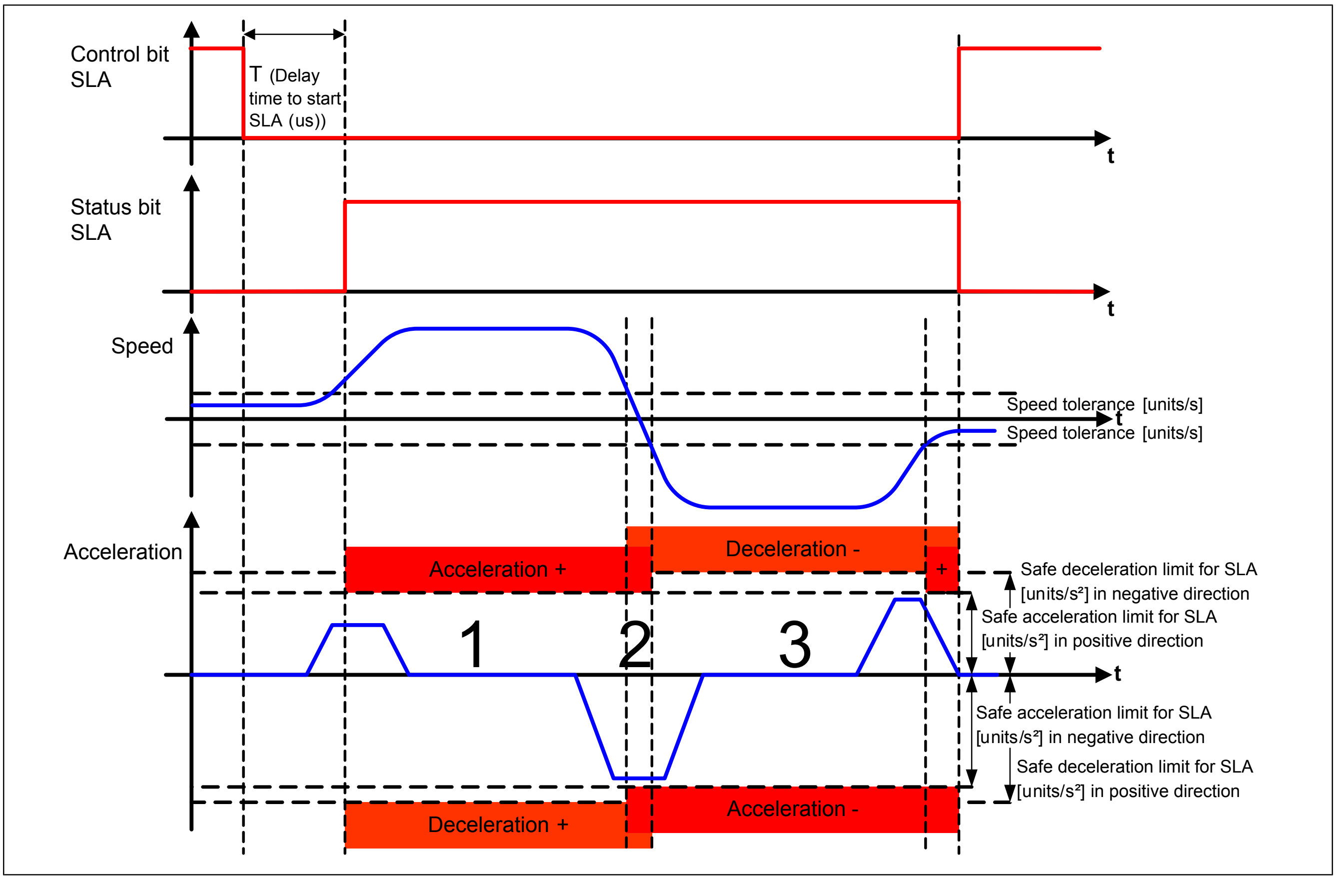


Figure 46: Safely Limited Acceleration (SLA)

Monitoring of acceleration and deceleration limits can be classified into the following 3 types (see Figure 46 "Safely Limited Acceleration (SLA)"):

1 Positive direction of movement

If a movement in the positive direction is detected (current speed is higher than the value of the "Speed Tolerance (units/s)" parameter for standstill monitoring), then the limit values set using the "Safe acceleration limit for SLA (units/s²) in positive direction" and "Safe deceleration limit for SLA (units/s²) in positive direction" parameters are monitored.

2 Standstill

If standstill is detected (current speed is within ± the value set for the "Speed Tolerance (units/s)" parameter for standstill monitoring), then the lowest limit value is used for monitoring in each case:

- "Safe acceleration limit for SLA (units/s²) in positive direction" and "Safe deceleration limit for SLA (units/s²) in negative direction"
- "Safe deceleration limit for SLA (units/s²) in positive direction" and "Safe acceleration limit for SLA (units/s²) in negative direction"

3 Negative direction of movement

If a movement in the negative direction is detected (current speed is lower than the speed tolerance configured with the "Speed Tolerance (units/s)" parameter for standstill monitoring in the negative direction), then the limits set using the "Safe acceleration limit for SLA (units/s²) in negative direction" and "Safe deceleration limit for SLA (units/s²) in negative direction" are monitored.

Danger!

If an acceleration or deceleration limit is violated, then the module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state.

The drive loses all torque/power and coasts to a stop!

In the event of an error, a synchronous axis will no longer be synchronous. The S_NotErrFUNC output on the function block is reset.

Danger!

Situations involving external forces (e.g. hanging loads) can result in dangerous movements!
If this poses a safety risk, then the user must implement the necessary equipment to eliminate the risk (e.g. mechanical brakes)! This equipment must correspond to the required safety level!

Danger!

When calculating the residual distance when the monitored limit values are violated, the worst case scenario – i.e. the maximum speed possible – must be assumed. The maximum possible speed of the drive in the event of an error is calculated based on the speed at the time of the error, the maximum acceleration and the error response time.

It must be ensured that the movement performed while coasting to a stop or the residual distance do not present any danger!

Danger!

When acceleration or deceleration is safety-monitored, a dynamic forward movement may occur during the error response time. During this time, the drive can accelerate to its maximum before coasting to a stop. The limit being monitored must be set so that the calculated forward movement will not cause any danger.

The dangerous movement must be determined by a risk analysis.

Danger!

If the safety function is used in the safety application, then it must be tested when commissioning the machine by selecting and deselecting it!

The test should contain at least one violation of each configured limit. The error response must be tested accordingly!

4.15 Safe Homing

Information:

The Safe Homing safety function is only available with Safety Release R 1.4 and higher!

4.15.1 Parameters

Parameter	Unit	Description	Default value	Starting in Safety Release
Home Position or Home Offset (units)	[units]	Home position or home offset	0	R 1.4
Max. trigger speed (units/s)	[units/s]	Maximum permissible speed for evaluating the reference switch / reference pulse	0	R 1.4
Homing Monitoring Time (µs)	[µs]	Monitoring time for the homing procedure	0	R 1.4
Mode	Direct / Reference Switch / *Home Offset /* *Home Offset with Correction*	Selects the homing mode *The modes "Home Offset" and "Home Offset with Correction" are only available for the ACOPOSmulti SafeMOTION EnDat 2.2!*	Direct	R 1.4
Edge of reference switch	Positive / Negative	Selects the switching edge for the reference switch The switching edge for the reference switch input is positive if the logical state of the reference switch changes from SAFEFALSE to SAFETRUE in the positive direction of movement.	Positive	R 1.4
Trigger direction	Positive / Negative	Selects the trigger direction If the homing procedure requires a movement, then this parameter specifies the direction for evaluating the reference switch / reference pulse.	Positive	R 1.4
Reference pulse	*Used /* *Not Used*	*Selects whether or not to use a reference pulse for homing* *This parameter is only available for the ACOPOSmulti SafeMOTION EnDat 2.2.*	*Not Used*	R 1.4
Remanent safe position	*Used /* *Not Used*	*Selects whether or not to use the remanent safe position* *This parameter is only available for the ACOPOSmulti SafeMOTION EnDat 2.2.*	*Not Used*	R 1.9
Blocking distance (% encoder reference system)	*%*	*Distance within which evaluation of the reference pulse will be suppressed.* *This is calculated starting at the configured reference switch edge and indicated as a percentage of the encoder reference system.* *A single revolution is used as the encoder reference system for rotary encoders.* *This parameter is only available for the ACOPOSmulti SafeMOTION EnDat 2.2.*	*0*	R 1.4

Table 121: SafeMOTION parameter group: Homing

4.15.2 Behavior

The Safe Homing function provides a way to establish a reference between the encoder position and the machine position.

Depending on the homing mode, it may be necessary for the drive to perform a homing procedure. A homing procedure requires the control functions between the electronic controller and the drive motor to be active. Other safety functions might have to be selected in order to prevent a hazardous state during the homing procedure.

The following homing modes are supported:

- Direct
- Reference switch
- Home Offset / Home Offset with Correction *(only available with ACOPOSmulti SafeMOTION EnDat 2.2!)*

Information:

Safe homing requires safe evaluation of the position.
If the function is programmed in the safety application and if an error is detected in the safe encoder evaluation, then the SafeMOTION module immediately switches to the FAIL SAFE state after the function block is activated! The only way to exit the FAIL SAFE state is to complete a power off/on cycle!

A rising edge on the **S_RequestHoming** control bit starts "Safe Homing" and simultaneously resets the **S_SafePositionValid** status bit.
As soon as the homing procedure is finished, the **S_SafePositionValid** status bit is set and the **S_RequestHoming** control bit must be reset.
The homing procedure must be complete within the "Homing Monitoring Time (µs)" or else the SafeMOTION module will switch to the FUNCTIONAL FAIL SAFE state.

The homing procedure will be aborted if the **S_RequestHoming** control bit is reset before the procedure is completed.

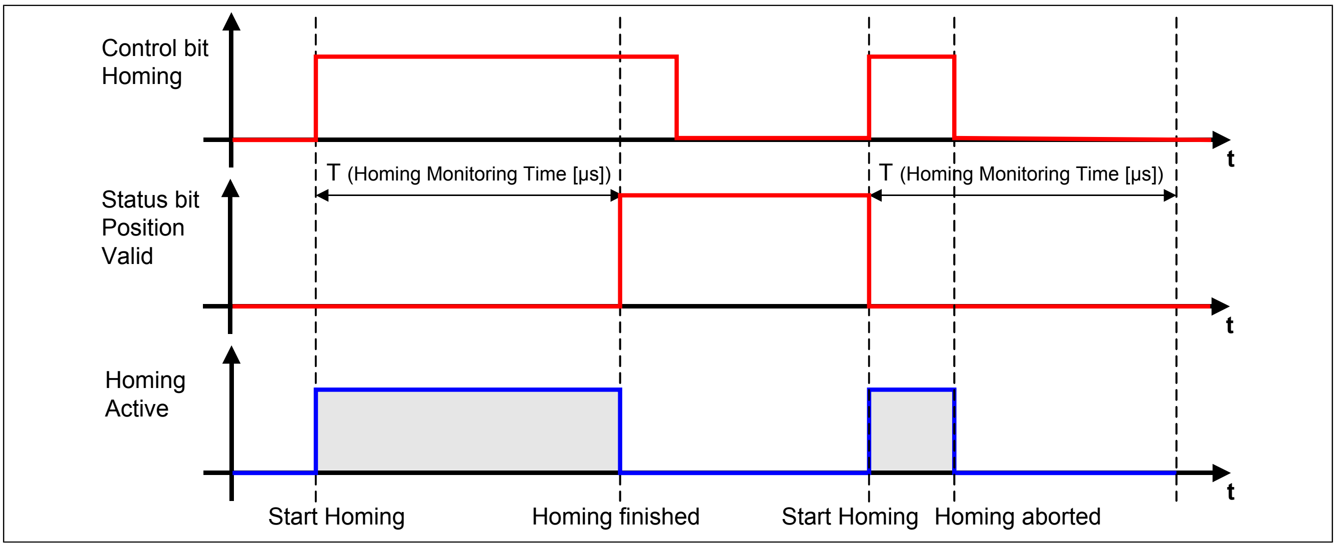


Figure 47: Safe Homing

Information:

The Safe Homing safety function is a prerequisite for implementing the SLP and SMP safety functions and for using the safe position. The S_SafePositionValid status will remain set to SAFEFALSE until safe homing has been performed!

Danger!

If an error occurs during the homing procedure, then the module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state.
The S_NotErrFUNC output on the function block is reset, and the drive loses all torque/power and coasts to a stop!
In the event of an error, a synchronous axis will no longer be synchronous.

Danger!

If the safe position is used in SafeDESIGNER, then the "Position Valid" output of the SF_SafeMC_Position_BR(_V2) function block must also always be evaluated.
This will be reset immediately only with referenced axes SAFETRUE, and the first time an encoder error occurs (SAFEFALSE).
This enables the safety application to detect any encoder error, even if only brief.
If a machine reference is not required for the application, then the axis can be referenced using "Direct" mode.

4.15.2.1 ReqHominOK status

The ReqHominOK status is only available with Safety Release R 1.9 and higher. The ReqHominOK status provides feedback in SafeDESIGNER regarding whether direct homing is performed when the "PositionValid" status bit is already set, even for large cycle times.

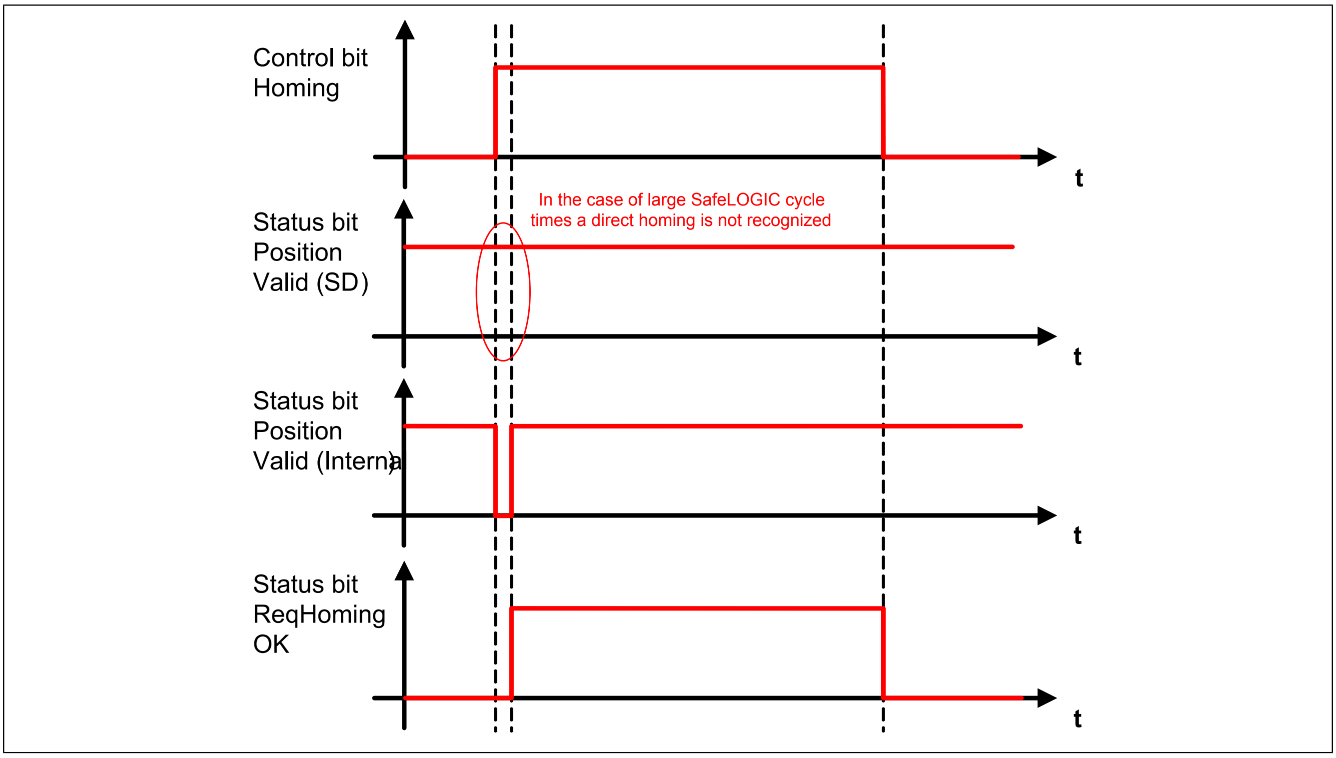


Figure 48: Safe Homing - ReqHomingOK status

4.15.3 "Direct" mode

4.15.3.1 Parameters

Parameter	Unit	Description	Default value
Homing			
Home Position or Home Offset (units)	[units]	Home position or home offset	0
Mode	Direct / Reference Switch / *Home Offset /* *Home Offset with Correction*	Selects the homing mode *The modes "Home Offset" and "Home Offset with Correction" are only available for the ACOPOSmulti SafeMOTION EnDat 2.2!*	Direct
Reference pulse	*Used / Not used*	*Selects whether or not to use a reference pulse for homing*	*Not Used*
General settings			
Safe Maximum Position	Used / Not used	Activates the SMP safety function from the configuration	Not used
Safety Position Limits			
Safe Lower Position Limit for SMP (units)	[units]	Lower position limit for the machine's full range of movement	0
Safe Upper Position Limit for SMP (units)	[units]	Upper position limit for the machine's full range of movement	0
Safety Standstill and Direction Tolerances			
Speed Tolerance	[units/s]	Speed tolerance for standstill monitoring	0

Table 122: "Safe Homing" safety function - "Direct" mode - Parameters

4.15.3.2 Behavior

"Direct" mode is used if the current position of the axis is known and only needs to be applied to the SafeMOTION module.

The following scenario is an example of how this mode can be used:

- A functional homing procedure is first carried out on the ACOPOSmulti SafeMOTION module.
- The ACOPOSmulti SafeMOTION module then moves the axis to a defined position.
- The operator confirms via a safe button that the position is correct → internally, a safe homing procedure is initiated in "Direct" mode.

When homing in "Direct" mode, the actual position of the axis is set to the value specified in the "Home Position or Home Offset" parameter immediately after the homing command (rising edge on the **S_RequestHoming** input).

The **S_ReferenceSwitch** input is not evaluated.

Information:

The axis must be at a standstill when the homing request is made.
The values configured under "Safety Standstill and Direction Tolerances" are monitored in this regard.
If the standstill tolerances are violated, then the module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state. The S_NotErrFUNC output on the function block is reset, and the drive loses all torque/power and coasts to a stop!

Information:

A reference pulse is not permitted to be used in "Direct" mode!
If a reference pulse is enabled ("Reference pulse" = Used), then the system will switch to the FAIL SAFE state when the configuration is checked during startup.
The only way to exit the FAIL SAFE state is to complete a power off/on cycle and modify the safety application!

Information:

If Safe Maximum Position has been activated in the configuration ("Safe Maximum Position" = Used), then the value set for the "Home Position or Home Offset" parameter must lie within the permitted SMP window ("Safe Lower Position Limit for SMP (units)" and "Safe Upper Position Limit for SMP (units)" parameters).
If this is not the case, then the system will switch to the FAIL SAFE state when the configuration is checked during startup.
The only way to exit the FAIL SAFE state is to complete a power off/on cycle and modify the safety application!

Danger!

Situations involving external forces (e.g. hanging loads) can result in dangerous movements!
If this poses a safety risk, then the user must implement the necessary equipment to eliminate the risk (e.g. mechanical brakes)! This equipment must correspond to the required safety level!

4.15.4 "Reference Switch" mode

4.15.4.1 Parameters

Parameter	Unit	Description	Default value
Homing			
Home Position or Home Offset (units)	[units]	Home position or home offset	0
Max. trigger speed (units/s)	[units/s]	Maximum permissible speed for evaluating the reference switch / reference pulse	0
Homing Monitoring Time (µs)	[µs]	Monitoring time for the homing procedure	0
Mode	Direct / Reference Switch / *Home Offset /* *Home Offset with Correction*	Selects the homing mode *The "Home Offset" and "Home Offset with Correction" modes are only available for the ACOPOSmulti SafeMOTION EnDat 2.2!*	Direct
Edge of reference switch	Positive / Negative	Selects the switching edge for reference switch The switching edge for the reference switch input is positive if the logical state of the reference switch changes from SAFEFALSE to SAFETRUE in the positive direction of movement.	Positive
Trigger direction	Positive / Negative	Selects the trigger direction If the homing procedure requires a movement, then this parameter specifies the direction for evaluating the reference switch / reference pulse.	Positive
Reference pulse	*Used /* *Not Used*	*Selects whether or not to use a reference pulse for homing* *This parameter is only available for the ACOPOSmulti SafeMOTION EnDat 2.2.*	*Not Used*
Blocking distance (% encoder reference system)	*%*	*Distance within which evaluation of the reference pulse will be suppressed. This is calculated starting at the configured reference switch edge and indicated as a percentage of the encoder reference system. A single revolution is used as the encoder reference system for rotary encoders.* *This parameter is only available for the ACOPOSmulti SafeMOTION EnDat 2.2.*	*0*
Position Tolerance	[units]	Position tolerance for standstill and direction monitoring	0

Table 123: "Safe Homing" safety function - "Reference Switch" mode - Parameters

4.15.4.2 Behavior

"Reference Switch" mode correlates with the "Switch Gate", "Abs Switch" and "Limit Switch" homing modes on the ACOPOSmulti SafeMOTION inverter module.

Information:

If the reference switch input (S_ReferenceSwitch) on the function block is not connected, the SafeMOTION module will switch to the FAIL SAFE state.
The only way to exit the FAIL SAFE state is to complete a power off/on cycle and modify the safety application!

Depending on the configuration, the ACOPOSmulti SafeMOTION inverter module will pass over the reference switch / limit switch several times.

Danger!

The reference switch / limit switch is part of the safety function and must therefore be taken into account in the risk analysis.

Use a debounced position switch suitable for safety applications!

The machine manufacturer is responsible for implementing a suitable switch!

After the homing command (i.e. rising edge of the S_RequestHoming input), the SafeMOTION module uses the reference switch edge that matches the "Edge of reference switch" and "Trigger direction" settings as long as it is passed below the "Max Trigger Speed".
If the reference switch is passed with a speed higher than the "Max Trigger Speed", then the reference switch edge is ignored.

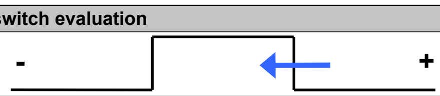
Configuration	Reference switch evaluation
Edge of reference switch = Negative Trigger direction = Negative	
Edge of reference switch = Positive Trigger direction = Negative	

Table 124: Selecting the reference switch edge

Configuration	Reference switch evaluation
Edge of reference switch = Negative Trigger direction = Positive	
Edge of reference switch = Positive Trigger direction = Positive	

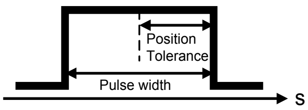
Table 124: Selecting the reference switch edge

Information:

After the homing command is given, the homing procedure must be completed within the configured "Homing Monitoring Time (µs)". Otherwise, the module will switch to the acknowledgeable FUNCTIONAL FAIL SAFE error state.
The S_NotErrFUNC output on the function block is reset, and the drive loses all torque/power and coasts to a stop!
In the event of an error, a synchronous axis will no longer be synchronous.

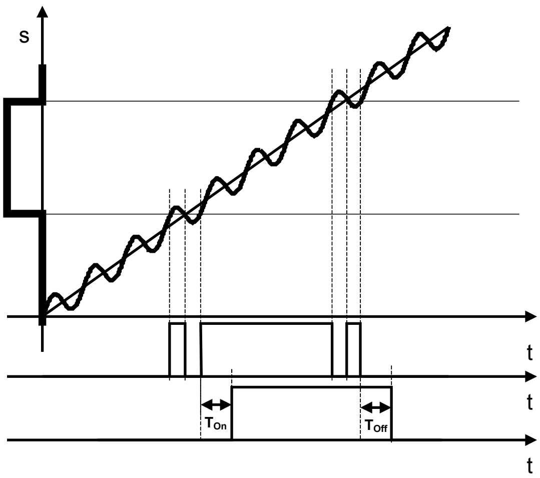
Danger!

The standstill "Position Tolerance" must be less than or equal to half the pulse width of the reference switch being used!



Danger!

The necessary filter (T_{on}, T_{off}) when reading the reference switch edges in SafeDESIGNER must be determined according to the control behavior during standstill.



Errors in the referenced absolute position due to the delay caused by the filter times must be taken into account!

4.15.4.2.1 ACOPOSmulti SafeMOTION SinCos

The home position is applied immediately after the reference switch edge is evaluated successfully.

4.15.4.2.2 ACOPOSmulti SafeMOTION EnDat 2.2

Reference pulse = Not Used

If the reference pulse is disabled, then the home position is applied immediately after the reference switch edge is evaluated successfully.

Reference pulse = Used

This mode is recommended when the positions of the ACOPOSmulti system and the SafeMOTION module must match exactly. Evaluation of the reference pulse compensates for the speed-dependent position difference by processing the two values at different times.

> ## Information:
> **If "Reference pulse" is set to "Used", then a rotary EnDat 2.2 functional safety encoder must be used. The reference pulse is generated at each single-turn overflow.**

If "Reference pulse = Used", then the home position is not applied until the first valid reference pulse after the reference switch edge is reached.

After a valid reference switch edge is evaluated, the evaluation of the reference pulse is suppressed for the distance set by the "Blocking distance (% encoder reference system)" parameter. The next reference pulse is only evaluated after this distance has been exceeded, at which point the home position is applied.

For a homing procedure to be valid, the direction of movement must not change between the time the reference switch edge occurs and the valid reference pulse; the "Max Trigger Speed" limit must also not be exceeded.

> ## Information:
> **If the direction of movement changes while searching for the reference pulse, the reference switch must be passed again.**

> ## Information:
> **If the "Max Trigger Speed" speed limit is exceeded while searching for the reference pulse, the module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state.**
> **The S_NotErrFUNC output on the function block is reset, and the drive loses all torque/power and coasts to a stop!**
> **In the event of an error, a synchronous axis will no longer be synchronous.**

> ## Danger!
> **Situations involving external forces (e.g. hanging loads) can result in dangerous movements!**
> **If this poses a safety risk, then the user must implement the necessary equipment to eliminate the risk (e.g. mechanical brakes)! This equipment must correspond to the required safety level!**

4.15.5 "Home Offset" and "Home Offset with Correction" modes (only available for ACOPOSmulti SafeMOTION EnDat 2.2)

Information:

The "Home Offset" and "Home Offset with Correction" modes are only available for ACOPOSmulti SafeMOTION EnDat 2.2!

4.15.5.1 Parameters

Parameter	Unit	Description	Default value
Homing			
Home Position or Home Offset (units)	[units]	Home position or home offset	0
Mode	Direct / Reference Switch / *Home Offset /* *Home Offset with Correction*	Selects the homing mode *The modes "Home Offset" and "Home Offset with Correction" are only available for ACOPOSmulti SafeMOTION EnDat 2.2!*	Direct
General settings			
Safe Maximum Position	Used/Unused	Activates the SMP safety function from the configuration	Unused
Safety Position Limits			
Safe Lower Position Limit for SMP (units)	[units]	Lower position limit for the machine's full range of movement	0
Safe Upper Position Limit for SMP (units)	[units]	Upper position limit for the machine's full range of movement	0
Safe Lower Position Limit for SLP (units)	[units]	Lower position limit for the monitoring range	0
Safe Upper Position Limit for SLP (units)	[units]	Upper position limit for the monitoring range	0

Table 125: "Safe Homing" safety function - Modes: Home offset / Home offset with correction - Parameters

4.15.5.2 Behavior

If an absolute encoder is being used, then the machine reference can be established via an offset to the encoder position.
A homing procedure is not necessary.
The "Home Offset" mode uses this offset directly, while "Home Offset with Correction" takes into account any encoder overrun that might occur in the permissible range of movement.
The offset is configured in SafeDESIGNER using the "Home Position or Home Offset" parameter.

The **S_ReferenceSwitch** input is not evaluated.

Danger!

This homing mode can only be used for absolute encoders (single-turn encoders / multi-turn encoders / linear encoders). Using another encoder for this mode will cause the SafeMOTION module to switch to the FAIL SAFE state.
The only way to exit the FAIL SAFE state is to complete a power off/on cycle and modify the safety application!

Information:

If the SMP and/or SLP safety functions are used, then their position window must be smaller than the safety-related encoder counting range.
If one of the two position windows is configured greater than the encoder counting range, the SafeMOTION module will switch to the FAIL SAFE state.
The only way to exit the FAIL SAFE state is to complete a power off/on cycle and modify the safety application!

For more information, see the section Safe encoder counting range (only applies to ACOPOSmulti SafeMOTION EnDat 2.2).

Danger!

Situations involving external forces (e.g. hanging loads) can result in dangerous movements!
If this poses a safety risk, then the user must implement the necessary equipment to eliminate the risk (e.g. mechanical brakes)! This equipment must correspond to the required safety level!

Home Offset

This mode is particularly suited for absolute encoders that provide unique position values over the entire range of movement. The home offset allows the encoder position to accurately represent the machine position over the entire range of movement.

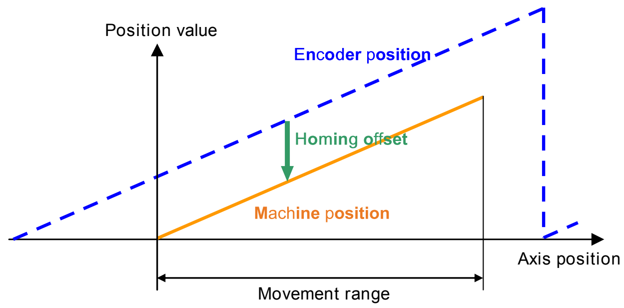


Figure 49: Home Offset homing mode

The home offset can be determined by performing a calibration movement (e.g. homing with a reference switch).

Home Offset with Correction

In addition to setting the home offset, this homing mode checks to determine if the machine position is within the movement range defined by the SMP position limits. If this is not the case, the home offset in the safety-relevant encoder counting range is corrected.

Information:

The SMP safety function must be activated when using this mode. If SMP is deactivated, the SafeMOTION module switches to the FAIL SAFE state.
The only way to exit the FAIL SAFE state is to complete a power off/on cycle and modify the safety application!

Counting range correction is needed when using absolute encoders if the encoder returns a unique position value over the entire range of movement but an encoder overflow occurs within the range of movement. In this case, the home offset depends on whether the machine was calibrated at a position to the right or the left of the overflow point.

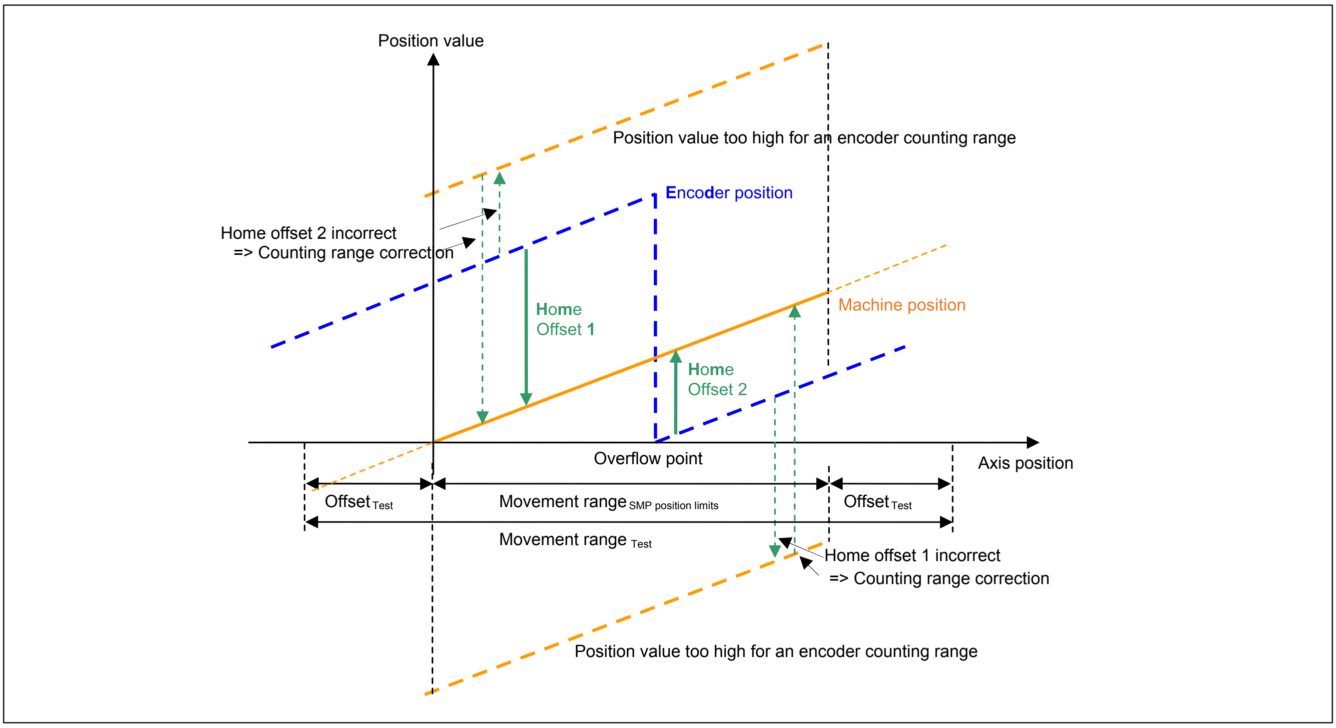


Figure 50: Homing mode - Home Offset with Correction

To the right of the overflow point, Home Offset 1 – which applies to the left side – would lead to an incorrect position value. To the left of the overflow point, Home Offset 2 – which applies to the right side – would lead to an incorrect position value. This can be compensated for with counting range correction.

Information:

Counting range correction only works if the encoder range is greater than or equal to the range of movement! Keep in mind that only the safety-relevant part of the encoder counting range is used.

4.16 Remanent Safe Position (RSP)

Information:

This safety function is only available with Safety Release R 1.9 or higher and only for ACOPOSmulti SafeMOTION EnDat 2.2 inverter modules!

Information:

In order to be able to use the RSP safety function:

- **The axis must first be homed using the "Safe Homing" safety function. It does not matter which homing mode is used, but the respective safety notices must be observed.**
- **The STO and SOS safety functions must be used in accordance with the respective safety notices.**

Danger!

The RSP safety function may only be used if suitable technical measures are taken to prevent impermissible movement of the axis when it is switched off (e.g. motor holding brake, self-locking gear, etc.). The axis is not in the OPERATIONAL state and not permitted to be moved further than the lag tolerance (max. half the safe absolute encoder counting range - 2 * SOS position tolerance).

$$\Delta x_{Danger} > \frac{x_{SafeEncoderRange}}{2} - 2 \cdot x_{SOStol}$$

It is the user's responsibility to take suitable technical measures to prevent excess movement.

Danger!

In order to perform testing and validation of the RSP safety function in the course of maintenance, the ACOPOSmulti SafeMOTION inverter module must have performed the RSP procedure.

Danger!

If the module is replaced, an initial homing procedure must be performed without the S_SwitchHomingMode activated.

Danger!

The RSP safety function is not suitable for continuously rotating axes. If an INT32 overflow of the safe position occurs during homing, homing using RSP will result in the FUNCTIONAL FAIL SAFE state.

4.16.1 Parameters

Parameter	Unit	Description	Default value
Homing			
Remanent safe position	*Used / Not used*	*Selects whether or not to use the remanent safe position* *Parameter is only available with ACOPOSmulti SafeMOTION EnDat 2.2.*	*Not Used*
Safety Standstill and Direction Tolerances			
Speed Tolerance	[units/s]	Speed tolerance for standstill monitoring	0
Position Tolerance	[units]	Position tolerance for standstill and direction monitoring	0

Table 126: RSP safety function - Parameters

4.16.2 Behavior

The RSP safety function can be activated or deactivated via the configuration.

With this safety function, after the safe position has been homed once to the machine position, the homed safe position does not have to be homed again after a power off/on cycle. It is only possible to store valid position data after a controlled standstill of the drive. The standstill must therefore be ensured. It must also be ensured that no power is supplied to the drive while the data is being saved so that it is not possible for the drive to move. These requirements are met when using the STO and SOS safety functions.

Information:

If the RSP safety function is used and the S_RequestHoming, S_SwitchHomingMode, S_RequestSTO and S_RequestSOS inputs on the function block are not connected, the SafeMOTION module will switch to the FAIL SAFE state.

The only way to exit the FAIL SAFE state is to complete a power off/on cycle and modify the safety application!

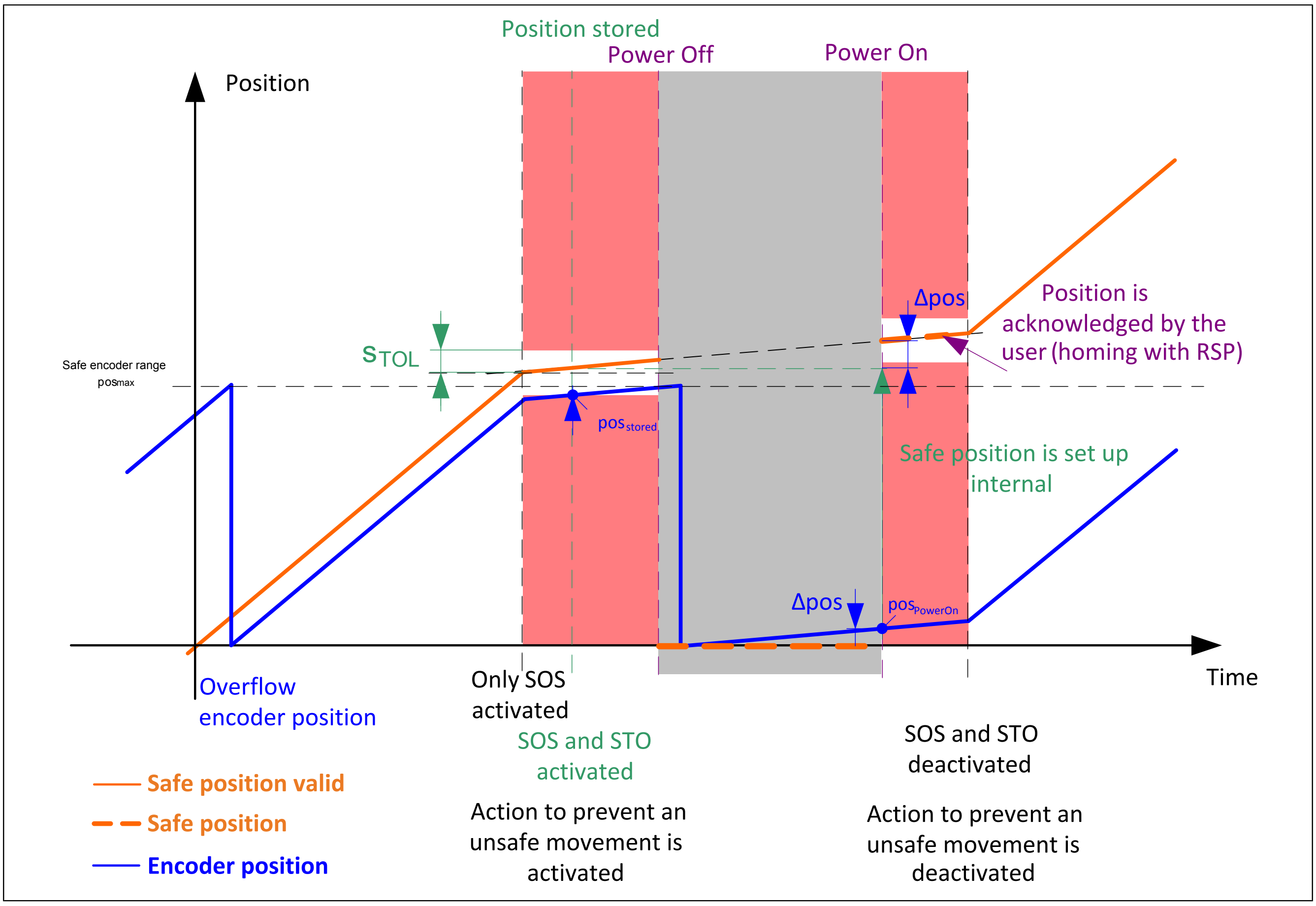


Figure 51: RSP safety function - Timing diagram with encoder overflow during power off

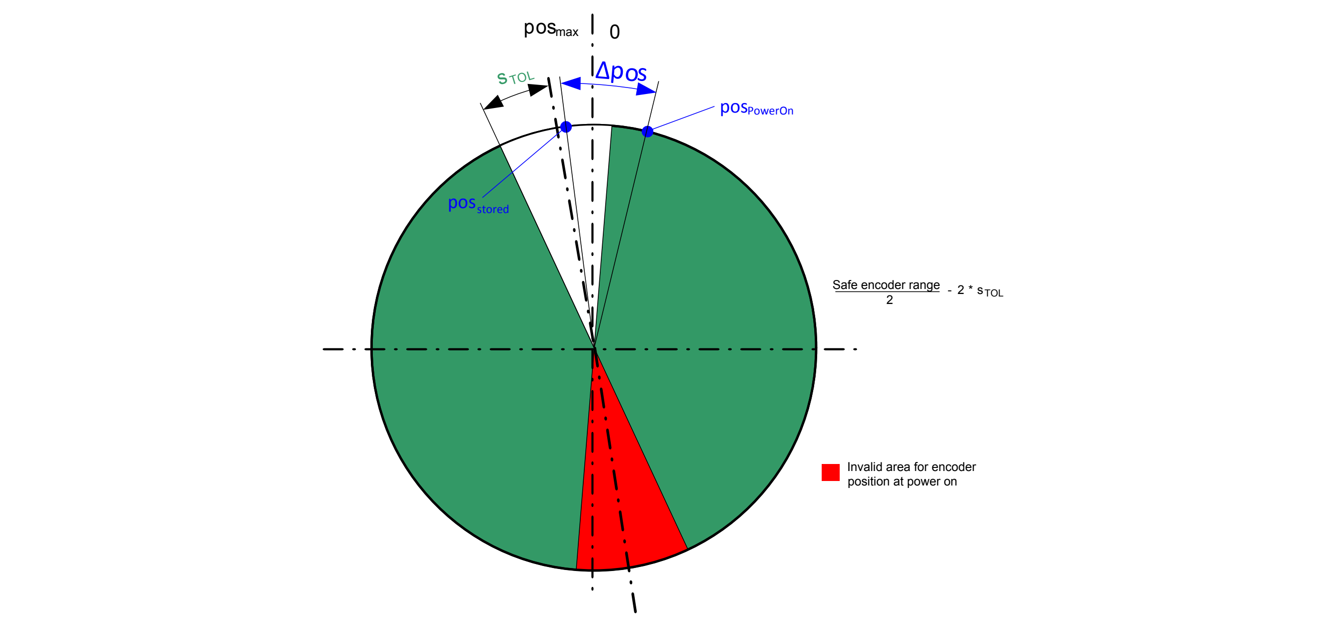


Figure 52: RSP safety function with respect to position for one revolution

4.16.2.1 RSP procedure

This safety function is not intended to provide a functional safe position following an uncontrolled machine failure. The following procedure is defined in order to achieve a controlled stop and enable the use of the remanent safe position:

1. Stop the axis in a controlled manner (valid safe position required).
2. Achieve the "RSPValid" status.
   This indicates whether the position has been stored and whether homing with RSP will be possible after powering off. The following conditions must be met in order to achieve the "RSPValid" status:
   - STO and SOS are selected.
   - STO and SOS are active and in their safe state.
   - The axis has been homed and the safe position is valid (**S_SafePositionValid** = TRUE).
   - The store procedure is completed after the other conditions have been fulfilled.
3. Activate the technical measures required to prevent a dangerous movement. Execute a power off. A dangerous movement is one that corresponds to half the safe encoder counting range minus two times the SOS position tolerance.
   $\Delta x_{Danger} > \frac{x_{SafeEncoderRange}}{2} - 2 \cdot x_{SOStol}$
4. Confirm the restored position by homing with RSP after powering on.
   - To confirm the restored position after powering on, execute a homing command (i.e. rising edge of the **S_RequestHoming** input) with the **S_SwitchHomingMode** input enabled.

Information:

If the switching frequency of the RSPValid status is too fast to complete the store procedure, a warning is entered in the Safety Logger. The SOS and STO safety functions are active in this state and are not deselected until the most recent store procedure is completed.

Information:

If the module is powered on after a controlled stop and homing is performed without the S_SwitchHomingMode input enabled, or if an encoder error is detected, then homing with RSP will cause the module to switch to the acknowledgeable FUNCTIONAL FAIL SAFE error state.

The drive loses all torque/power!

Information:

If an error or change in the configuration is detected when powering on after a controlled stop, then the position is not applied and homing with RSP will cause the module to switch to the acknowledgeable FUNCTIONAL FAIL SAFE error state.

The drive loses all torque/power!

Information:

If the FUNCTIONAL FAIL SAFE error state occurs when homing with RSP, the axis must be homed again with the S_SwitchHomingMode input disabled in order to obtain a new, valid safe position.

4.17 Safely Limited Position (SLP)

Information:

The "Safely Limited Position" safety function is only available with Safety Release 1.4 and higher!

4.17.1 Parameters

Parameter	Unit	Description	Default value
Safety Deceleration Ramp			
Deceleration Ramp	[units/s²]	Slope of the deceleration ramp to be monitored	1073676289
Safety Position Limits			
Safe Lower Position Limit for SLP (units)	[units]	Lower position limit for the monitoring range	0
Safe Upper Position Limit for SLP (units)	[units]	Upper position limit for the monitoring range	0
Safety Standstill and Direction Tolerances			
Speed Tolerance	[units/s]	Speed tolerance for standstill monitoring	0
Position Tolerance	[units]	Position tolerance for standstill and direction monitoring	0
Safety Additional Parameters			
Delay time to start SLP (us)	[µs]	Delay time between the SLP request and start of monitoring	0

Table 127: SLP safety function - Parameters

4.17.2 Behavior

The purpose of the SLP safety function is to monitor a specified position window.

The "Safe Lower Position Limit for SLP" and "Safe Upper Position Limit for SLP" parameters can be used to configure the limits of the monitoring range.

Setting the **S_RequestSLP** input to SAFEFALSE requests the SLP safety function.

After the configured "Delay time to start SLP" has expired, the position window is monitored.

The **S_SafetyActiveSLP** status bit will be set to SAFETRUE if no errors occur while monitoring is active.

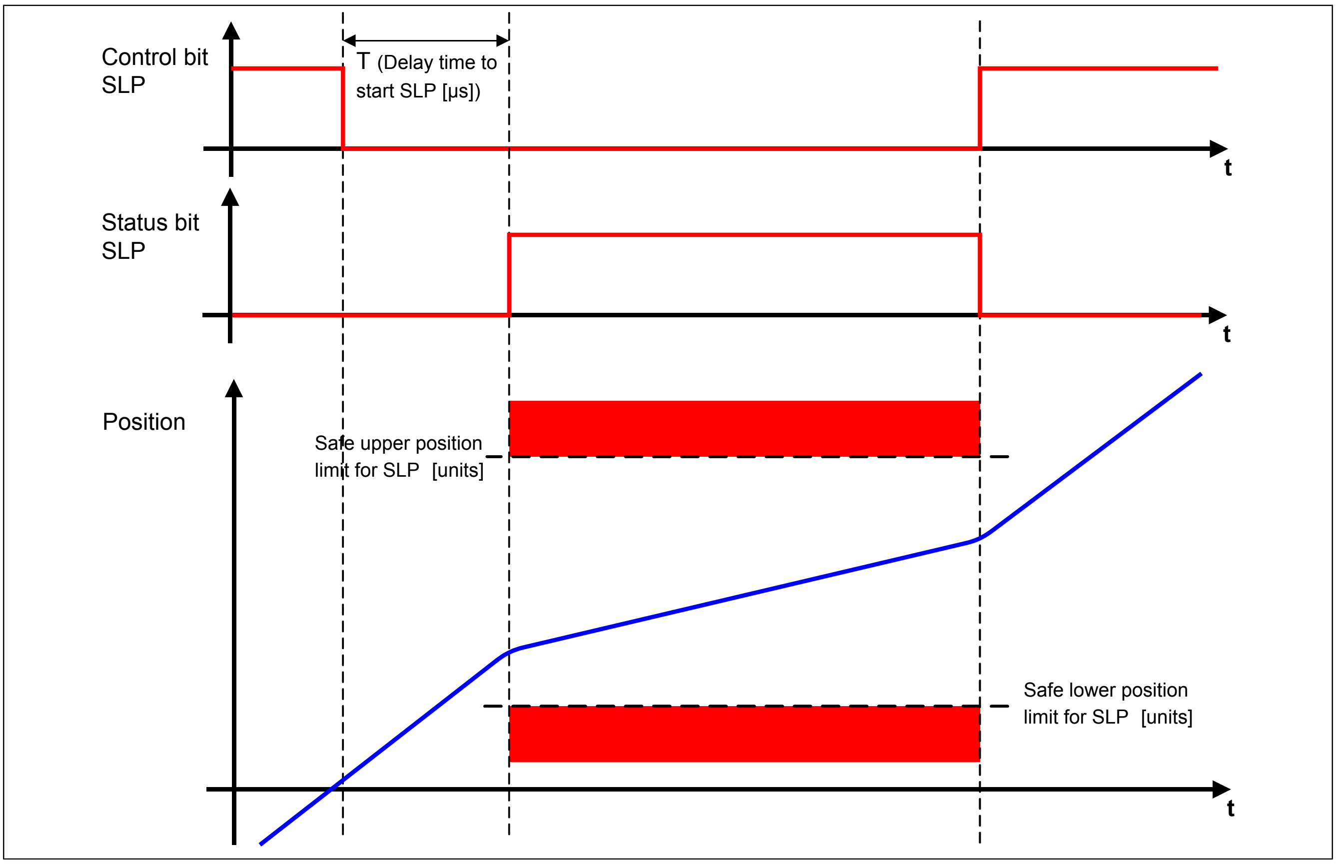


Figure 53: Safely Limited Position (SLP)

Information:

The axis must be homed successfully before using the Safely Limited Position safety function.
If a homing procedure is not completed successfully or the S_SafePositionValid status changes, then the request for the SLP safety function causes the module to switch to the acknowledgeable FUNCTIONAL FAIL SAFE error state.
The drive loses all torque/power and coasts to a stop! In the event of an error, a synchronous axis will no longer be synchronous.
The S_NotErrFUNC output on the function block is reset.

Danger!

Situations involving external forces (e.g. hanging loads) can result in dangerous movements!
If this poses a safety risk, then the user must implement the necessary equipment to eliminate the risk (e.g. mechanical brakes)! This equipment must correspond to the required safety level!

To minimize the residual distance when the position window is exceeded, a position-dependent speed limit is monitored in addition to the position.

Danger!

In the worst case, the monitored position window can be violated while the axis is coasting to a stop. This must be taken into account when defining the limits!

When the position limit is approached, the monitored speed limit is calculated in such a way that the drive will come to a full stop before the positioning limit is reached using the configured deceleration ramp parameter.

Permitted speed in the direction of the upper position limit:

$$v_{LIM,POS} = \sqrt{2(LIM_{SLP,POS} - s) \cdot a}$$

Permitted speed in the direction of the lower position limit:

$$v_{LIM,NEG} = \sqrt{2(s - LIM_{SLP,NEG}) \cdot a}$$

The position-dependent speed limit is illustrated in the following figure.

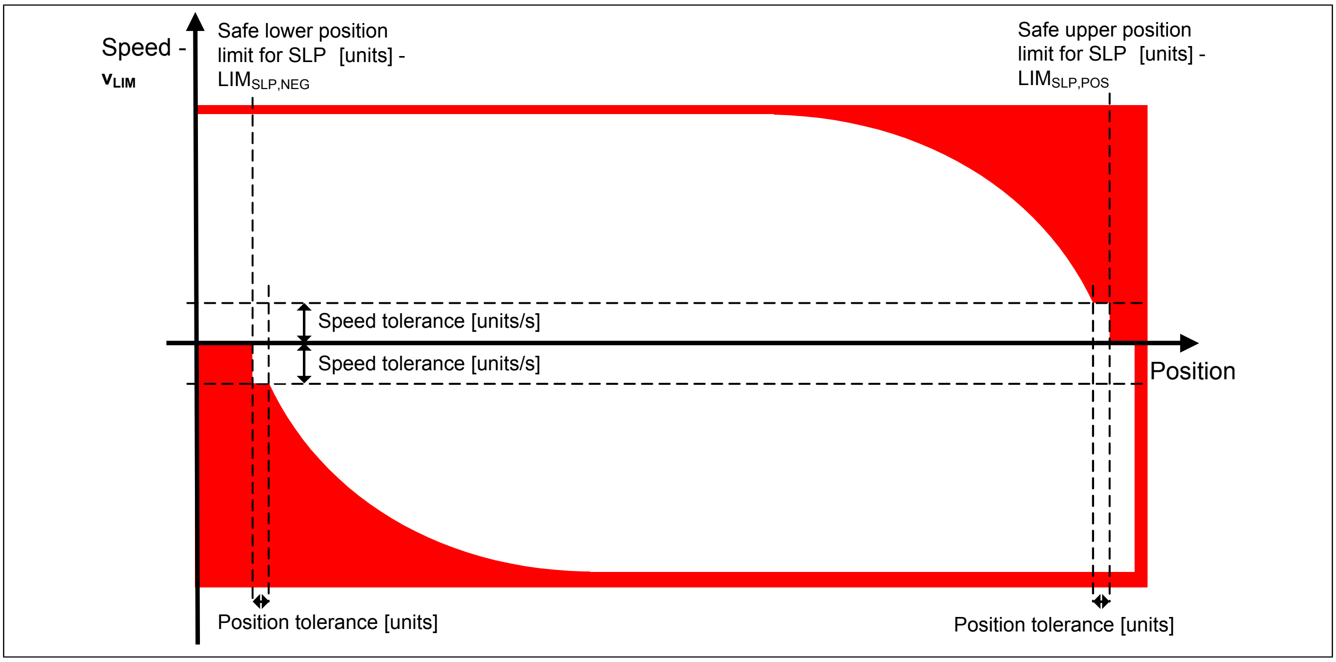


Figure 54: Position-dependent speed window

Danger!

If the position window or the position-dependent speed limit is violated while the SLP safety function is activated or the S_SafePositionValid status is lost, then the module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state.
The S_NotErrFUNC output on the function block is reset, and the drive loses all torque/power and coasts to a stop!
In the event of an error, a synchronous axis will no longer be synchronous.

Danger!

If the SLP safety function is used in the safety application, then it must be tested when commissioning the machine by selecting and deselecting it!
The test should contain at least one violation of each position limit. The error response must be tested accordingly!

4.18 Safe Maximum Position (SMP)

Information:

The "Safe Maximum Position" safety function is only available with Safety Release 1.4 and higher!

4.18.1 Parameters

Parameter	Unit	Description	Default value
Safety Deceleration ramp			
Deceleration ramp	[units/s²]	Slope of the deceleration ramp to be monitored	1073676289
General settings			
Safe Maximum Position	Used / Not used	Activates the SMP safety function from the configuration	Not used
Safety Position Limits			
Safe Lower Position Limit for SMP (units)	[units]	Lower position limit for the machine's full range of movement	0
Safe Upper Position Limit for SMP (units)	[units]	Upper position limit for the machine's full range of movement	0
Safety Standstill and Direction Tolerances			
Speed Tolerance	[units/s]	Speed tolerance for standstill monitoring	0
Position Tolerance	[units]	Position tolerance for standstill and direction monitoring	0

Table 128: SMP safety function - Parameters

4.18.2 Behavior

The difference between SMP and SLP is that SMP cannot be actively requested. It is either enabled or disabled by the configuration.

When enabled, the current position is constantly monitored against a defined position window.

The "Safe Lower Position Limit for SMP" and "Safe Upper Position Limit for SMP" parameters can be used to configure the limits of the monitoring range.

The SMP safety function only works with homed axes since it requires a safe absolute position.
If SMP is configured, a 15-minute timeout period begins when pulse disabling is activated. The homing procedure must take place during this time.
When homing is completed and if there were no errors during monitoring, the **S_SafetyActiveSMP** status bit is set to SAFETRUE.

Information:

The axis must be homed successfully before using the "Safe Maximum Position" safety function.
If the homing procedure does not complete successfully within 15 minutes after pulse disabling is activated, the S_SafePositionValid status is lost for an already homed axis or there is a violation of the position window or position-dependent speed limit, then the module switches to the FUNCTIONAL FAIL SAFE error state.
The S_NotErrFUNC output on the function block is reset, and the drive loses all torque/power and coasts to a stop! In the event of an error, a synchronous axis will no longer be synchronous.

As with the SLP safety function, the "Safe Maximum Position" safety function also monitors a position-dependent speed limit in addition to the position in order to minimize the residual distance if the position window is exceeded. For more information, see the description of the "Safely Limited Position (SLP)" safety function.

Danger!

In the worst case, the monitored position window can be violated while the axis is coasting to a stop. This must be taken into account when defining the limits!
If the position window has been exceeded, then movement is only possible in the direction of the position window after the FUNCTIONAL FAIL SAFE state has been acknowledged.
Attempting to move beyond the standstill tolerance in the unsafe direction (i.e. away from the position window) will cause the module to switch to the acknowledgeable FUNCTIONAL FAIL SAFE error state.

Danger!

If the SMP safety function is used in the safety application, then it must be tested when commissioning the machine! The test should contain at least one violation of each position limit. The error response must be tested accordingly!

Danger!

Situations involving external forces (e.g. hanging loads) can result in dangerous movements!
If this poses a safety risk, then the user must implement the necessary equipment to eliminate the risk (e.g. mechanical brakes)! This equipment must correspond to the required safety level!

4.19 Safe Brake Test (SBT)

Information:

This functionality is only available with Safety Release R 1.7 or higher and only for ACOPOSmulti SafeMOTION SinCos inverter modules!

Danger!

The "Safe Brake Test" safety function can only be used for synchronous motors!

Danger!

Use of the "Safe Brake Test" safety function requires fault exclusion for encoder shaft breakage or that safe encoder connection monitoring is active.

This requires either a safe encoder mounting, or the application must meet the necessary requirements for safe encoder shaft breakage monitoring!

Information:

Determining the added value of using this function depends on the requirements of the brake being used and is your responsibility as user.

Danger!

The "Safe Brake Test", SBT safety function is not a typical safety function!

It is only used to test an engaged holding brake by applying a configurable stator current for a certain period of time.

The test is carried out at the specified safety level and with the specified precision.

Danger!

Overheating of the motor can change the torque constant (K_T) and therefore negatively influence the functionality of the "Safe Brake Test (SBT)".

Ensure that the motor has been sized so as to prevent overheating.

4.19.1 Parameters

Parameter	Unit	Description	Default value
Safety Additional Parameters			
Delay time to start SBT (us)	[µs]	Delay time between the SBT request and activation of the safety function	0
Safe Brake Test			
Safe Brake Test interval (s)	[s]	Retry interval for the safe brake test	28800
Safe Brake Test threshold (uA)	[µA]	Threshold value for the stator current that must be exceeded during the brake test	0
Safe Brake Test external load (uA)	[µA]	External load	0
Safe Brake Test maximum torque duration (us)	[µs]	Duration of the test for which the maximum torque must be present	0
Safe Brake Test position tolerance (units)	[units]	Position tolerance	0

Table 129: SBT safety function - Parameters

The parameters are checked when the SafeMOTION module is started. If a parameter is invalid, the module switches to an error state. In addition, a corresponding error entry is made in the logger.

If an external load is not configured, the following guidelines apply:

- The "Safe Brake Test threshold" value must be greater than the measurement imprecision of the module being used.

The following additional guidelines apply for an external load:

- The external load is not permitted to be greater than the threshold value.
- The external load must be greater than the measurement imprecision of the module being used.

4.19.2 Behavior

The "Safe Brake Test" safety function allows an engaged brake to be tested by applying a configurable stator current for a certain period of time.

Using torque constant K_T, the torque is proportional to the stator current I_S:

$T = I_S * K_T$

An external load can be taken into consideration if it is configured in SafeDESIGNER using the "Safe Brake Test external load" parameter. In this case, the expected testing torque after measuring the configured load is reduced by the value for the external load.

The brake test must be performed by the standard application; the SafeMOTION module monitors this process.

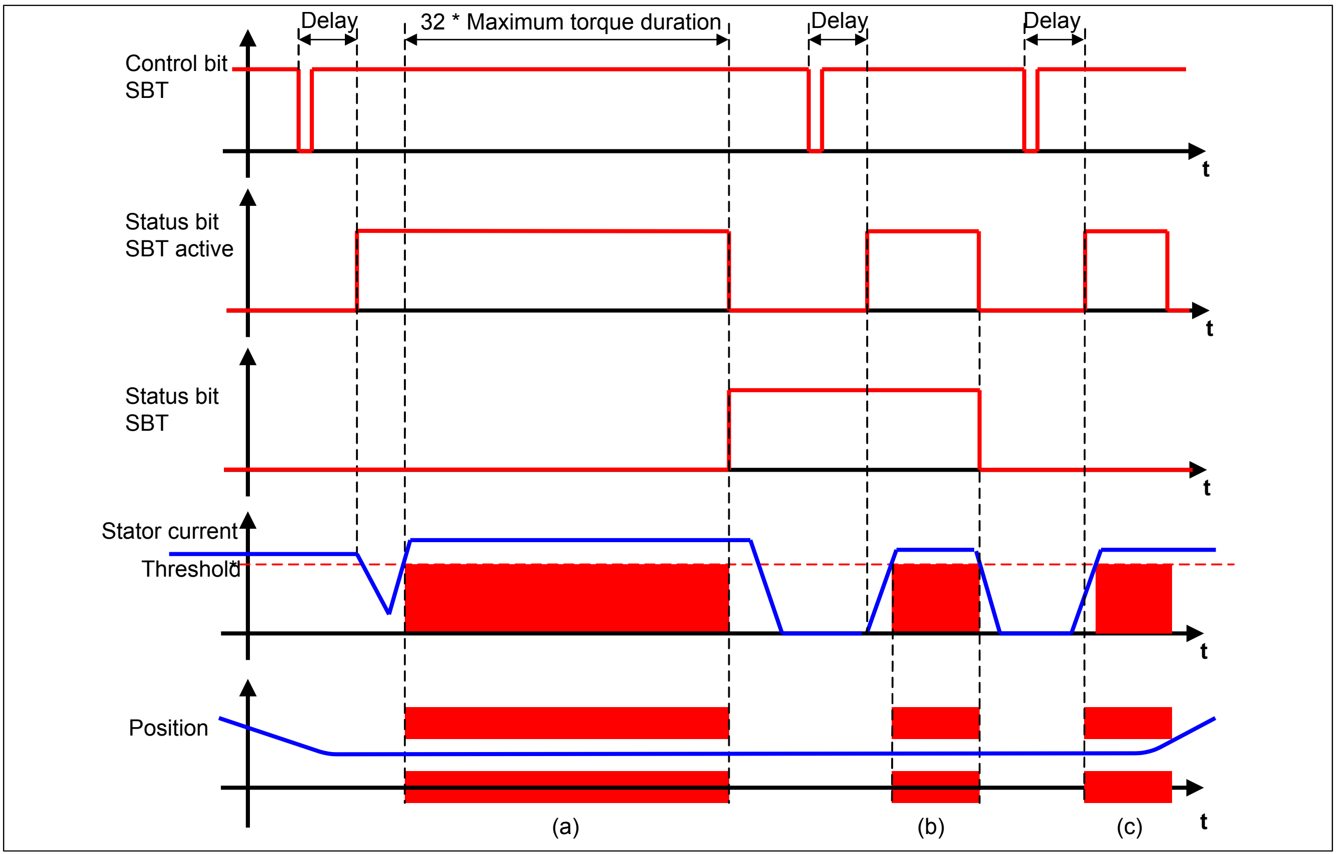


Figure 55: Safe Brake Test (SBT)

A corresponding mode is available in the PLCopen function block MC_BR_BrakeControl.

The SF_SafeMC_SBT_BR_V1_00 function block is available in SafeDESIGNER to request the safe brake test.

A falling edge on the SBT control bit starts the safe brake test ("Safe Brake Test (SBT)"); the "SBT Active" status bit is set at the same time.

As soon as the brake test has been completed successfully, the SBT status bit is set; "SBT Active" is reset at the same time.

The request for the safe brake test is edge-controlled. Resetting the SBT control bit to SAFETRUE has no effect on the rest of the process.

Immediately after the safe brake test is requested, the actual brake test is delayed by the "Delay time to start SBT" counter. This time allows the standard application to react to the status of the request bit and bring the axis to a standstill if necessary.

The safe brake test is handled differently depending on whether or not an external load is present at the time of the test.

4.19.3 Safe brake test without external load

If no external load is configured in SafeDESIGNER, monitoring of the load on the brake starts immediately after the "Delay" has expired. The safe brake output is simultaneously switched to 0 V.

4.19.4 Safe brake test with configured external load

After the "Delay" has expired, the value of the stator current required to hold the load is immediately checked against the expected value. This means that at the time the stator current is checked, it must be within a window of ±6.25% of the expected "Safe Brake Test external load" value. If it is, the safe brake output is switched to 0 V, and the stator current must be below the reduced threshold value.

Because an external load is already exerting torque on the engaged brake, the amount of torque that the drive must apply to test the brake is reduced. The test current is reduced by the amount of the configured load.

Danger!

This function cannot be used with a variable load.

Danger!

In order for the measurement of the external load to provide valid results, the load must be held by the drive at the time of measurement. This means that the brake must not be engaged!

4.19.5 Brake load monitoring

From this point on, the safe brake test procedure is the same with or without a configured external load.

The MC_BR_BrakeControl function block in the standard application ensures that the desired amount of torque is applied to the brake. The stator current is increased in a ramped form until it reaches the setpoint. From the time the stator current exceeds the threshold value "Safe Brake Test threshold", the safe position is stored and a position window is calculated.
The size of the position window can be configured using the "Safe Brake Test position tolerance [units]" parameter. The "SBT Active" status bit is simultaneously set and monitoring is started.

The "Safe Brake Test maximum torque duration [µs]" parameter defines the minimum duration of the test, during which the test torque must be applied. The total duration of monitoring is 32x this time (see Figure 55 "Safe Brake Test (SBT)" on page 250 (a)).
During this time, the test current is not permitted to fall below the threshold value; the safe position is not permitted to leave the position window.

If the stator current falls below its threshold value during active monitoring (see Figure 55 "Safe Brake Test (SBT)" on page 250 (b)) or the position tolerance window is violated (see Figure 55 "Safe Brake Test (SBT)" on page 250 (c)), then the safe brake test becomes invalid and is aborted. If the SBT status bit is already set, it is reset. In addition, a corresponding entry is made in the Safety Logger.

After a successful brake test, the SBT status bit is set and a configurable timer is started ("Safe Brake Test interval [s]" parameter). After this timer has expired, the SBT status bit is reset to indicate that a new brake test is required.

4.19.6 Accuracy of current measurement

Problems with commutation can affect the accuracy of current measurement. Nevertheless, the testing principle used guarantees that this measurement error is <2%.

The accuracy of current measurement also depends on the maximum measurement error of the current transformer, which in turn depends on the performance class of the inverter module being used.

The threshold value must therefore be additionally increased by this value. This ensures valid results from the brake test, even with maximum measurement error.

The following table lists the maximum measurement error for each performance class.

Performance class	Continuous current [A]	Transformer measurement error
8BVI0014HxSA	1.9	108.6 mA
8BVI0028HxSA	3.8	293 mA
8BVI0055HxSA	7.6	488.2 mA
8BVI0110HxSA	15.1	976.6 mA
8BVI0220HxSA	22	1101.6 mA
8BVI0330HxSA	33	2406.4 mA
8BVI0440HxSA	44	2406.4 mA
8BVI0660HxSA	66	4.813 A
8BVI0880HxSA	88	4.813 A
8BVI1650HxSA	165	7.344 A

The following applies for the value to be set for the I_{SET} threshold:

$I_{SET} = I_{Test} * 1.02 + \text{measurement error}$

Danger!

If the accuracy of the current measurement is not taken into account when setting the threshold value, the monitored stator current could be too low under certain conditions. In this case, it is not possible to guarantee that the target test torque is achieved, and the results of the brake test would be invalid!

Information:

The values for the test current and duration of the test depend on the application and the brake being used; it is the user's responsibility to set these values appropriately.

4.20 Safe machine options

4.20.1 Parameters

Parameter	Unit	Description	Default value
Additional Parameter			
Activate safe machine options	Deactivated/ Activated	Activates/Deactivates the "Safe machine options" safety function	Deactivated

Table 130: "Safe machine options" safety function - Parameters

4.20.2 Behavior

The primary method for configuring a SafeMOTION module is to set the parameters in SafeDESIGNER and transfer them to the SafeLOGIC controller along with the safety application. From there, they are transferred to the SafeMOTION module. These parameters are labeled as "Default parameters" and require the use of SafeDESIGNER.

To allow them to be configured without using SafeDESIGNER, Safety Release 1.9 introduces the "Safe machine options" safety function.

"Safe machine options" is used to modify the parameters of the SafeMOTION module from the standard application.

The safe machine options are transferred from the standard application to the SafeLOGIC controller as a data block, and stored there permanently. The SafeMOTION module needs to restart in order to transfer the safe machine options, and in some cases this occurs automatically. This means that the parameters cannot be changed at runtime.

Information:

It is only possible to use the "Safe machine options" safety function:

- **On SG4 target systems**
- **With SafeLOGIC X20SL8100**
- **With Automation Runtime AR 4.06 or higher**

Danger!

Changing the module's parameters using the "Safe machine options" is equivalent to modifying the safety application.

Acknowledgment and activation requests must be handled by authorized personnel. Automated acknowledgment and activation logic is not permitted. This requirement must be verified in a code review document.

Also take note of the danger warnings in the "Maintenance scenarios" section of the technical data sheets for X20SL8xxx and X20SLXxxx series devices. Functions are only permitted to be executed by personnel with proper authorization. Access to the respective visualization components must be limited to the authorized group of personnel using suitable means.

Personnel authorized to acknowledge data are responsible for examining the data that is to be acknowledged (project CRC, project save date, machine option contents, etc.).

Local personnel must be informed when one of these functions is accessed. The user must implement suitable measures to ensure that remote access is not possible without notifying local personnel.

Proper functionality must be verified with thorough functional testing. All test procedures and results must be documented. Testing must be able to identify any data mismatches between the visualization application and the safety application. Complete functional testing must be carried out to ensure proper functionality after the standard application is created or modified as well as after any changes are made to Automation Runtime.

The following description assumes that the "Activate safe machine options" module parameter has been set to "Activated".

4.20.3 Transferring to the SafeLOGIC controller

The safeDownloadData() function block from the AsSafety library is used to transfer the safe machine options. Information regarding the use of this function block can be found in the AS help system for the AsSafety library.

As mentioned above, the safe machine options are transferred as a data block. This data block contains a 64-byte array, variables for version identification and the safety parameters themselves. The format of the safe machine options depends on the Safety Release of the module type (see "Data structure of safe machine options, Safety Release 1.9").

With Safety Release 1.9, the "SafeMC" library contains structure types for both the ACOPOSmulti SafeMOTION EnDat 2.2 inverter module and the ACOPOSmulti SafeMOTION SinCos inverter module. Please note the minimum required ACP10 version (see 3 "System requirements" on page 157).

Since the entire safe machine option data block is always transferred, the "enable bits" can be used to enable each parameter. Each bit corresponds to a parameter. For parameters whose "enable bit" is set, the default value (as configured in SafeDESIGNER) is overwritten by the value in the structure. For parameters whose "enable bit" is not set, the default value (as configured in SafeDESIGNER) is retained.

Information:

When the safe machine options are transferred to the SafeLOGIC controller, their ranges are not checked. It is therefore possible to set values that are outside the valid ranges. To prevent malfunctions, the range check is performed on the SafeMOTION module. If faulty parameter settings are detected, the SafeMOTION module enters the FAIL SAFE state during startup.

Information:

The application that handles the transfer must be developed in accordance with currently applicable regulations. Manipulation of parameters by unauthorized personnel is not permitted and must be prevented.

After parameters have been changed, a complete functional test must be performed in order to ensure that the behavior of the safety application meets specifications.

Information:

The format of the safe machine options is backward compatible.

4.20.4 Transferring to the SafeMOTION module

The transfer takes place in the PREOPERATIONAL state. When the safe machine options on the SafeLOGIC controller are changed after a download, they are automatically transferred to the respective SafeMOTION module. On the SafeMOTION module, each of the "enable bits" is evaluated; for any that are set, the default value of the corresponding parameter is overwritten by the value of the safe machine option. Each parameter has a valid range of values which may depend on the values of other parameters (SMS/SLS speed limits, etc.). This range of values is checked on the SafeMOTION module.

If faulty parameter settings are detected, the SafeMOTION module enters the FAIL SAFE state and a corresponding error is entered in the Safety Logger.

4.20.5 Missing safe machine options

If the "Safe machine options" safety function is activated, then the safe machine options must be found on the SafeLOGIC controller. If there is no data block for the respective SafeMOTION module, then the SafeMOTION module does not switch to the OPERATIONAL state and can therefore not be used.

Downloading safe machine options to the SafeLOGIC controller triggers an automatic restart of the SafeMOTION module, and the safe machine options are transferred from the SafeLOGIC controller to the SafeMOTION module.

4.20.6 Data structure of safe machine options, Safety Release 1.9

Data structure of safe machine options for Safety Release 1.9 of:

- ACOPOSmulti SafeMOTION EnDat 2.2
- ACOPOSmulti SafeMOTION SinCos

Parameters that are set using a drop-down menu in SafeDESIGNER have a specific range of values, which is listed in the following table for each parameter.

Data type	EnDat 2.2		SinCos		Name	Constant / Name in SafeDESIGNER
	Index	Byte offset	Index	Byte offset		
USINT[64]		0 .. 63		0 .. 63	EnableBits	
UINT		64 .. 65		64 .. 65	StructInfoAxisTypeID	Axis type ID of the ACOPOSmulti SafeMOTION inverter module
UINT		66 .. 67		66 .. 67	StructInfoSize	Size of the parameter structure
UDINT		68 .. 71		68 .. 71	StructInfoVersion	StructInfoVersion
USINT	**0**	72	**0**	72	EncoderType	Encoder type **SafeMOTION EnDat 2.2** Encoder used = 0 Encoder not used = 1 **SafeMOTION SinCos** Rotary encoder = 0 Linear encoder = 1 Encoder not used = 2
USINT	**1**	73	**1**	73	*AlignmentByte0*	*Alignment placeholder. Do not use!*
USINT	**2**	74	**2**	74	*AlignmentByte1*	*Alignment placeholder. Do not use!*
USINT	**3**	75	**3**	75	*AlignmentByte2*	*Alignment placeholder. Do not use!*
UDINT	Not used		**4**	76 .. 79	NrOfSignalperiods	Number of signal periods
DINT	**4**	76 .. 79	**5**	80 .. 83	ScaleRevo	Count of physical reference system
DINT	**5**	80 .. 83	**6**	84 .. 87	ScaleUnits	Units per count of physical reference system [units]
DINT	**6**	84 .. 87	**7**	88 .. 91	ScaleDirection	Counting direction Default = 0 Inverse = 1
DINT	**7**	88 .. 91	**8**	92 .. 95	ScaleLength	Length of physical reference system for linear encoder (nm)
DINT	**8**	92 .. 95	**9**	96 .. 99	ScaleNormSpeedMax	Maximum speed to normalize the speed range [units/s]
DINT	**9**	96 .. 99	**10**	100 .. 103	AccelerationMax	Maximum acceleration (rad/s² or mm/s²)
DINT	**10**	100 .. 103	**11**	104 .. 107	HomingPos	Home Position or Home Offset (units)
DINT	**11**	104 .. 107	**12**	108 .. 111	HomingMaxSpeed	Max. trigger speed (units/s)
DINT	**12**	108 .. 111	**13**	112 .. 115	HomingTMon	Homing Monitoring Time (µs)
USINT	**13**	112	**14**	116	HomingMode	Mode Direct = 0 Reference switch = 1 Home Offset = 2 (SafeMOTION EnDat 2.2 only) Home Offset with Correction = 3 (SafeMOTION EnDat 2.2 only)
USINT	**14**	113	**15**	117	HomingRefSwEdge	Edge of reference switch Negative = 0 Positive = 1
USINT	**15**	114	**16**	118	HomingTriggerDir	Trigger direction Negative = 0 Positive = 1
USINT	**16**	115	Not used		HomingRefPulse	Reference pulse Not Used = 0 Used = 1
USINT	**17**	116	Not used		HomingRemanentSafePos	Remanent safe position Not Used = 0 Used = 1
USINT	**18**	117	Not used		HomingRefPBlock	Blocking distance (% encoder reference system)
USINT	**19**	118	**17**	119	*AlignmentByte3*	*Alignment placeholder. Do not use!*
USINT	**20**	119	Not used		*AlignmentByte4*	*Alignment placeholder. Do not use!*
DINT	**21**	120 .. 123	**18**	120 .. 123	DecelerationRamp	Deceleration Ramp [units/s²]
USINT	**22**	124	**19**	124	UseSMS	Safe Maximum Speed Used = 0 Not Used = 1
USINT	**23**	125	**20**	125	UseAutoResetAtStartup	Automatic Reset at Startup Used = 0 Not Used = 1
USINT	**24**	126	**21**	126	SelectSTO1channel	Channel selection for One Channel STO (STO1) Highside = 0 Lowside = 1
USINT	**25**	127	**22**	127	UseRampMonitoringSS1	Rampmonitoring for SS1 Deactivated = 0 Activated = 1
USINT	**26**	128	**23**	128	UseRampMonitoringSS2	Rampmonitoring for SS2 Deactivated = 0 Activated = 1
USINT	**27**	129	**24**	129	UseRampMonitoringSLS	Rampmonitoring for SLS Deactivated = 0 Activated = 1

Table 131: Data structure of safe machine options, Safety Release 1.9

Data type	EnDat 2.2		SinCos		Name	Constant / Name in SafeDESIGNER
	Index	Byte offset	Index	Byte offset		
USINT	**28**	130	**25**	130	UseEarlyLimitMon	Early Limit Monitoring Deactivated = 0 Activated = 1
USINT	**29**	131	**26**	131	UseSMP	Safe Maximum Position Used = 0 Not Used = 1
USINT	**30**	132	**27**	132	UseEncPosMon	Encoder Position Monitoring Deactivated = 0 Activated = 1
USINT	**31**	133	**28**	133	UseEncSpeedMon	Encoder Speed Monitoring Deactivated = 0 Activated = 1
USINT	**32**	134	**29**	134	UseSetPosAliveTest	Set position alive testing Deactivated = 0 Activated = 1
USINT	**33**	135	**30**	135	FuncFailSafeMode	Behavior of Functional Fail Safe STO = 0 STO1 and STO with time delay = 1
DINT	**34**	136 .. 139	**31**	136 .. 139	FuncFailSafeDelaySTO	Delay for STO in Functional Fail Safe [µs]
DINT	**35**	140 .. 143	**32**	140 .. 143	FuncFailSafeDelayBrk	Delay time until the brake engages [µs]
DINT	**36**	144 .. 147	**33**	144 .. 147	AccelerationLimPos	Safe acceleration limit for SLA (units/s²) in pos. direction
DINT	**37**	148 .. 151	**34**	148 .. 151	DecelerationLimPos	Safe deceleration limit for SLA (units/s²) in pos. direction
DINT	**38**	152 .. 155	**35**	152 .. 155	AccelerationLimNeg	Safe acceleration limit for SLA (units/s²) in neg. direction
DINT	**39**	156 .. 159	**36**	156 .. 159	DecelerationLimNeg	Safe deceleration limit for SLA (units/s²) in neg. direction
DINT	**40**	160 .. 163	**37**	160 .. 163	SpeedLimitSMS	Maximum speed
DINT	**41**	164 .. 167	**38**	164 .. 167	SpeedLimitSLS1	Safe Speedlimit 1 for SLS
DINT	**42**	168 .. 171	**39**	168 .. 171	SpeedLimitSLS2	Safe Speedlimit 2 for SLS
DINT	**43**	172 .. 175	**40**	172 .. 175	SpeedLimitSLS3	Safe Speedlimit 3 for SLS
DINT	**44**	176 .. 179	**41**	176 .. 179	SpeedLimitSLS4	Safe Speedlimit 4 for SLS
DINT	**45**	180 .. 183	**42**	180 .. 183	PosLimitMinSMP	Safe Lower Position Limit for SMP (units)
DINT	**46**	184 .. 187	**43**	184 .. 187	PosLimitMaxSMP	Safe Upper Position Limit for SMP (units)
DINT	**47**	188 .. 191	**44**	188 .. 191	PosLimitMinSLP	Safe Lower Position Limit for SLP (units)
DINT	**48**	192 .. 195	**45**	192 .. 195	PosLimitMaxSLP	Safe Upper Position Limit for SLP (units)
DINT	**49**	196 .. 199	**46**	196 .. 199	SpeedTolerance	Speed Tolerance (units/s)
DINT	**50**	200 .. 203	**47**	200 .. 203	PositionTolerance	Position Tolerance (units)
DINT	**51**	204 .. 207	**48**	204 .. 207	SliPositionWindow	Safe Increments (units)
DINT	**52**	208 .. 211	**49**	208 .. 211	SliToffDelay	SLI Off Delay (µs)
DINT	**53**	212 .. 215	**50**	212 .. 215	RampMonTimeSS1	Ramp Monitoring Time for SS1
DINT	**54**	216 .. 219	**51**	216 .. 219	RampMonTimeSS2	Ramp Monitoring Time for SS2
DINT	**55**	220 .. 223	**52**	220 .. 223	RampMonTimeSLS1	Ramp Monitoring Time for SLS1
DINT	**56**	224 .. 227	**53**	224 .. 227	RampMonTimeSLS2	Ramp Monitoring Time for SLS2
DINT	**57**	228 .. 231	**54**	228 .. 231	RampMonTimeSLS3	Ramp Monitoring Time for SLS3
DINT	**58**	232 .. 235	**55**	232 .. 235	RampMonTimeSLS4	Ramp Monitoring Time for SLS4
DINT	**59**	236 .. 239	**56**	236 .. 239	DelayRampMonitoring	Delay time to start ramp monitoring (µs)
DINT	**60**	240 .. 243	**57**	240 .. 243	DelaySDI	Delay time to start SDI (µs)
DINT	**61**	244 .. 247	**58**	244 .. 247	DelaySBC	Delay time to start SBC (µs)
DINT	**62**	248 .. 251	**59**	248 .. 251	DelaySLP	Delay time to start SLP (µs)
DINT	Not used		**60**	252 .. 255	DelaySBT	Delay time to start SBT (µs)
DINT	**63**	252 .. 255	**61**	256 .. 259	DelaySLA	Delay time to start SLA (us)
DINT	**64**	256 .. 259	**62**	260 .. 263	EarlyLimitMonTime	Early Limit Monitoring time (µs)
DINT	**65**	260 .. 263	**63**	264 .. 267	EncMonitoringPosTol	Encoder Monitoring Position Tolerance (units)
DINT	**66**	264 .. 267	**64**	268 .. 271	EncMonitoringSpeedTol	Encoder Monitoring Speed Tolerance (units/s)
DINT	Not used		**65**	272 .. 275	SbtInterval	Safe Brake Test interval (s)
DINT	Not used		**66**	276 .. 279	SbtTreshold	Safe Brake Test threshold (uA)
DINT	Not used		**67**	280 .. 283	SbtExternalLoad	Safe Brake Test external load (uA)
DINT	Not used		**68**	284 .. 287	SbtDuration	Safe Brake Test maximum torque duration (us)
DINT	Not used		**69**	288 .. 291	SbtPositionTolerance	Safe Brake Test position tolerance (units)

Table 131: Data structure of safe machine options, Safety Release 1.9

In order for the SafeMOTION module to interpret and verify the data correctly, information regarding module type, size and version must be entered in the structure. The structure elements "StructInfoAxisTypeID", "StructInfoSize" and "StructInfoVersion" are provided for this purpose.

For these structure elements, the correct values must be entered for the module type and structure version being used.

Variable	ACOPOSmulti SafeMOTION EnDat 2.2	ACOPOSmulti SafeMOTION SinCos
StructInfoAxisTypeID	1	2
StructInfoSize	196	220
StructInfoVersion	4	5

Danger!

Entering the wrong values will cause the data to be interpreted incorrectly and may result in dangerous situations when using the SafeMOTION module.

5 LED status indicators

see "Status indicators" on page 21

6 ACOPOSmulti SafeMOTION - Register description

6.1 Parameters in the I/O configuration of the SafeMOTION module

Group: Function model

Parameter	Unit	Description	Default value
Function model	---	This parameter is reserved for future functional expansions.	Default

Table 132: SafeMOTION I/O configuration parameters: Function model

Group: General

<table>
<tr><th>Parameter</th><th>Unit</th><th>Description</th><th>Default value</th></tr>
<tr><td>Module supervised</td><td>on/off</td><td>System behavior when a module is missing
<table><tr><th>Parameter value</th><th>Description</th></tr><tr><td>On</td><td>A missing module causes service mode to be activated.</td></tr><tr><td>Off</td><td>A missing module is ignored.</td></tr></table></td><td>Off</td></tr>
<tr><td>SafeLOGIC ID</td><td>---</td><td>In applications with multiple SafeLOGIC controllers, this parameter specifies the SafeMOTION module's association with a particular SafeLOGIC controller.
• Permissible values: 1 - 1024</td><td>Assigned automatically</td></tr>
<tr><td>SafeMODULE ID</td><td>---</td><td>This parameter is reserved for future functional expansions.</td><td>Assigned automatically</td></tr>
</table>

Table 133: SafeMOTION I/O configuration parameters: General

Group: Extended

Parameter	Unit	Description	Default value
Turn-off delay in μs	[μs]	This parameter defines the delay before the SafeMOTION module should turn off if POWERLINK communication is lost.	0

Table 134: SafeMOTION I/O configuration parameters: Extended

Group: Encoder

<table>
<tr><th>Parameter</th><th>Unit</th><th>Description</th><th>Default value</th></tr>
<tr><td>Encoder model</td><td>-</td><td>Selects the encoder system and corresponding parameters
<table><tr><th>Parameter value</th><th>Description</th></tr><tr><td>EnDat 2.1 encoder</td><td>Configuration for an EnDat 2.1 encoder</td></tr><tr><td>SSI absolute encoder</td><td>Configuration for an SSI absolute encoder
• Encoder scale: Increments per encoder revolution
• SSI number of leading zeros
• SSI number of data bits
• SSI data coding
• SSI parity check
• Baud rate [kbaud]</td></tr><tr><td>SSI sinusoidal encoder</td><td>Configuration for an SSI sinusoidal encoder
• Encoder scale: Increments per encoder revolution
• SSI number of leading zeros
• SSI number of data bits
• SSI data coding
• Serial resolution per sine period
• Phasing of the serial position
• Baud rate [kbaud]</td></tr><tr><td>Sine encoder</td><td>Configuration for a sinusoidal encoder
• Encoder scale: Increments per encoder revolution</td></tr><tr><td>Sinusoidal encoder with DCM</td><td>Configuration for a sinusoidal encoder
• Encoder scale: Increments per encoder revolution
• DCM general distance [pulses]
• DCM distance difference [pulses]</td></tr></table></td><td>EnDat 2.1 encoder</td></tr>
</table>

Table 135: SafeMOTION I/O configuration parameters: Encoder (ACOPOSmulti SafeMOTION SinCos only)

6.2 SafeDESIGNER parameters

Group: Basic

<table>
<tr><th>Parameter</th><th>Unit</th><th>Description</th><th>Default value</th><th>Starting in Safety Release</th></tr>
<tr><td>Min_required_FW_Rev</td><td>Basic Release/
Test Version</td><td>This parameter is reserved for future functional expansions.</td><td>Basic release</td><td>R 1.3</td></tr>
<tr><td>Optional</td><td>No /
Yes /
Startup</td><td>This parameter can be used to configure the module as "optional". Optional modules do not have to be present, i.e. the SafeLOGIC controller will not indicate that these modules are not present. However, this parameter does not influence the module's signal or status data.
<table>
<tr><th>Value</th><th>Description</th></tr>
<tr><td>No</td><td>This module is absolutely necessary for the application.
The module has to go to OPERATIONAL mode after startup and safe communication to the SafeLOGIC device must be properly established (SafeModulOk = SAFETRUE).
Processing of the safe application on the SafeLOGIC controller is delayed after startup until this state is achieved for all modules with "Optional = No".
After startup, module problems are indicated by a quickly blinking MXCHG LED on the SafeLOGIC controller. An entry is also made in the logbook.</td></tr>
<tr><td>Yes</td><td>This module is not necessary for the application.
The module is not taken into consideration during startup, which means the safety application is started regardless of whether the modules with "Optional = Yes" are in OPERATIONAL mode or if safe communication is properly established between these modules and the SafeLOGIC controller.
After startup, module problems are NOT indicated by a quickly blinking MXCHG LED on the SafeLOGIC controller. An entry is NOT made in the logbook.</td></tr>
<tr><td>Startup</td><td>This module is optional; the system determines how the module will proceed during startup.
If it is determined that the module is physically present during startup (regardless of whether it is in OPERATIONAL mode or not), then the module behaves as if "Optional = No" is set.
If it is determined that the module is not physically present during startup, then the module behaves as if "Optional = Yes" is set.</td></tr>
</table></td><td>No</td><td>R 1.3</td></tr>
<tr><td>External_UDID</td><td>No /
Yes-ATTENTION</td><td>This parameter enables the option on the module for the expected UDID to be specified externally by the CPU.
<table>
<tr><th>Value</th><th>Description</th></tr>
<tr><td>Yes-ATTENTION</td><td>The UDID is determined by the CPU. The SafeLOGIC controller must be restarted when the UDID is changed.</td></tr>
<tr><td>No</td><td>The UDID is specified by a teach-in procedure during startup.</td></tr>
</table></td><td>No</td><td>R 1.3</td></tr>
</table>

Table 136: SafeMOTION parameter group: Basic

Danger!

If the "External_UDID = Yes-ATTENTION" option is used, incorrect specifications from the CPU can lead to safety-critical situations.
Perform an FMEA (Failure Mode and Effects Analysis) in order to detect these situations and implement additional safety measures to handle them.

Group: Safety_Response_Time

<table>
<tr><th>Parameter</th><th>Unit</th><th>Description</th><th>Default value</th><th>Starting in Safety Release</th></tr>
<tr><td>Manual_Configuration</td><td>Yes / No</td><td>This parameter makes it possible to manually and individually configure the safety response time for the module.
The parameters for safety response time are generally configured in the same way for all stations involved in the application. This is why these parameters are configured for the SafeLOGIC controller in SafeDESIGNER. For application situations in which individual safety functions require optimal response time behavior, the parameters for the safety response time can be configured individually on the respective module.
<table>
<tr><th>Value</th><th>Description</th></tr>
<tr><td>Yes</td><td>The parameters used to calculate the safe response time are taken from the module's "Safety_Response_Time" group.</td></tr>
<tr><td>No</td><td>The parameters used to calculate the safety response time are taken from the "Safety_Response_Time" group on the SafeLOGIC controller.</td></tr>
</table></td><td>No</td><td>R 1.3</td></tr>
<tr><td>Synchronous_Network_Only</td><td>Yes / No</td><td>This parameter determines the synchronization characteristics of the network being used.
<table>
<tr><th>Value</th><th>Description</th></tr>
<tr><td>Yes</td><td>In order to calculate the safety response time, networks must be synchronous and their cycle times must either be the same or an integer ratio of the cycle times.</td></tr>
<tr><td>No</td><td>No requirement for synchronization of the networks.</td></tr>
</table></td><td>Yes</td><td>R 1.3</td></tr>
<tr><td>Max_X2X_CycleTime_us</td><td>[µs]</td><td>This parameter corresponds to the maximum duration of communication between the SafeMOTION module and the POWERLINK interface.
• Permissible values: 200 - 30,000 µs</td><td>1600</td><td>R 1.3</td></tr>
<tr><td>Max_Powerlink_CycleTime_us</td><td>[µs]</td><td>This parameter specifies the maximum POWERLINK cycle time used to calculate the safety response time.
• Permissible values: 200 - 30,000 µs</td><td>5000</td><td>R 1.3</td></tr>
<tr><td>Max_CPU_CrossLinkTask_CycleTime_us</td><td>[µs]</td><td>This parameter specifies the maximum cycle time for the copy task on the CPU used to calculate the safety response time. A value of 0 indicates that a copy task is not included for the response time.
• Permissible values: 0 - 30,000 µs</td><td>5000</td><td>R 1.3</td></tr>
<tr><td>Min_X2X_CycleTime_us</td><td>[µs]</td><td>This parameter corresponds with the minimum duration of communication between the SafeMOTION module and the POWERLINK interface.
• Permissible values: 200 - 30,000 µs</td><td>600</td><td>R 1.3</td></tr>
<tr><td>Min_Powerlink_CycleTime_us</td><td>[µs]</td><td>This parameter specifies the minimum POWERLINK cycle time used to calculate the safety response time.
• Permissible values: 200 - 30,000 µs</td><td>200</td><td>R 1.3</td></tr>
<tr><td>Min_CPU_CrossLinkTask_CycleTime_us</td><td>[µs]</td><td>This parameter specifies the minimum cycle time for the copy task on the CPU used to calculate the safety response time. A value of 0 indicates that configurations without a copy task are also included for the response time.
• Permissible values: 0 - 30,000 µs</td><td>0</td><td>R 1.3</td></tr>
<tr><td>Worst_Case_Response_Time_us</td><td>[µs]</td><td>This parameter specifies the limit value for monitoring the safety response time.
• Permissible values: 3000 - 50,000 µs</td><td>50000</td><td>R 1.3</td></tr>
</table>

Table 137: SafeMOTION parameter group: Safety_Response_Time

Group: Additional Parameter

Parameter	Unit	Description	Default value	Starting in Safety Release
Activate safe machine options	Deactivated/ Activated	Activates/Deactivates the "Safe machine options" safety function	Deactivated	R 1.9

Table 138: SafeMOTION parameter group: Additional Parameter

Group: Encoder Unit System

<table>
<tr><th>Parameter</th><th>Unit</th><th>Description</th><th>Default value</th><th>Starting in Safety Release</th></tr>
<tr><td>Encoder Type</td><td>Rotary encoder /
Linear encoder /
Encoder used /
Encoder not used</td><td>Determines the type of encoder used:
ACOPOSmulti SafeMOTION SinCos (Safety Release 1.7 or higher)
Rotary encoder: Rotary encoder
Linear encoder: Linear encoder
Encoder not used: No encoder being used
ACOPOSmulti SafeMOTION EnDat 2.2 (Safety Release 1.9 or higher)
Encoder used: Rotary encoder used
Encoder not used: No encoder being used</td><td>Rotary encoder (SinCos)

Encoder used (EnDat 2.2)</td><td>R 1.7

R 1.9</td></tr>
<tr><td>Number of signal periods</td><td>-</td><td>Number of signal periods per revolution (rotary encoder) or length of the physical reference system (linear encoder)</td><td>1</td><td>R 1.7</td></tr>
<tr><td>Count of physical reference system</td><td>---</td><td>Rotary encoder unit scale: x revolutions
Linear encoder unit scale: x reference lengths (reference length = length of the physical reference system)

Any unit (mm, 1/100 mm, 1/20 inch, degree of angle, etc.) can be used for positions (and data which can result such as speed and acceleration). For this reason, the relationship between an integer multiple of this unit (units per x revolutions / units per x reference lengths) and a certain number of x revolutions / x reference lengths has to be previously defined.</td><td>1</td><td>R 1.4</td></tr>
<tr><td>Units per count of physical reference system [units]</td><td>[units]</td><td>Rotary encoder unit-scale: Units per x revolutions
Linear encoder unit scale: Units per x reference lengths

Any unit (mm, 1/100 mm, 1/20 inch, degree of angle, etc.) can be used for positions (and data which can result such as speed and acceleration). For this reason, the relationship between an integer multiple of this unit (units per x revolutions / units per x reference lengths) and a certain number of x revolutions / x reference lengths has to be previously defined.</td><td>1000</td><td>R 1.4</td></tr>
<tr><td>Counting direction</td><td>Standard /
Inverse</td><td>Counting direction of the position or speed<table><tr><th>Value</th><th>Description</th></tr><tr><td>Standard</td><td>Encoder counting direction is equal to the counting direction of the unit system.</td></tr><tr><td>Inverse</td><td>Encoder counting direction is negative to the counting direction of the unit system.</td></tr></table></td><td>Standard</td><td>R 1.3</td></tr>
<tr><td>Length of physical reference system for linear encoder (nm)</td><td>[nm]</td><td>For linear measurement systems, the length of a physical reference system is defined here.
This value is not used for rotary encoders, where the reference system is a single revolution.</td><td>1000000000</td><td>R 1.4</td></tr>
<tr><td>Maximum speed to normalize the speed range (units/s)</td><td>[units/s]</td><td>Maximum speed to which the displayed speed should be normalized</td><td>32767</td><td>R 1.3</td></tr>
<tr><td>Maximum acceleration (rad/s² or mm/s²)</td><td>[rad/s²] or [mm/s²]</td><td>Maximum permissible encoder acceleration</td><td>100000</td><td>R 1.4</td></tr>
</table>

Table 139: SafeMOTION parameter group: Encoder Unit System

Information:

The physical drive speed is not permitted to exceed the value set for the "Maximum speed to normalize the speed range (units/s)" parameter; otherwise, the SafeMOTION module will switch to the error state!

Danger!

If the manufacturer of the measuring instrument specifies a limitation of the maximum acceleration, this must be monitored by the SafeMOTION module. The acceleration to be monitored can be configured using the "Maximum acceleration" parameter.

Danger!

Incorrectly configuring the unit system can result in dangerous situations.
When validating the application, the monitored speed limits must be intentionally violated and their physical values tested! The same must also be done for the monitored direction of rotation!

Group: Homing

Parameter	Unit	Description	Default value	Starting in Safety Release
Home Position or Home Offset (units)	[units]	Home position or home offset	0	R 1.4
Max. trigger speed (units/s)	[units/s]	Maximum permissible speed for evaluating the reference switch / reference pulse	0	R 1.4
Homing Monitoring Time (µs)	[µs]	Monitoring time for the homing procedure	0	R 1.4
Mode	Direct / Reference Switch / *Home Offset /* *Home Offset with Correction*	Selects the homing mode *The modes "Home Offset" and "Home Offset with Correction" are only available for the ACOPOSmulti SafeMOTION EnDat 2.2!*	Direct	R 1.4
Edge of reference switch	Positive / Negative	Selects the switching edge for the reference switch The switching edge for the reference switch input is positive if the logical state of the reference switch changes from SAFEFALSE to SAFETRUE in the positive direction of movement.	Positive	R 1.4
Trigger direction	Positive / Negative	Selects the trigger direction If the homing procedure requires a movement, then this parameter specifies the direction for evaluating the reference switch / reference pulse.	Positive	R 1.4
Reference pulse	*Used /* *Not Used*	*Selects whether or not to use a reference pulse for homing* *This parameter is only available for the ACOPOSmulti SafeMOTION EnDat 2.2.*	*Not Used*	R 1.4
Remanent safe position	*Used /* *Not Used*	*Selects whether or not to use the remanent safe position* *This parameter is only available for the ACOPOSmulti SafeMOTION EnDat 2.2.*	*Not Used*	R 1.9
Blocking distance (% encoder reference system)	*%*	*Distance within which evaluation of the reference pulse will be suppressed.* *This is calculated starting at the configured reference switch edge and indicated as a percentage of the encoder reference system.* *A single revolution is used as the encoder reference system for rotary encoders.* *This parameter is only available for the ACOPOSmulti SafeMOTION EnDat 2.2.*	*0*	R 1.4

Table 140: SafeMOTION parameter group: Homing

Group: Safety Deceleration Ramp

Parameter	Unit	Description	Default value	Starting in Safety Release
Deceleration Ramp [units/s²]	[units/s²]	Slope of the deceleration ramp to be monitored	1073676289	R 1.3

Table 141: SafeMOTION parameter group: Safety Deceleration Ramp

Group: General Settings

<table>
<tr><th>Parameter</th><th>Unit</th><th>Description</th><th>Default value</th><th>Starting in Safety Release</th></tr>
<tr><td>Safe Maximum Speed</td><td>Used /
Unused</td><td>Activates the SMS safety function by configuration<table><tr><th>Value</th><th>Description</th></tr><tr><td>Used</td><td>SMS activated</td></tr><tr><td>Unused</td><td>SMS deactivated</td></tr></table></td><td>Used</td><td>R 1.3</td></tr>
<tr><td>Automatic Reset at Startup</td><td>Used /
Unused</td><td>Activates automatic reset of the function block at startup<table><tr><th>Value</th><th>Description</th></tr><tr><td>Used</td><td>After starting up, the module automatically switches to the OPERATIONAL state (Startreset). The Reset input does not have to be enabled!</td></tr><tr><td>Unused</td><td>After startup, the module remains in an Init state until a rising edge of the Reset input is detected.</td></tr></table></td><td>Unused</td><td>R 1.3</td></tr>
<tr><td>Channel selection for One Channel STO (STO1)</td><td>HighSide/
LowSide</td><td>Selects the HighSide or LowSide IGBT in the one channel STO function<table><tr><th>Value</th><th>Description</th></tr><tr><td>HighSide</td><td>The HighSide IGBTs are actuated with the function STO1.</td></tr><tr><td>LowSide</td><td>The LowSide IGBTs are actuated with the function STO1.</td></tr></table></td><td>HighSide</td><td>R 1.3</td></tr>
<tr><td>Rampmonitoring for SS1</td><td>Activated/
Deactivated</td><td>Activates ramp-based monitoring (in addition to time-based monitoring) when the SS1 function is requested<table><tr><th>Value</th><th>Description</th></tr><tr><td>Activated</td><td>When transitioning to the safe state of the SS1 function, a deceleration ramp is monitored in addition to the configurable time.</td></tr><tr><td>Deactivated</td><td>When transitioning to the safe state of the SS1 function, only a configurable time is monitored.</td></tr></table></td><td>Activated</td><td>R 1.3</td></tr>
</table>

Table 142: SafeMOTION parameter group: General Settings

<table>
<tr><th>Parameter</th><th>Unit</th><th>Description</th><th>Default value</th><th>Starting in Safety Release</th></tr>
<tr><td>Rampmonitoring for SS2</td><td>Activated/
Deactivated</td><td>Activates ramp monitoring (in addition to time-based monitoring) when the SS2 function is requested
<table>
<tr><th>Value</th><th>Description</th></tr>
<tr><td>Activated</td><td>When changing to the safe state of the SS2 function, a deceleration ramp is also monitored, in addition to the configurable time</td></tr>
<tr><td>Deactivated</td><td>When changing to the safe state of the SS2 function, only a configurable time is monitored</td></tr>
</table></td><td>Activated</td><td>R 1.3</td></tr>
<tr><td>Rampmonitoring for SLS</td><td>Activated/
Deactivated</td><td>Activates ramp-based monitoring (in addition to time-based monitoring) when the SLS function is requested
<table>
<tr><th>Value</th><th>Description</th></tr>
<tr><td>Activated</td><td>When changing to the safe state of the SLS function, a deceleration ramp is also monitored, in addition to the configurable time</td></tr>
<tr><td>Deactivated</td><td>When changing to the safe state of the SLS function, only a configurable time is monitored</td></tr>
</table></td><td>Activated</td><td>R 1.3</td></tr>
<tr><td>Early Limit Monitoring</td><td>Activated/
Deactivated</td><td>Deceleration ramp monitoring is terminated prematurely if the value falls below the lower limit
"Early Limit Monitoring": If the current speed during the deceleration process falls below the end speed limit of the activated safety function for a defined amount of time, then the safe state of the respective function will be activated prematurely.
<table>
<tr><th>Value</th><th>Description</th></tr>
<tr><td>Activated</td><td>"Early Limit Monitoring" is active!</td></tr>
<tr><td>Deactivated</td><td>"Early Limit Monitoring" is not active!</td></tr>
</table></td><td>Deactivated</td><td>R 1.3</td></tr>
<tr><td>Safe Maximum Position</td><td>Used /
Unused</td><td>Activates the SMP safety function from the configuration
<table>
<tr><th>Value</th><th>Description</th></tr>
<tr><td>Used</td><td>SMP is activated</td></tr>
<tr><td>Unused</td><td>SMP is deactivated</td></tr>
</table></td><td>Unused</td><td>R 1.4</td></tr>
</table>

Table 142: SafeMOTION parameter group: General Settings

Danger!

The "Automatic Reset at Startup" parameter activates/deactivates the restart inhibit during startup or when a network failure occurs.

If the "Automatic Reset at Startup" parameter is set to "Used", then the module automatically switches to the OPERATIONAL state (i.e. pulse disabling and the motor holding brake are enabled)!

Configuring an automatic restart can result in critical situations in relation to safety. Implement additional measures to ensure proper safety-related functionality!

Group: Encoder Monitoring

<table>
<tr><th>Parameter</th><th>Unit</th><th>Description</th><th>Default value</th><th>Starting in Safety Release</th></tr>
<tr><td>Encoder Position Monitoring</td><td>Activated /
Deactivated</td><td>Activates/Deactivates monitoring of the position lag error generated on the SafeMOTION module
<table>
<tr><th>Value</th><th>Description</th></tr>
<tr><td>Activated</td><td>Monitoring active</td></tr>
<tr><td>Deactivated</td><td>Monitoring not active</td></tr>
</table></td><td>Activated</td><td>R 1.3</td></tr>
<tr><td>Encoder Speed Monitoring</td><td>Activated /
Deactivated</td><td>Activates/Deactivates monitoring of the speed error generated on the SafeMOTION module
<table>
<tr><th>Value</th><th>Description</th></tr>
<tr><td>Activated</td><td>Monitoring active</td></tr>
<tr><td>Deactivated</td><td>Monitoring not active</td></tr>
</table></td><td>Activated</td><td>R 1.3</td></tr>
<tr><td>Set position alive testing</td><td>Activated /
Deactivated</td><td>Activates/Deactivates the monitor that detects whether the set position generated on the SafeMOTION module is frozen.
<table>
<tr><th>Value</th><th>Description</th></tr>
<tr><td>Activated</td><td>Monitoring active</td></tr>
<tr><td>Deactivated</td><td>Monitoring not active</td></tr>
</table></td><td>Deactivated</td><td>R 1.3</td></tr>
</table>

Table 143: SafeMOTION parameter group: Encoder Monitoring

Group: Behavior of Functional Fail Safe

<table>
<tr><th>Parameter</th><th>Unit</th><th>Description</th><th>Default value</th><th>Starting in Safety Release</th></tr>
<tr><td>Behavior of Functional Fail Safe</td><td>STO /
STO1 and STO with time delay</td><td>In the FUNCTIONAL FAIL SAFE state, STO and SBC are activated immediately, or STO1 is activated and then STO after a delay.<table><tr><th>Value</th><th>Description</th></tr><tr><td>STO</td><td>In the FUNCTIONAL FAIL SAFE state, STO and SBC are activated immediately.</td></tr><tr><td>STO1 and STO with time delay</td><td>In the FUNCTIONAL FAIL SAFE state, STO1 and SBC are activated first, and then STO after a delay.</td></tr></table></td><td>STO</td><td>R 1.3</td></tr>
<tr><td>Delay for STO in Functional Fail Safe [µs]</td><td>[µs]</td><td>Delay time between STO1 and STO (and SBC) in the FUNCTIONAL FAIL SAFE state</td><td>0</td><td>R 1.3</td></tr>
<tr><td>Delay time until the brake engages [µs]</td><td>[µs]</td><td>Delay time before the brake engages
The second enable channel is activated after this delay time if STO1 and time-delayed STO and SBC are configured for FUNCTIONAL FAIL SAFE.</td><td>0</td><td>R 1.3</td></tr>
</table>

Table 144: SafeMOTION parameter group: Behavior of Functional Fail Safe

Group: Safely Limited Acceleration

Parameter	Unit	Description	Default value	Starting in Safety Release
Safe acceleration limit for SLA (units/s²) in positive direction	[units/s²]	Limit for acceleration in the positive direction of movement	0	R 1.9
Safe deceleration limit for SLA (units/s²) in positive direction	[units/s²]	Limit for deceleration in the positive direction of movement	0	R 1.9
Safe acceleration limit for SLA (units/s²) in negative direction	[units/s²]	Limit for acceleration in the negative direction of movement	0	R 1.9
Safe deceleration limit for SLA (units/s²) in negative direction	[units/s²]	Limit for deceleration in the negative direction of movement	0	R 1.9

Table 145: SafeMOTION parameter group: Safely Limited Acceleration

Group: Safety Speed Limits

Parameter	Unit	Description	Default value	Starting in Safety Release
Maximum Speed for SMS (units/s)	[units/s]	Speed limit of the maximum speed (SMS)	0	R 1.3
Safe Speedlimit 1 for SLS (units/s)	[units/s]	Speed limit 1 for SLS (SLS1)	0	R 1.3
Safe Speedlimit 2 for SLS (units/s)	[units/s]	Speed limit 2 for SLS (SLS2)	0	R 1.3
Safe Speedlimit 3 for SLS (units/s)	[units/s]	Speed limit 3 for SLS (SLS3)	0	R 1.3
Safe Speedlimit 4 for SLS (units/s)	[units/s]	Speed limit 4 for SLS (SLS4)	0	R 1.3

Table 146: SafeMOTION parameter group: Safety Speed Limits

Danger!

The respective monitored speed limit must be set in such a manner that, with consideration for the error response time and the resulting movement in the worst case scenario, a dangerous speed cannot be exceeded in the event of error.

The dangerous speed must be determined by a risk analysis.

Information:

The following application rule must be observed:

$\mathbf{LIM_{SOS} \leq LIM_{SLS4} \leq LIM_{SLS3} \leq LIM_{SLS2} \leq LIM_{SLS1} \leq LIM_{SMS} \leq NormSpeedMax}$

This is required for setting priority of the safety functions on the SafeMOTION module.

If this rule is not adhered to, then the SafeMOTION module immediately switches to the FAIL SAFE state after startup. The application must be set accordingly in SafeDESIGNER!

Group: Safety Position Limits

Parameter	Unit	Description	Default value	Starting in Safety Release
Safe Lower Position Limit for SMP (units)	[units]	Lower position limit for the machine's full range of movement	0	R 1.4
Safe Upper Position Limit for SMP (units)	[units]	Upper position limit for the machine's full range of movement	0	R 1.4
Safe Lower Position Limit for SLP (units)	[units]	Lower position limit for the monitoring range	0	R 1.4
Safe Upper Position Limit for SLP (units)	[units]	Upper position limit for the monitoring range	0	R 1.4

Table 147: SafeMOTION parameter group: Safety Position Limits

Danger!

The position limits being monitored must be set in such a manner that, with consideration for the error response time and the resulting movement in the worst case scenario, a dangerous movement cannot occur in the event of error.

The dangerous movement must be determined by a risk analysis.

Information:

The following application rule must be observed:

$\mathbf{LIM_{SMP,NEG} \leq LIM_{SLP,NEG} \leq LIM_{SLP,POS} \leq LIM_{SMP,POS}}$

If this rule is not adhered to, then the SafeMOTION module immediately switches to the FAIL SAFE state after startup. The application must be set accordingly in SafeDESIGNER!

Group: Safety Standstill and Direction Tolerances

Parameter	Unit	Description	Default value	Starting in Safety Release
Speed Tolerance (units/s)	[units/s]	Speed tolerance for standstill monitoring (SOS)	0	R 1.3
Position Tolerance (units)	[units]	Position tolerance for standstill and direction monitoring	0	R 1.3

Table 148: SafeMOTION parameter group: Safety Standstill and Direction Tolerances

Danger!

The speed limit and position limit being monitored must be set in such a manner that, with consideration for the error response time and the resulting movement in the worst case scenario, a dangerous movement cannot occur in the event of error.

The dangerous movement must be determined by a risk analysis.

Group: Safely Limited Increment

Parameter	Unit	Description	Default value	Starting in Safety Release
Safe Increments (units)	[units]	Maximum movable increments when SLI is active	0	R 1.3
SLI Off Delay (μs)	[μs]	Switch off delay of SLI	0	R 1.3

Table 149: SafeMOTION parameter group: Safely Limited Increment

Danger!

The maximum increment range must be set in such a manner that, with consideration for the error response time and the resulting movement in the worst case scenario, a dangerous movement cannot occur in the event of error.

The dangerous movement must be determined by a risk analysis.

Group: Safety Ramp Monitoring Times

Parameter	Unit	Description	Default value	Starting in Safety Release
Ramp Monitoring Time for SS1 (us)	[µs]	Deceleration ramp monitoring time for SS1	0	R 1.3
Ramp Monitoring Time for SS2 (us)	[µs]	Deceleration ramp monitoring time for SS2	0	R 1.3
Ramp Monitoring Time for SLS1 (us)	[µs]	Deceleration ramp monitoring time for SLS1	0	R 1.3
Ramp Monitoring Time for SLS2 (us)	[µs]	Deceleration ramp monitoring time for SLS2	0	R 1.3
Ramp Monitoring Time for SLS3 (us)	[µs]	Deceleration ramp monitoring time for SLS3	0	R 1.3
Ramp Monitoring Time for SLS4 (us)	[µs]	Deceleration ramp monitoring time for SLS4	0	R 1.3

Table 150: SafeMOTION parameter group: Safety Ramp Monitoring Times

Group: Safety Additional Parameters

Parameter	Unit	Description	Default value	Starting in Safety Release
Delay time to start ramp monitoring (us)	[µs]	Delay time between the request for ramp-based monitoring and the start of monitoring	0	R 1.3
Delay time to start SDI (us)	[µs]	Delay time between the SDI request and activation of the safety function	0	R 1.3
Delay time to start SBC (us)	[µs]	Delay time between the SBC request and activation of the safety function	0	R 1.3
Delay time to start SLP (us)	[µs]	Delay time between the SLP request and start of monitoring	0	R 1.4
Delay Time to start SBT (us)	[µs]	Delay time between the SBT request and activation of the safety function	0	R 1.7
Delay time to start SLA (us)	[µs]	Delay time between the SLA request and activation of the safety function	0	R 1.9
Early Limit Monitoring time (us)	[µs]	Time during which the speed must be below the target speed limit in order to prematurely end the deceleration ramp and to assume the safety function's end state	0	R 1.3

Table 151: SafeMOTION parameter group: Safety Additional Parameters

Danger!

The delay parameters cause a delay before the safety function is started. This delay must be taken into account when determining the intervals and performing the risk analysis!

Group: Encoder Monitoring Tolerances

Parameter	Unit	Description	Default value	Starting in Safety Release
Encoder Monitoring Position Tolerance (units)	[units]	Position lag error tolerance for shaft breakage monitoring	0	R 1.3
Encoder Monitoring Speed Tolerance (units/s)	[units/s]	Speed error tolerance for encoder monitoring	0	R 1.3

Table 152: SafeMOTION parameter group: Encoder Monitoring Tolerances

Group: Safe Brake Test

Parameter	Unit	Description	Default value	Starting in Safety Release
Safe Brake Test interval (s)	[s]	Retry interval for the safe brake test	28800	R 1.7
Safe Brake Test threshold (uA)	[µA]	Threshold value for the stator current that must be exceeded during the brake test	0	R 1.7
Safe Brake Test external load (uA)	[µA]	External load	0	R 1.7
Safe Brake Test maximum torque duration (us)	[µs]	Duration of the test for which the maximum torque must be present	0	R 1.7
Safe Brake Test position tolerance (units)	[units]	Position tolerance	0	R 1.7

Table 153: SafeMOTION parameter group: Safe Brake Test

6.3 Channel list

Channel name	Starting with Safety Release	Access via Automation Studio	Access via SafeDESIGNER	Data type	Description
ModulOK	R 1.3	Read	---	BOOL	Indicates if the module is OK
SerialNumber	R 1.3	Read [1]	---	UDINT	Module serial number
ModuleID	R 1.3	Read [1]	---	UINT	Module code
HardwareVariant	R 1.3	Read [1]	---	UINT	Hardware variant
FirmwareVersion	R 1.3	Read [2]	---	UINT	Module firmware version
UDID_low	R 1.3	(Read) [2]	---	UDINT	UDID, lower 4 bytes
UDID_high	R 1.3	(Read) [2]	---	UINT	UDID, upper 2 bytes
SafetyFWversion1	R 1.3	(Read) [2]	---	UINT	Firmware version of safety processor 1
SafetyFWversion2	R 1.3	(Read) [2]	---	UINT	Firmware version of safety processor 2
Diag1_Temp	R 1.3	(Read) [2]	---	UINT	Module temperature in °C
Diag1_24V	R 1.3	(Read) [2]	---	UINT	Voltage measurement µP1 - 24V
Diag1_3V3	R 1.3	(Read) [2]	---	UINT	Voltage measurement µP1 - 3V3
Diag1_5V	R 1.3	(Read) [2]	---	UINT	Voltage measurement µP1 - 5V
Diag2_24V	R 1.3	(Read) [2]	---	UINT	Voltage measurement µP2 - 24V
Diag2_3V3	R 1.3	(Read) [2]	---	UINT	Voltage measurement µP2 - 3V3
Diag2_5V	R 1.3	(Read) [2]	---	UINT	Voltage measurement µP2 - 5V
SafeModuleOK	R 1.3	---	Read	SAFEBOOL	Indicates if the safe communication channel is OK
SafetyActiveSTO	R 1.3	Read	(Read) [3]	SAFEBOOL	Status of STO safety function (TRUE = safe state)
SafetyActiveSBC	R 1.3	Read	(Read) [3]	SAFEBOOL	Status of SBC safety function (TRUE = safe state)
SafetyActiveSOS	R 1.3	Read	(Read) [3]	SAFEBOOL	Status of SOS safety function (TRUE = safe state)
SafetyActiveSS1	R 1.3	Read	(Read) [3]	SAFEBOOL	Status of SS1 safety function (TRUE = safe state)
SafetyActiveSS2	R 1.3	Read	(Read) [3]	SAFEBOOL	Status of SS2 safety function (TRUE = safe state)
SafetyActiveSLS1	R 1.3	Read	(Read) [3]	SAFEBOOL	Status of SLS1 safety function (TRUE = safe state)
SafetyActiveSLS2	R 1.3	Read	(Read) [3]	SAFEBOOL	Status of SLS2 safety function (TRUE = safe state)
SafetyActiveSLS3	R 1.3	Read	(Read) [3]	SAFEBOOL	Status of SLS3 safety function (TRUE = safe state)
SafetyActiveSL4	R 1.3	Read	(Read) [3]	SAFEBOOL	Status of SLS4 safety function (TRUE = safe state)
SafetyActiveSTO1	R 1.3	Read	(Read) [3]	SAFEBOOL	Status of STO1 safety function (TRUE = safe state)
SafetyActiveSDIpos	R 1.3	Read	(Read) [3]	SAFEBOOL	Status of SDIpos safety function (TRUE = safe state)
SafetyActiveSLI	R 1.3	Read	(Read) [3]	SAFEBOOL	Status of SLI safety function (TRUE = safe state)
SafetyActiveSDIneg	R 1.3	Read	(Read) [3]	SAFEBOOL	Status of SDIneg safety function (TRUE = safe state)
SafetyActiveSLP	R 1.4	Read	(Read) [3]	SAFEBOOL	Status of SLP safety function (TRUE = safe state)
SafetyActiveSMP	R 1.4	Read	(Read) [3]	SAFEBOOL	Status of SMP safety function (TRUE = safe state)
SafePositionValid	R 1.4	Read	(Read) [3]	SAFEBOOL	Status of the safe position (TRUE = valid position referencing and no errors found)
SafetyActiveSLA	R 1.9	Read	(Read) [3]	SAFEBOOL	Status of the SLA safety function (TRUE = safe status)
StatusSetPosAlive	R 1.3	Read	---	SAFEBOOL	Status of position setpoint "Alive Testing" (TRUE = valid)
ReqHomingOK	R 1.9	(Read) [4]	(Read) [3]	SAFEBOOL	Feedback for homing in SafeDESIGNER (TRUE = safe position is valid and request for safe homing is TRUE)
AllReqFuncAct	R 1.3	Read	(Read) [3]	SAFEBOOL	Status of the requested safety functions (TRUE = all requested safety functions are active)
SafetyActiveSDC	R 1.3	Read	(Read) [3]	SAFEBOOL	Status of the delay monitor (TRUE = delay monitoring is active)
Operational	R 1.3	Read	---	SAFEBOOL	Status of the function block (TRUE = function block is in the state OPERATIONAL, SAFE or WAIT FOR CONFIRMATION)
NotErrENC	R 1.3	Read	(Read) [3]	SAFEBOOL	Status of the safe encoder (FALSE = pending encoder error)
NotErrFUNC	R 1.3	Read	(Read) [3]	SAFEBOOL	Status of the SafeMOTION module (FALSE = SafeMOTION module is in the FUNCTIONAL FAIL SAFE error state)
ScaledSpeed	R 1.3	Read	(Read) [3]	SAFEINT	Safe scaled speed
SafePos	R 1.4	Read	(Read) [3]	SAFEDINT	Safe position
SafetyActiveSBT	R 1.7	Read	(Read) [3]	SAFEBOOL	SBT Active bit (TRUE = active)
SafetyStatusSBT	R 1.7	Read	(Read) [3]	SAFEBOOL	SBT Status bit (TRUE = valid)
RSPValid	R 1.9	Read	(Read) [3]	SAFEBOOL	Remanent safe position is validated and saved (TRUE = safe position is saved, Power Off for homing with RSP is possible)

Table 154: SafeMOTION channel list

Channel name	Starting with Safety Release	Access via Automation Studio	Access via SafeDESIGNER	Data type	Description
RequestSTO	R 1.3	(Read) [4]	(Write) [5]	SAFEBOOL	Selects/Deselects the STO safety function
RequestSBC	R 1.3	(Read) [4]	(Write) [5]	SAFEBOOL	Selects/Deselects the SBC safety function
RequestSOS	R 1.3	(Read) [4]	(Write) [5]	SAFEBOOL	Selects/Deselects the SOS safety function
RequestSS1	R 1.3	(Read) [4]	(Write) [5]	SAFEBOOL	Selects/Deselects the SS1 safety function
RequestSS2	R 1.3	(Read) [4]	(Write) [5]	SAFEBOOL	Selects/Deselects the SS2 safety function
RequestSLS1	R 1.3	(Read) [4]	(Write) [5]	SAFEBOOL	Selects/Deselects the SLS1 safety function
RequestSLS2	R 1.3	(Read) [4]	(Write) [5]	SAFEBOOL	Selects/Deselects the SLS2 safety function
RequestSLS3	R 1.3	(Read) [4]	(Write) [5]	SAFEBOOL	Selects/Deselects the SLS3 safety function
RequestSLS4	R 1.3	(Read) [4]	(Write) [5]	SAFEBOOL	Selects/Deselects the SLS4 safety function
RequestSTO1	R 1.3	(Read) [4]	(Write) [5]	SAFEBOOL	Selects/Deselects the STO1 safety function
RequestSDIpos	R 1.3	(Read) [4]	(Write) [5]	SAFEBOOL	Selects/Deselects the SDIpos safety function
RequestSLI	R 1.3	(Read) [4]	(Write) [5]	SAFEBOOL	Selects/Deselects the SLI safety function
RequestSDIneg	R 1.3	(Read) [4]	(Write) [5]	SAFEBOOL	Selects/Deselects the SDIneg safety function
RequestSLP	R 1.4	(Read) [4]	(Write) [5]	SAFEBOOL	Selects/Deselects the SLP safety function
RequestHoming	R 1.4	(Read) [4]	(Write) [5]	SAFEBOOL	Requests safe homing
ReferenceSwitch	R 1.4	(Read) [4]	(Write) [5]	SAFEBOOL	Safe input for using a reference switch
RequestSBT	R 1.7	(Read) [4]	(Write) [5]	SAFEBOOL	SBT Control Bit
RequestSLA	R 1.9	(Read) [4]	(Write) [5]	SAFEBOOL	Selects/Deselects the SLA safety function
SwitchHomingMode	R 1.9	(Read) [4]	(Write) [5]	SAFEBOOL	Activates homing with RSP (TRUE = RSP homing mode is active)
Activate	R 1.3	(Read) [4]	(Write) [5]	SAFEBOOL	Enables the function block
Reset	R 1.3	(Read) [4]	(Write) [5]	SAFEBOOL	Reset input to acknowledge the FUNCTIONAL FAIL SAFE state

Table 154: SafeMOTION channel list

1) Channel only visible if the "*Module Information*" parameter has been set to "on".
2) This data is accessed in Automation Studio using the ASIOACC library.
3) This data is accessed indirectly via the outputs of the function blocks SF_SafeMC_BR, SF_SafeMC_BR_V2, SF_SafeMC_Speed_BR, SF_SafeMC_Position_BR or SF_SafeMC_Position_BR_V2.
4) This data can be accessed via NC Action or Trace.
5) This data is accessed indirectly via the inputs of the function blocks SF_SafeMC_BR, SF_SafeMC_BR_V2 or SF_SafeMC_BR_V3.

7 Configuring the safety functions

The concept of integrated safety technology in the ACOPOSmulti SafeMOTION inverter module is based on keeping all functional control in the inverter module, with the SafeMOTION module dedicated to monitoring configurable limits.

The only exception is that the SafeMOTION module activates safe pulse disabling and the safe motor holding brake.

The standard application must react accordingly to the request for a safety function.

To ensure proper interaction between the standard and the safety application (and thereby ensuring maximum availability of the system), the different timing of the two applications must be taken into account.

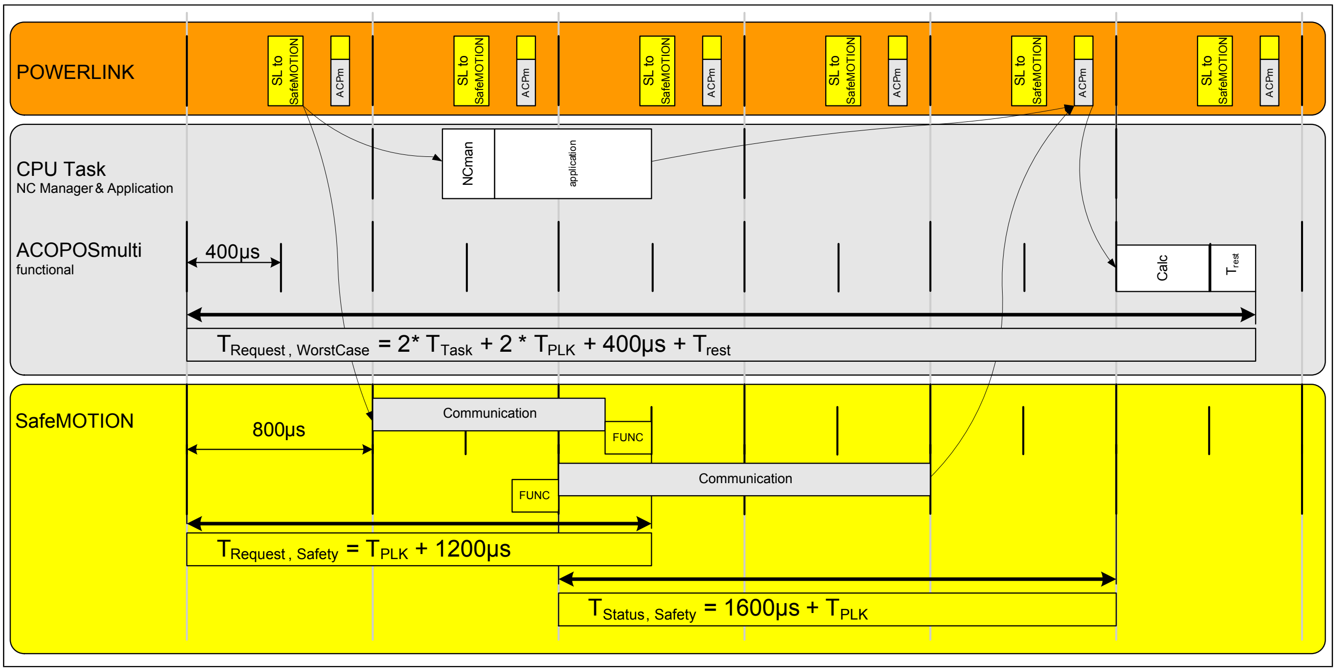


Figure 56: Inverter module timing - SafeMOTION module

The differing runtimes of the standard and the safety application can be taken into account with the "Delay times for requesting a safety function" parameters.

Parameter	Unit	Description	Default value
Delay time to start ramp monitoring (us)	[µs]	Delay time between the request for ramp-based monitoring and the start of monitoring	0
Delay time to start SDI (us)	[µs]	Delay time between the SDI request and activation of the safety function	0
Delay time to start SBC (us)	[µs]	Delay time between the SBC request and activation of the safety function	0
Delay time to start SLP (us) [1]	[µs]	Delay time between the SLP request and start of monitoring	0
Delay Time to start SBT (us) [2]	[µs]	Delay time between the SBT request and activation of the safety function	0
Delay Time to start SLA (us) [3]	[µs]	Delay time between the SLA request and activation of the safety function	0

Table 155: Delay times for requesting a safety function

1) Only available with Safety Release 1.4 or higher!
2) Only available with Safety Release 1.7 or higher and only for ACOPOSmulti SafeMOTION SinCos!
3) Only available with Safety Release 1.9 or higher!

7.1 SafeMOTION Help Tool

The SafeMOTION Help Tool assists in the development of SafeMOTION projects. This program can be used to make calculations that are required frequently.

7.1.1 "Status and Control Bits" tab

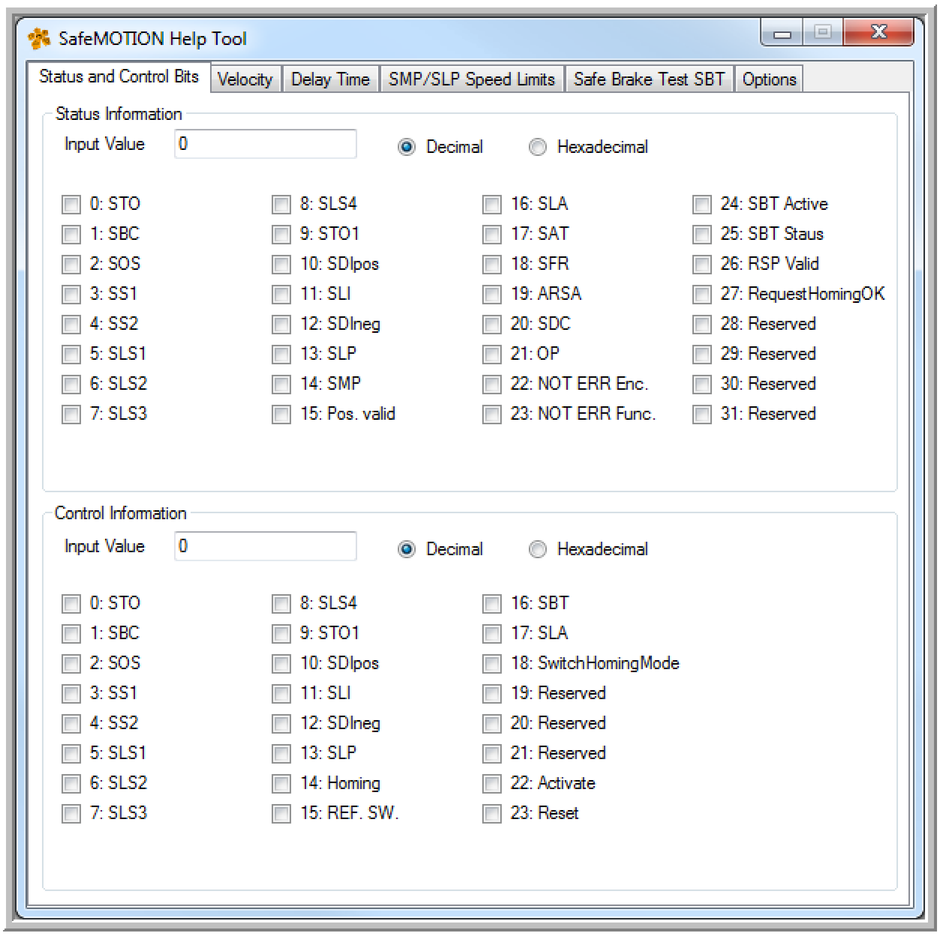


Figure 57: SafeMOTION Help Tool - "Status and Control Bits" tab

"Status Information" section

Information:

Status information can be determined by running a trace on the cyclic data (ParID 4).

<u>Showing status bits for the status information that has been determined</u>

1. Specify whether the value that has been determined for the status information is decimal or hexadecimal.
2. Enter the value that has been determined in the *Input value* field.
   → The checkboxes now show the status bits for the determined status information.

<u>Determining the input value for a combination of status bits</u>

1. Specify whether the input value should be displayed as a decimal or hexadecimal value.
2. Set the desired combination of status bits by selecting the checkboxes.
   → The input value that corresponds with the combination of status bits is shown.

"Control Information" section

Information:

Control information can be determined by running a trace on the cyclic data (ParID 5).

Showing status bits for the control information that has been determined

1. Specify whether the value that has been determined for the control information is decimal or hexadecimal.
2. Enter the value that has been determined in the *Input value* field.
   → The check boxes now show the control bits for the determined control information.

Determining the input value for a combination of control bits

1. Specify whether the input value should be displayed as a decimal or hexadecimal value.
2. Set the desired combination of control bits by selecting the check boxes.
   → The input value that corresponds with the combination of control bits is shown.

7.1.2 "Velocity" tab

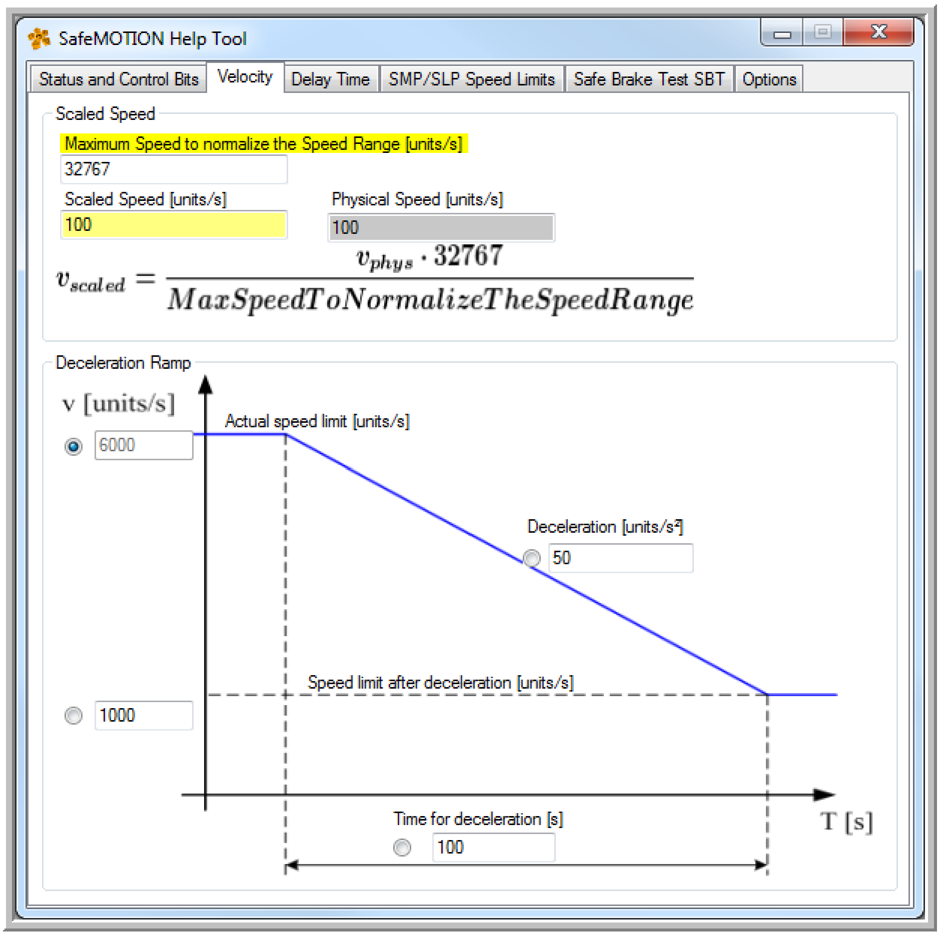


Figure 58: SafeMOTION Help Tool - "Velocity" tab

"Scaled Speed" section

In the *Scaled Speed* section, a scaled speed can be converted to a physical speed [units/s] and back again based on the "Maximum speed to normalize the speed range [units/s]" value.

Parameter names marked in yellow correspond to parameters in SafeDESIGNER.

Scaled → physical speed conversion

1. Enter the value for "Maximum speed to normalize the speed range [units/s]".
2. Enter the value for the scaled speed [units/s].
→ The respective value for the physical speed [units/s] is shown.

Physical → scaled speed conversion

1. Enter the value for "Maximum speed to normalize the speed range [units/s]".
2. Enter the value for the physical speed [units/s].
→ The respective value for the scaled speed [units/s] is shown.

"Deceleration Ramp" section

In the *Deceleration Ramp* section, three parameters are used to calculate a fourth parameter in order to define a deceleration ramp. You can choose which parameter should be determined.

Procedure

1. Choose the parameter to determine:
    - Current speed limit [units/s]
    - Delay [units/s]
    - Speed limit after the delay [units/s]
    - Delay time [s]
2. Enter the values for the three remaining parameters in their respective fields.
   → The calculated value for the fourth parameter is displayed.

7.1.3 "Delay Time" tab

This tab can be used to calculate the delay time for the SafeMOTION module, such as the "Delay time to start ramp monitoring" (see "Inverter module timing - SafeMOTION module" on page 270). The delay time is the difference between the times $T_{Request, Safety}$ and $T_{Request, WorstCase}$.

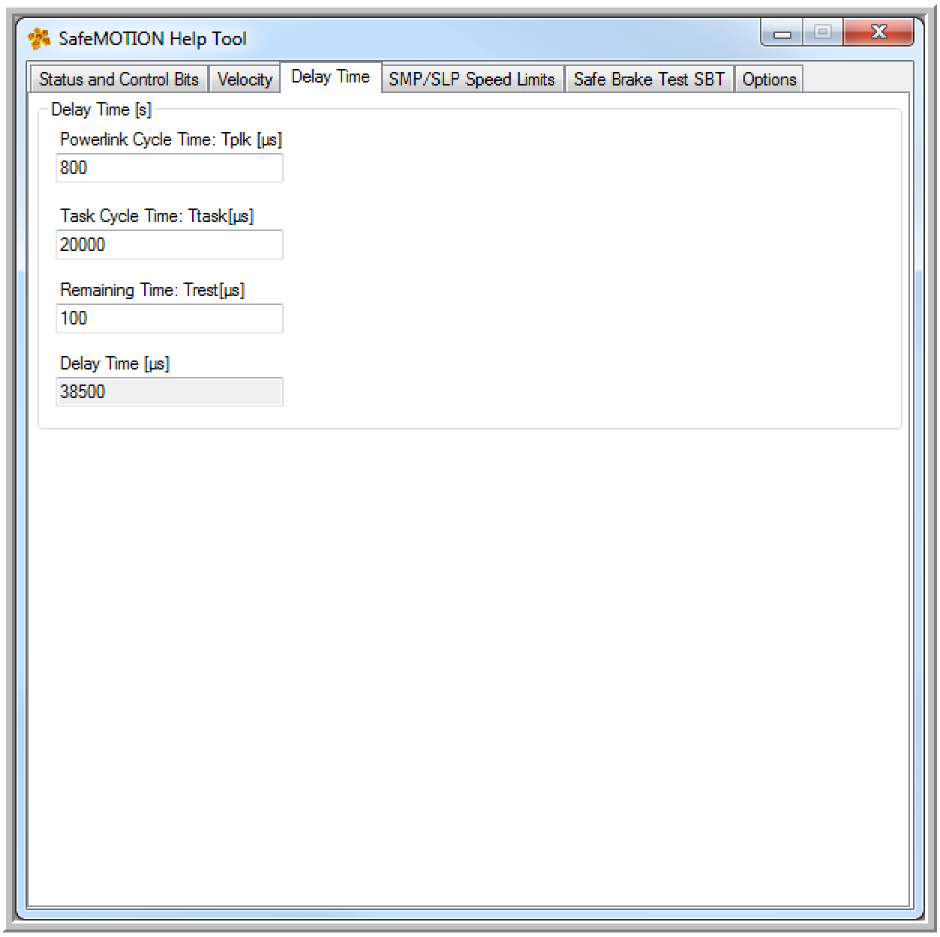


Figure 59: SafeMOTION Help Tool - "Delay Time" tab

"Delay Time" section

Procedure

1. Enter value for the POWERLINK cycle time [µs].
2. Enter value for the task cycle time [µs].
3. Enter value for the remaining time [µs].
   → The value calculated for the delay time [µs] is displayed.

7.1.4 "SMP/SLP Speed Limits" tab

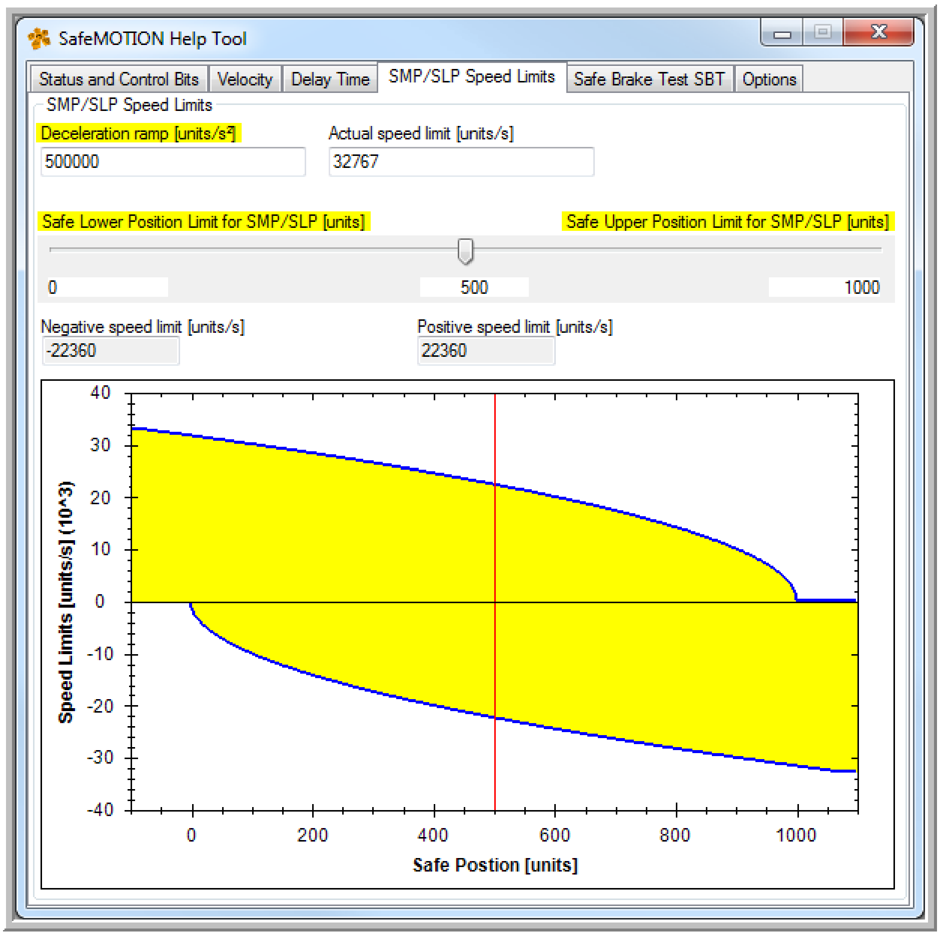


Figure 60: SafeMOTION Help Tool - "SMP/SLP Speed Limits" tab

SMP/SLP Speed Limits section

In the *SMP/SLP Speed Limits* section, the "Deceleration ramp [units/s²]" and "Actual speed limit [units/s]" parameters are used to determine the negative and positive speed limit and display them in a diagram.

The "Safe Lower Position Limit for SMP/SLP [units]" and the "Safe Upper Position Limit for SMP/SLP [units]" values can be preset. When a value between these limits is entered, the corresponding values for the negative and positive speed limit [units/s] are determined and displayed.

Parameter names marked in yellow correspond to parameters in SafeDESIGNER.

<u>Calculating negative and positive speed limits</u>

1. Enter the value for "Deceleration ramp [units/s²]".
2. Enter the value for "Actual speed limit [units/s]".
3. Preset the values for "Safe Lower Position Limit for SMP/SLP [units]" and the "Safe Upper Position Limit for SMP/SLP [units]".
4. Enter a value between the limits or move the arrow with the left mouse button
   This value is shown in the diagram as a red vertical line. The red line can be scrolled or shifted using the arrow pointer.
   → The corresponding values for the negative and positive speed limit [units/s] are displayed in the fields and in the diagram.

Diagram

This diagram illustrates the speed limit [units/s] in relation to the safe position [units].

Displaying and using the diagram

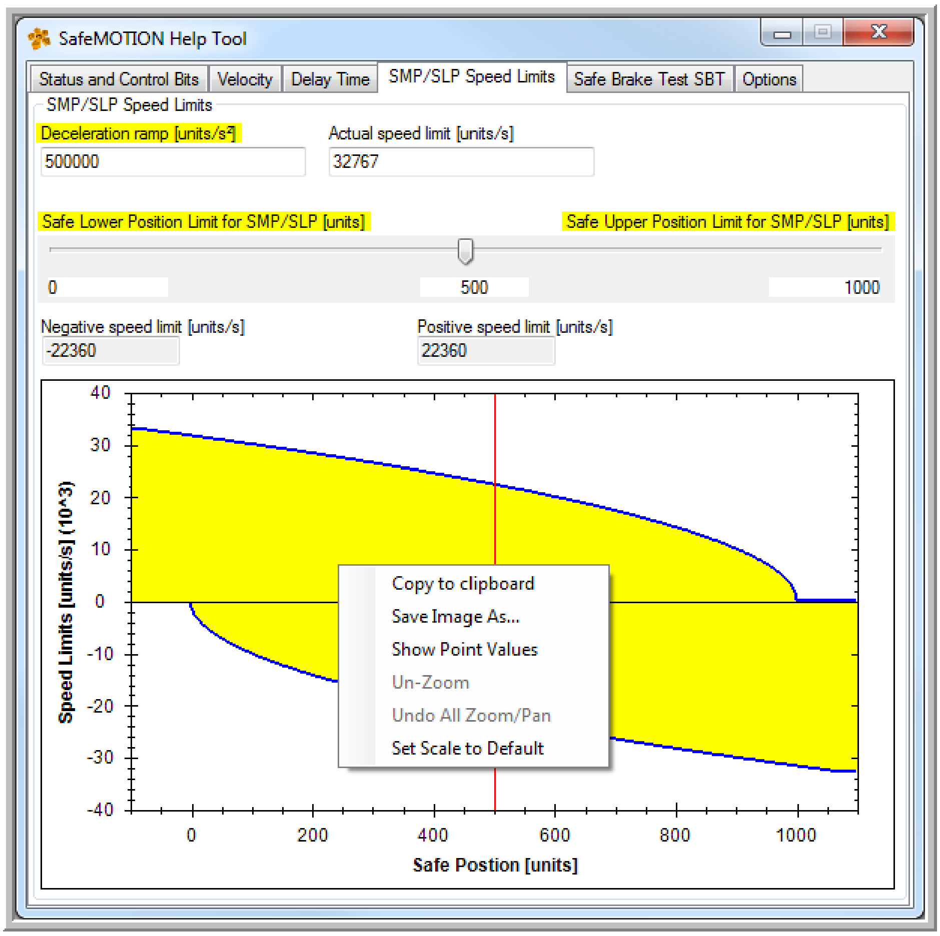


Figure 61: Displaying the diagram with the selection menu

Move the mouse pointer over the diagram.
→ A cross-hair pointer appears.
Holding the left mouse button and marking a section zooms in the diagram.
Scrolling with the mouse also zooms in the diagram.

Right-click inside the diagram.
→ A selection menu appears.
Select a menu item with the left mouse button.

Copy to clipboard	Copies the image to the clipboard
Save Image As...	Saves the image
Show Point Values	Displays the values of individual points when moving the cross-hair pointer over the line in the diagram
Un-Zoom	Reverts back to the previous zoom setting
Undo All Zoom/Pan	Resets all zoom/pan actions
Set Scale to Default	Sets scaling to the default values

7.1.5 "Safe Brake Test SBT" tab

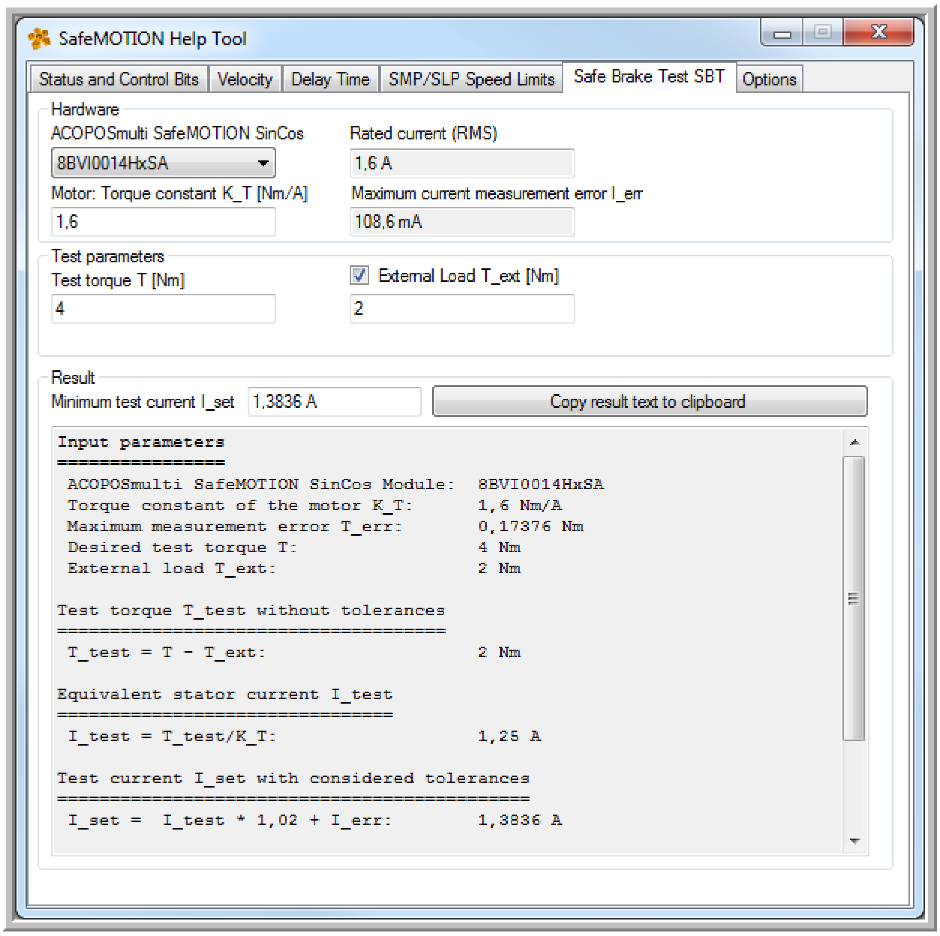


Figure 62: SafeMOTION Help Tool - "Safe Brake Test SBT" tab

The SafeMOTION Help Tool offers support for calculating the minimum required test torque for ACOPOSmulti SafeMOTION SinCos inverter modules, which is calculated taking into account the drive parameters, the *external load* T_{ext} and measurement imprecision.

The calculation is performed as described in the user's manual under ACOPOSmulti SafeMOTION / Safety technology / Integrated safety functions / Safe Brake Test (SBT).

"Hardware" section

The ACOPOSmulti SafeMOTION SinCos inverter module being used can be specified under "Hardware". This setting is necessary since the "*Maximum current measurement error* (I_{err})" parameter depends on the performance class.

The torque constant (K_T) of the motor must also be set; this can be found in the data sheet for the motor. The SafeMOTION Help Tool outputs the "*Maximum current measurement error* (I_{err})" parameter for the ACOPOSmulti SafeMOTION SinCos inverter module being used.

"Test Parameters" section

The parameters for the "*Safe Brake Test (SBT)*" are set in this section. It is possible to select whether an "*External Load* (T_{ext})" should be taken into account. The input values depend on the currently configured performance class. If an invalid value is entered, the respective limit value is shown.

"Result" section

The result of the calculation is the "*Minimum test current* (I_{set})", which needs to be set while taking the *External Load* (T_{ext}) and measurement imprecision into account.

If an invalid value is entered, then the respective limit value is output in the *Hardware* section and the results are not calculated.

The text of the results can be copied directly to the clipboard.

Information:

The SafeMOTION Help Tool is not designed according to strict safety criteria. It simply provides support for calculating the values to be set. The calculation and its results must be checked!

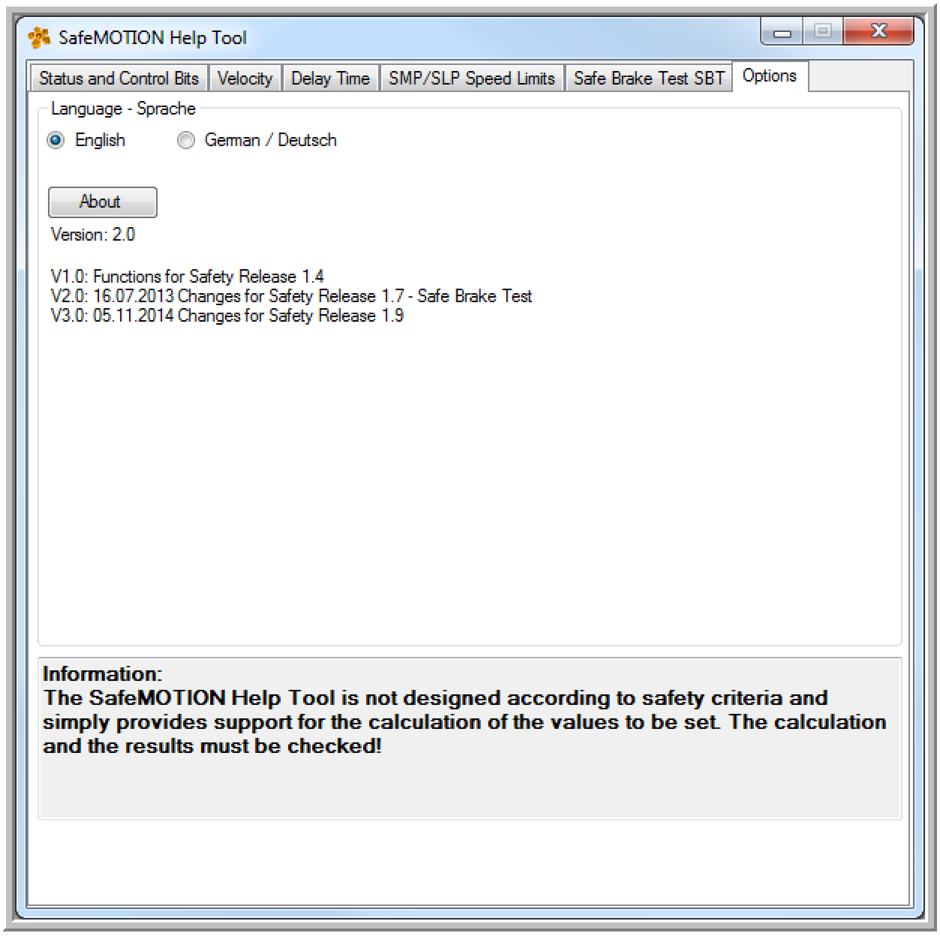
7.1.6 "Options" tab

"Language" section

Select English or German.

"About" button

Clicking on "About" displays information about the manufacturer.



7.2 The application in SafeDESIGNER

The safety application is implemented in SafeDESIGNER.

The following function blocks are available for controlling SafeMOTION modules:

Function block	Safety Release
SF_SafeMC_BR SF_SafeMC_Speed_BR	Safety Release 1.3 or higher
SF_SafeMC_BR_V2 SF_SafeMC_Position_BR	Safety Release 1.4 or higher
SF_SafeMC_SBT_BR	Safety Release 1.7 or higher
SF_SafeMC_BR_V3 SF_SafeMC_Position_BR_V2	Safety Release 1.9 or higher

Chapter 5 "PLCopen Safety" on page 292 contains detailed descriptions of how to use these function blocks, the safety functions associated with them and the safety parameters themselves.

Danger!

The safety application should only be developed by qualified personnel.
The respective processes specified in the standards must be followed!

The information provided in the "Integrated safety" user's manual (MASAFETY1-ENG) under SafeDESIGNER must also be taken into consideration.

Danger!

All of the safety functions that are being used must be tested.
A function is considered to be "in use" if the corresponding input is connected or the safety function has been configured!

7.3 Accessing data on the SafeMOTION module from Automation Studio

There are three ways to access safety-related data from a safe axis in Automation Studio.

7.3.1 I/O mapping

The states of individual safety functions can be accessed via the I/O mapping window for the respective SafeMOTION module. This information is provided in the form of status bits.

To connect PVs to the status bits, the "I/O mapping" window must be opened. As can be seen in the following image, the PV can then be selected in the "PV or channel name" column.

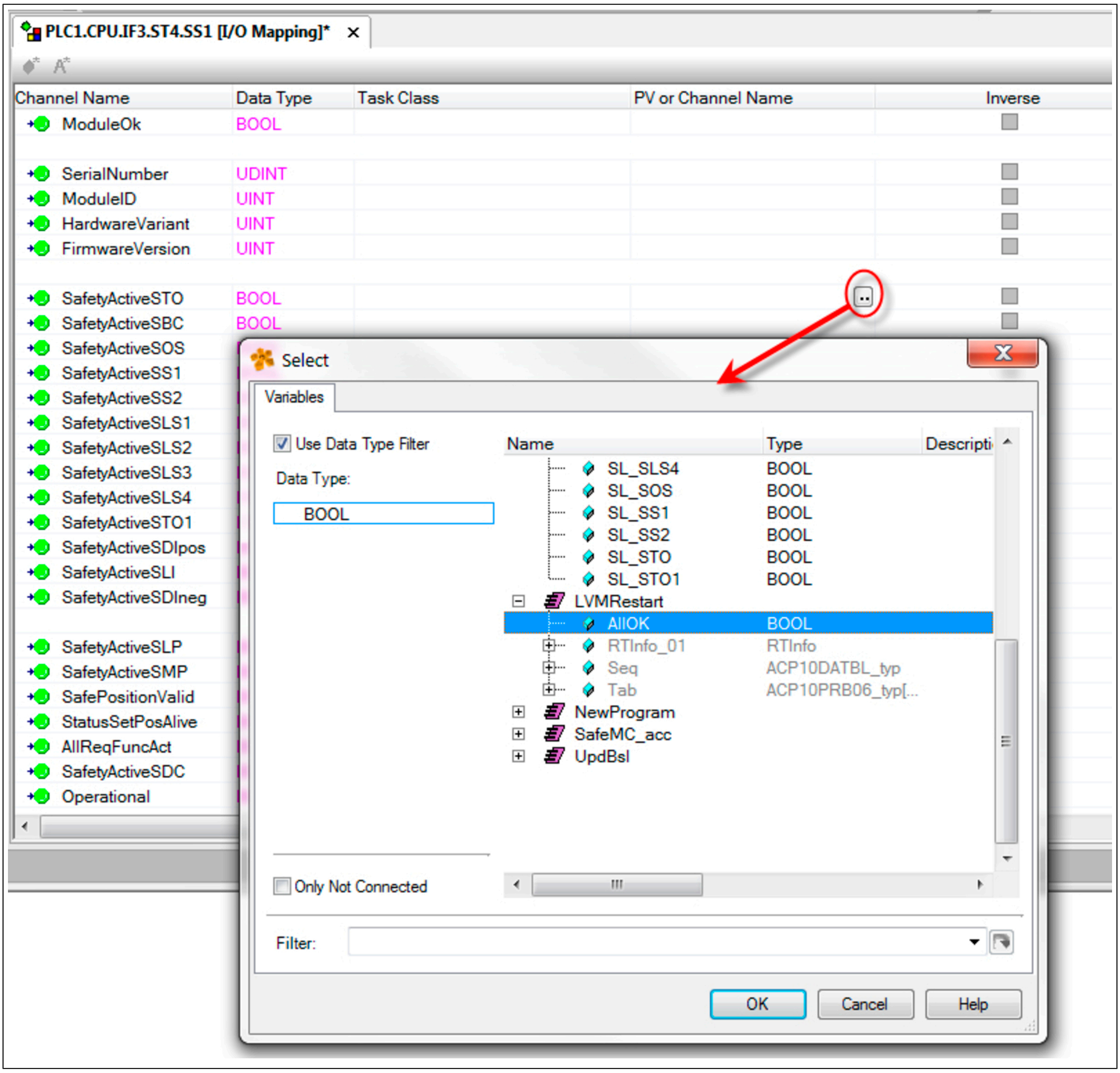


Figure 63: PV mapping

7.3.2 ACOPOSmulti parameter ID

The following parameter IDs are available to make SafeMOTION data available to the non-safety-related part of the ACOPOSmulti SafeMOTION inverter module.

ParID	Data type	NC constant (Define)	Description
4	UDINT	SAFEMC_STATUS	Status bits
5	UDINT	SAFEMC_CONTROL	Control bits
6	INT	SAFEMC_SPEED_ACT	Actual speed [scaled units/s]
7	INT	SAFEMC_SPEED_LIM	Speed limit value [scaled units/s], currently monitored speed limit
309	DINT	SAFEMC_POS_ACT	Safe position [units]

Table 156: ACOPOSmulti SafeMOTION parameter IDs for SafeMOTION

With these Par IDs, you can use all the familiar features of ACOPOSmulti (e.g. ACOPOSmulti Trace, reading parameters via service channel, SPT function block connections, etc.).

ACOPOSmulti Trace can be used, for example, to optimize how the standard application handles approaching speed limit values. This also provides an easy way of checking whether the values configured for "Delay times for requesting a safety function" are correct or sufficient.

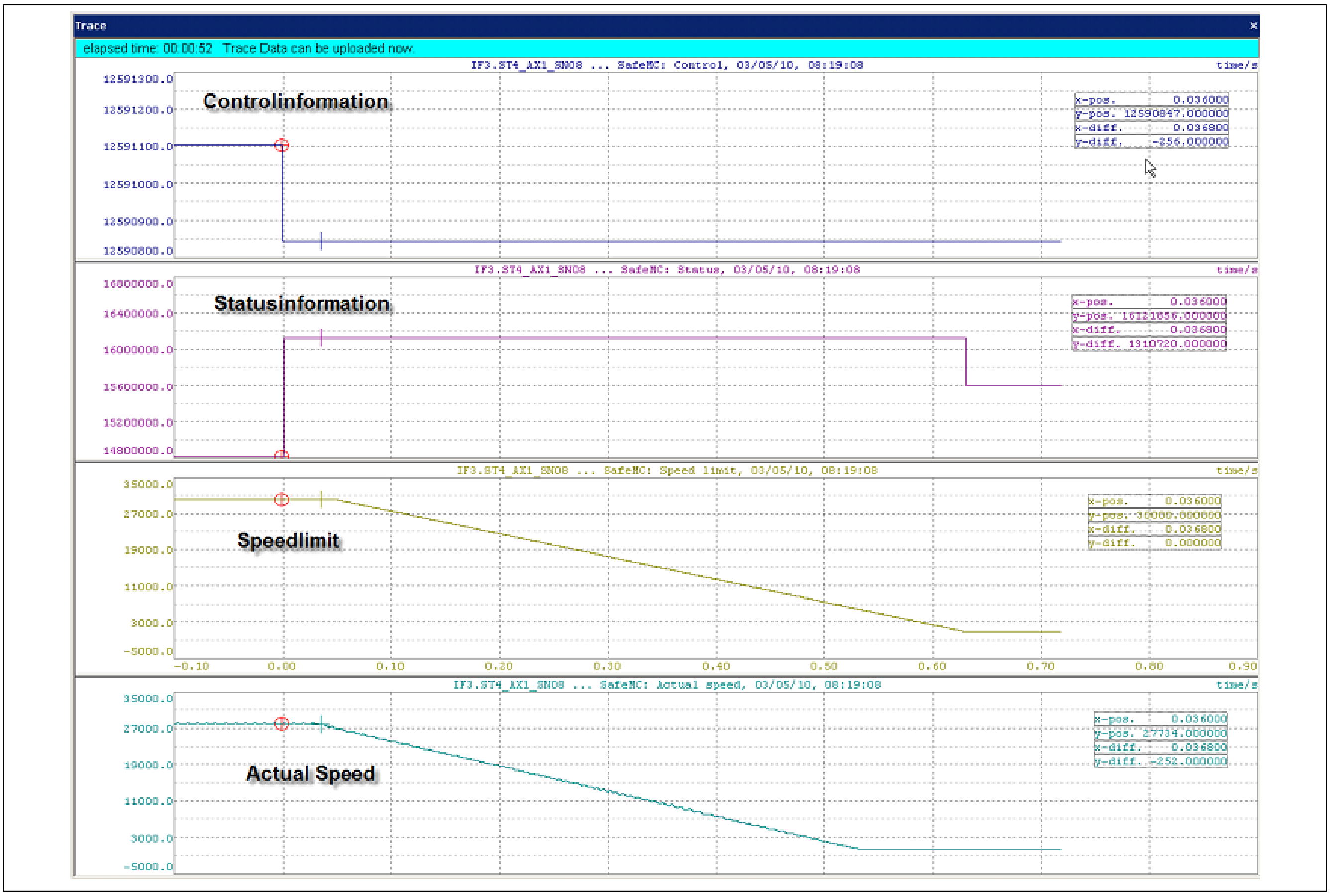


Figure 64: ACOPOSmulti Trace: Example with SafeMOTION data

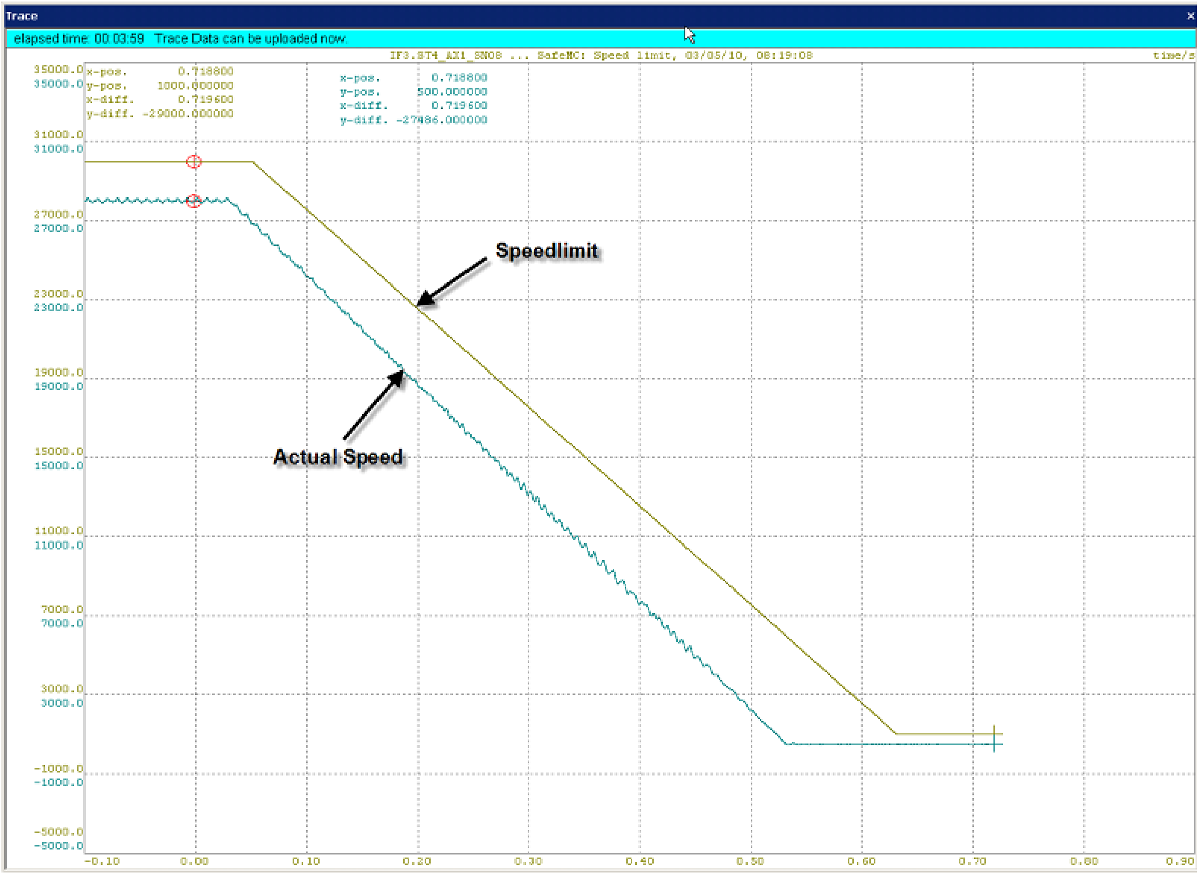


Figure 65: ACOPOSmulti Trace: Speed reserve

The parameter IDs "4 status bits" and "5 control bits" are bit-coded, with only the lower three bytes actually relevant. The following tables indicate the bit assignments:

Bit 0	**Bit 1**	**Bit 2**	**Bit 3**	**Bit 4**	**Bit 5**	**Bit 6**	**Bit 7**
STO	SBC	SOS	SS1	SS2	SLS1	SLS2	SLS3
Bit 8	**Bit 9**	**Bit 10**	**Bit 11**	**Bit 12**	**Bit 13**	**Bit 14**	**Bit 15**
SLS4	STO1	SDIpos	SLI	SDIneg	SLP 1)	SMP 1)	SafePosition Valid 1)
Bit 16	**Bit 17**	**Bit 18**	**Bit 19**	**Bit 20**	**Bit 21**	**Bit 22**	**Bit 23**
SLA 4)	Setposition Alive Testing	Safety Function Requested	All Requested Safetyfunctions active	SDC	Operational	NOT ERR Encoder	NOT ERR Functional
Bit 24	**Bit 25**	**Bit 26**	**Bit 27**	**Bit 28**	**Bit 29**	**Bit 30**	**Bit 31**
SBT active 2)	Status SBT 2)	RSPValid 3)	RequestHomingOK 4)	Reserved	Reserved	Reserved	Reserved

Table 157: Status bits

1) Only available with Safety Release 1.4 or higher!
2) Only available with Safety Release 1.7 or higher and only for ACOPOSmulti SafeMOTION SinCos!
3) Only available with Safety Release 1.9 or higher and only for ACOPOSmulti SafeMOTION EnDat 2.2!
4) Only available with Safety Release 1.9 or higher!

Bit 0	**Bit 1**	**Bit 2**	**Bit 3**	**Bit 4**	**Bit 5**	**Bit 6**	**Bit 7**
STO	SBC	SOS	SS1	SS2	SLS1	SLS2	SLS3
Bit 8	**Bit 9**	**Bit 10**	**Bit 11**	**Bit 12**	**Bit 13**	**Bit 14**	**Bit 15**
SLS4	STO1	SDIpos	SLI	SDIneg	SLP 1)	Homing 1)	Reference switch 1)
Bit 16	**Bit 17**	**Bit 18**	**Bit 19**	**Bit 20**	**Bit 21**	**Bit 22**	**Bit 23**
SBT 2)	SLA 3)	SwitchHoming-Mode 4)	Reserved	Reserved	Reserved	Activate	Reset

Table 158: Control bits

1) Only available with Safety Release 1.4 or higher!
2) Only available with Safety Release 1.7 or higher and only for ACOPOSmulti SafeMOTION SinCos!
3) Only available with Safety Release 1.9 or higher!
4) Only available with Safety Release 1.9 or higher and only for ACOPOSmulti SafeMOTION EnDat 2.2!

7.3.3 SafeMC library

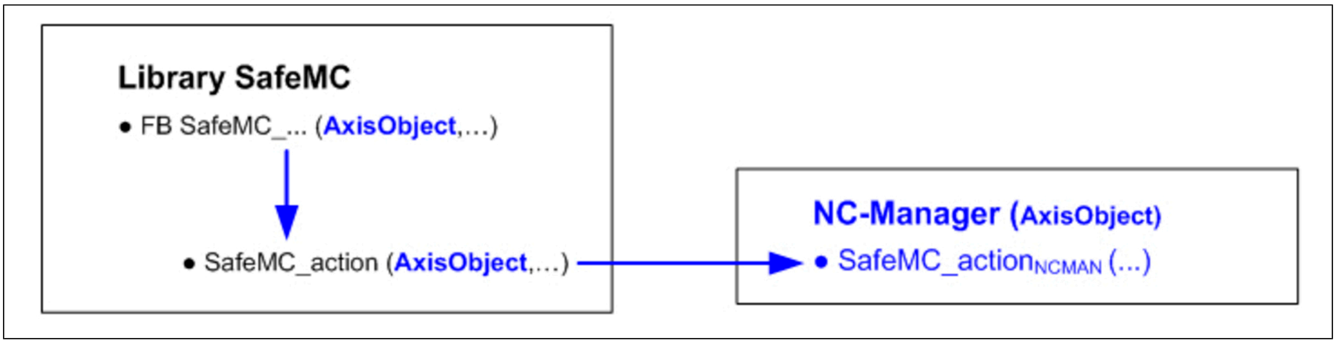
If ACOPOSmulti SafeMOTION inverter modules are being used, it is sometimes necessary to be able to read SafeMOTION data for an ACOPOSmulti axis:

- **Safe OUT**: Data from the SafeLOGIC (SL) controller to the ACOPOSmulti SafeMOTION inverter module
- **Safe IN**: Data from the ACOPOSmulti SafeMOTION inverter module to the SafeLOGIC (SL) controller

For **Safe IN** data, it would be possible in the I/O configuration to define PVs to which the data would then be copied cyclically. However, this data must be explicitly assigned to specific ACOPOSmulti axes by the user.

Automation Studio does not include a mechanism for read access to **Safe OUT** data.

The **SafeMC_action()** function in the SafeMC library makes it possible to access the SafeMOTION data of an ACOPOSmulti axis (described below). The SafeMOTION function blocks call the global **SafeMC_action()** function. Using the specified axis object, **SafeMC_action()** calls a **SafeMC_action$_{NCMAN}$()** function that is included in the NC Manager belonging to this NC object.



Information:

The SafeMC_action() function only contains a call frame. The actual functionality is part of the corresponding NC Manager function.

For this reason, the constants and data types for the functionalities implemented for the SafeMC_action() function are not included in the SafeMC library:

- **Constants are included in the NCGLOBAL library.**
- **Data types are included in the ACP10MAN library.**

7.3.3.1 SafeMC_action() function: Execute SafeMOTION action

status = SafeMC_action(nc_object, action, par_ptr, par_size)		
Input parameters:		
nc_object	UDINT	NC object
action	UDINT	Action to be executed
par_ptr	UDINT	Address of the parameter data
par_size	UDINT	Size of the parameter data in bytes
Output parameters:		
Status	UINT	ncOK or error code

Table 159: SafeMC_action()

Error codes (also used for SafeMC_ReadSafeOtData and SafeMC_ReadSafeInData function blocks):

10720	Invalid function pointer: • Error during NC software initialization (see Logger) • The NC Manager version on the PLC does not yet contain the SafeMC_action() function.
10721	Invalid NC object (parameter: "nc_object")
10723	The action ("action" parameter) is not defined or not allowed for this NC object.
10724	Invalid NC object type
10726	This action is not allowed since the corresponding initializations are not yet complete.
10729	The "par_ptr" parameter is zero.
10731	Invalid NC object data (is a PV being used as an NC object for which an INIT value is defined in the variable declaration?)
10732	The "par_size" parameter is not valid for this action.
10733	The network status is not valid for this action.
10734	Invalid network type (the NC object does not belong to a module on the POWERLINK network)
10735	Invalid length of corresponding network data

In addition, the following error codes are output for some actions, which suggests an initialization error in the SafeMOTION data:

10712	NC object not enabled (channel number too high or no PDO data defined)
20918	"data_len" provided by plAction(plACTION_GET_DP_INFO) too large
20953	"direction_id" provided by plAction(plACTION_GET_DP_INFO) invalid

All other error codes are provided by the functions in the "PowerInk" library. The following error code deserves special mention:

20923	Data point not available (not entered in the PDO mapping)

7.3.3.2 Accessing SafeMOTION data with the SafeMC_action() function

7.3.3.2.1 READ_SAFEOUT_DATA: Read SafeOUT data

Parameters:

```
ACP10SAFEOUTDAT_typ safeout_data;
```

Function call:

```
SafeMC_action(ax_obj,SafeMC_action_READ_SAFEOUT_DATA,
&safeout_data,sizeof(safeout_data));
```

Condition(s):

```
p_ax_dat->network.init == ncTRUE
```

ACP10SAFEOUTDAT_typ data structure (also used for the SafeMC_ReadSafeOutData function block):

RequestSTO	USINT	STO Control Bit
RequestSBC	USINT	SBC Control Bit
RequestSOS	USINT	SOS Control Bit
RequestSS1	USINT	SS1 Control Bit
RequestSS2	USINT	SS2 Control Bit
RequestSLS1	USINT	SLS1 Control Bit
RequestSLS2	USINT	SLS2 Control Bit
RequestSLS3	USINT	SLS3 Control Bit
RequestSLS4	USINT	SLS4 Control Bit
RequestSTO1	USINT	STO1 Control Bit
RequestSDIpos	USINT	SDI control bit (positive direction)
RequestSLI	USINT	SLI Control Bit
RequestSDIneg	USINT	SDI control bit (negative direction)
RequestSLP [1)]	USINT	SLP Control Bit [1)]
RequestHoming [1)]	USINT	Homing control bit [1)]
RequestSwitch [1)]	USINT	Reference switch [1)]
RequestSBT [2)]	USINT	SBT Control Bit [2)]
RequestSLA[3)]	USINT	SLA Control Bit [3)]
SwitchHomingMode [4)]	USINT	Switch Homing Mode Bit [4)]
reserved_ctrl_b19	*USINT*	*Reserved*
reserved_ctrl_b20	*USINT*	*Reserved*
reserved_ctrl_b21	*USINT*	*Reserved*
Activate	USINT	Activates the SafeMOTION module
Reset	USINT	Reset bit

1) Available with V2.250 or higher for Safety Release 1.4.
2) Available with V2.340 or higher for Safety Release 1.7 and only for ACOPOSmulti SafeMOTION SinCos!
3) Available with V2.480 or higher for Safety Release 1.9!
4) Available with V2.480 or higher for Safety Release 1.9 and only for ACOPOSmulti SafeMOTION EnDat 2.2!

7.3.3.2.2 READ_SAFEIN_DATA: Reading SafeIN data

Parameters:

```
ACP10SAFEINDAT_typ safein_data;
```

Function call:

```
SafeMC_action(ax_obj,SafeMC_action_READ_SAFEIN_DATA,
&safein_data,sizeof(safein_data));
```

Condition(s):

```
p_ax_dat->network.init == ncTRUE
```

ACP10SAFEINDAT_typ data structure (also used for SafeMC_ReadSafeInData function block):

SafetyActiveSTO	USINT	STO Status Bit
SafetyActiveSBC	USINT	SBC Status Bit
SafetyActiveSOS	USINT	SOS Status Bit
SafetyActiveSS1	USINT	SS1 Status Bit
SafetyActiveSS2	USINT	SS2 Status Bit
SafetyActiveSLS1	USINT	SLS1 Status Bit
SafetyActiveSLS2	USINT	SLS2 Status Bit
SafetyActiveSLS3	USINT	SLS3 Status Bit
SafetyActiveSLS4	USINT	SLS4 Status Bit
SafetyActiveSTO1	USINT	STO1 Status Bit
SafetyActiveSDIpos	USINT	SDI status bit (positive direction)
SafetyActiveSLI	USINT	SLI Status Bit
SafetyActiveSDIneg	USINT	SDI status bit (negative direction)
SafetyActiveSLP [1)]	USINT	SLP Status Bit [1)]
SafetyActiveSMP [1)]	USINT	SMP Status Bit [1)]
SafePositionValid [1)]	USINT	Safe position successfully homed and is valid [1)]
SafetyActiveSLA [4)]	USINT	SLA Status Bit
StatusSetPosAlive	USINT	Set position has been tested
StatusSFR	USINT	At least one safety function has been requested
AllReqFuncAct	USINT	All requested safety functions are active
SafetyActiveSDC	USINT	Delay monitoring is active
Operational	USINT	Function block is in the OPERATIONAL state
NotErrENC	USINT	Encoder error status bit
NotErrFUNC	USINT	Functional fail safe status bit
SafetyActiveSBT [2)]	USINT	SBT is active [2)]
SaftetyStatusSBT [2)]	USINT	SBT Status Bit [2)]
RSPValid [3)]	USINT	RSP Valid Bit [3)]
ReqHomingOK [4)]	USINT	Request Homing OK Bit [4)]
reserved_stat_b28	*USINT*	*Reserved*
reserved_stat_b29	*USINT*	*Reserved*
reserved_stat_b30	*USINT*	*Reserved*
reserved_stat_b31	*USINT*	*Reserved*
ScaledSpeed	INT	Scaled safe speed
SafePosition [1)]	DINT	Safe position [1)]

1) Available with V2.250 or higher for Safety Release 1.4.
2) Available with V2.340 or higher for Safety Release 1.7 and only for ACOPOSmulti SafeMOTION SinCos!
3) Available with V2.480 or higher for Safety Release 1.9 and only for ACOPOSmulti SafeMOTION EnDat 2.2!
4) Available with V2.480 or higher for Safety Release 1.9!

7.3.3.2.3 Example: Accessing SafeOUT and SafeIN data

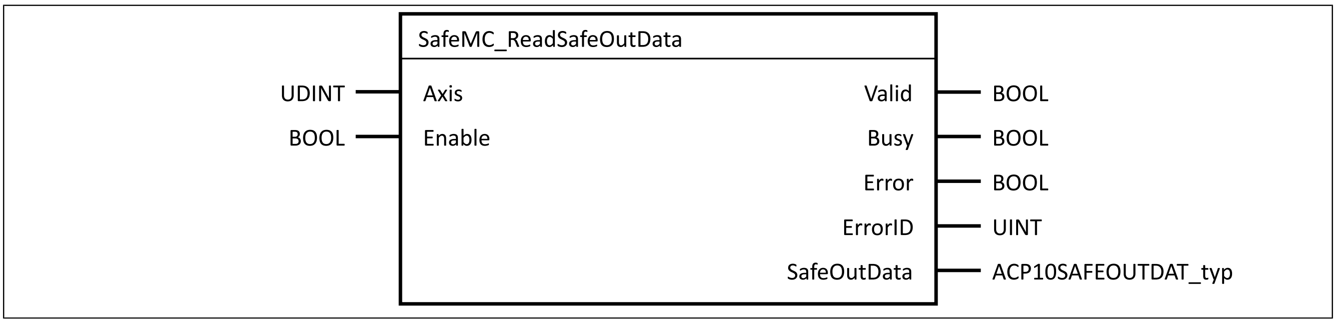
```
#include <bur/plctypes.h>
#include <SafeMC.h>

_LOCAL UINT                status_ncaccess;
_LOCAL UINT                status_safeout;
_LOCAL UINT                status_safein;

_LOCAL UDINT               ax_obj;
_LOCAL ACP10AXIS_typ       *p_ax_dat;

_LOCAL ACP10SAFEOUTDAT_typ safeout_data;
_LOCAL ACP10SAFEINDAT_typ  safein_data;
void _INIT SafeMC_accessINIT( void )
{
    status_ncaccess = ncaccess(ncACP10MAN,"AxisObj1",(void *)&ax_obj);
    p_ax_dat = (ACP10AXIS_typ*)ax_obj;
}
void _CYCLIC SafeMC_accessCYCLIC( void )
{
    if ( status_ncaccess != ncOK )
    {
        return;
    }
    if ( p_ax_dat->network.init == ncTRUE )
    {
        status_safeout = SafeMC_action(ax_obj, SafeMC_action_READ_SAFEOUT_DATA,
                                       &safeout_data,sizeof(safeout_data));
        status_safein  = SafeMC_action(ax_obj, SafeMC_action_READ_SAFEIN_DATA,
                                       &safein_data,sizeof(safein_data));
    }
}
```

Chapter 4
Safety technology

7.3.3.3 Accessing SafeMOTION data using SafeMOTION function blocks

7.3.3.3.1 SafeMC_ReadSafeOutData function block: Reading SafeOUT data

Function block



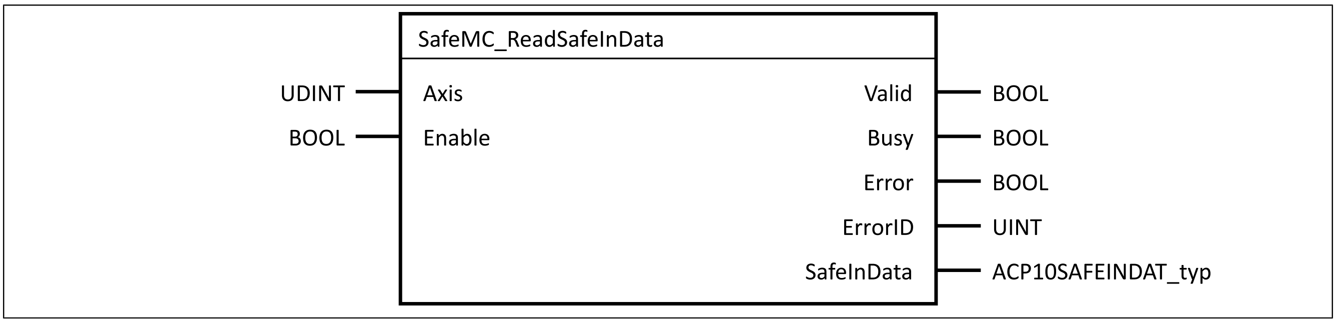
Parameter

I/O	Parameter	Data type	Description
IN	Axis	UDINT	Axis reference (NC object)
IN	Enable	BOOL	If "Enable" is set, then the data will be read.
OUT	Valid	BOOL	Indicates that data in the output data structure is valid
OUT	Busy	BOOL	Function block not yet completed
OUT	Error	BOOL	Indicates a function block error
OUT	ErrorID	UINT	Function block error code (see 7.3.3.1 "SafeMC_action() function: Perform SafeMOTION action / Error codes" on page 285)
OUT	SafeOutData	ACP10SAFEOUTDAT_typ	Output data structure

ACP10SAFEOUTDAT_typ data structure, see 7.3.3.2.1 "READ_SAFEOUT_DATA: Read SafeOUT data / Data structure" on page 286

7.3.3.3.2 Function block SafeMC_ReadSafeInData: Read SafeIN data

Function block



Parameter

I/O	Parameter	Data type	Description
IN	Axis	UDINT	Axis reference (NC object)
IN	Enable	BOOL	If "Enable" is set, then the data will be read.
OUT	Valid	BOOL	Indicates that data in the output data structure is valid
OUT	Busy	BOOL	Function block not yet completed
OUT	Error	BOOL	Indicates a function block error
OUT	ErrorID	UINT	Function block error code (see 7.3.3.1 "SafeMC_action() function: Perform SafeMOTION action / Error codes" on page 285)
OUT	SafeInData	ACP10SAFEINDAT_typ	Output data structure

ACP10SAFEINDAT_typ data structure, see 7.3.3.2.2 "READ_SAFEIN_DATA: Read SafeIN data / Data structure" on page 286

7.3.3.3.3 Example: Accessing SafeOUT and SafeIN data

```
#include <bur/plctypes.h>
#include <SafeMC.h>

_LOCAL UINT                        status_ncaccess;

_LOCAL UDINT                       ax_obj;
_LOCAL ACP10AXIS_typ               *p_ax_dat;
```

```
_LOCAL SafeMC_ReadSafeOutData_typ SafeMC_ReadSafeOutData_0;
_LOCAL SafeMC_ReadSafeInData_typ  SafeMC_ReadSafeInData_0;

void _INIT SafeMC_accessINIT( void )
{
    status_ncaccess = ncaccess(ncACP10MAN,"AxisObj1",(void *)&ax_obj);
    p_ax_dat = (ACP10AXIS_typ*)ax_obj;

    SafeMC_ReadSafeOutData_0.Axis = ax_obj;
    SafeMC_ReadSafeInData_0.Axis  = ax_obj;
}

void _CYCLIC SafeMC_accessCYCLIC( void )
{
    if ( status_ncaccess != ncOK )
    {
        return;
    }
    SafeMC_ReadSafeOutData_0.Enable = p_ax_dat->network.init;
    SafeMC_ReadSafeOutData(&SafeMC_ReadSafeOutData_0);
    SafeMC_ReadSafeInData_0.Enable  = p_ax_dat->network.init;
    SafeMC_ReadSafeInData(&SafeMC_ReadSafeInData_0);
}
```

7.4 Validating the safety functions

Danger!

You are responsible for performing functional testing of safety equipment.

You must therefore ensure that your safety equipment undergoes validation!

Information:

Applicable standards specify certain processes that must be followed when developing safety-related applications. You are solely responsible for establishing and adhering to these processes.

Danger!

Safety applications are only permitted to be developed by qualified personnel. Acceptance of the final product, validation and verification in particular, must also be performed by qualified personnel.

When commissioning a machine, the complete safety application must be tested, validated and verified in accordance with the SRS (Safety Requirements Specification).

When performing a comprehensive safety function test, all specified limits and timing values must be tested in accordance with the SRS. All monitored limits must be violated and the respective error responses then evaluated.

Each of the safety functions being used must be fully tested in regard to their respective limit values.
The physical units of the monitored limits must be tested! A function is considered "in use" if the respective function block input is used in the safety application.

The following tests are mandatory in all cases:

Safety function	Select/Deselect the safety function	Check the safe outputs	Violation of the deceleration ramp	Violation of the monitored speed limit	Violation of the monitored path
STO	✓	✓	---	---	---
STO1	✓	✓	---	---	---
SBC	✓	✓	---	---	---
SOS	✓	---	---	✓	✓
SS1	✓	✓	✓	---	---
SS2	✓	---	✓	✓	---
SLS1	✓	---	✓	✓	---
SLS2	✓	---	✓	✓	---
SLS3	✓	---	✓	✓	---
SLS4	✓	---	✓	✓	---
SMS	---	---	---	✓	---
SDIpos	✓	---	---	---	✓
SDIneg	✓	---	---	---	✓
SLI	✓	---	---	---	✓
SLP	✓	---	✓ [1)]	✓ [1)]	✓
SMP	---	---	✓ [1)]	✓ [1)]	✓
SBT [2)]	✓	Violation of upper/lower limit for test torque or torque of external load			✓
SLA [3)]	✓	Violation of monitored limit for acceleration or deceleration with respect to current direction of movement			---
RSP [4)]	Checked by performing the RSP procedure				

Table 160: Test matrix for the safety functions

1) Speed limit calculated dynamically according to the current position.
2) Available with Safety Release 1.7 or higher and only for ACOPOSmulti SafeMOTION SinCos!
3) Available with Safety Release 1.9 or higher!
4) Available with Safety Release 1.9 or higher and only for ACOPOSmulti SafeMOTION EnDat 2.2!

Danger!

Check the parameter settings for the unit system! An incorrectly configured unit system can cause dangerous situations since the monitored limits may not correspond to the physical limits under certain conditions!

7.5 Maintenance scenarios

7.5.1 Commissioning

When commissioning a machine, its safety functions must always undergo comprehensive testing, as described in 7.4 "Validating the safety functions" on page 290.

Danger!

All of the safety functions that are being used must be tested.
A function is considered to be "in use" if the corresponding input is connected or the safety function has been configured!

7.5.2 Replacing ACOPOSmulti SafeMOTION safe inverter modules

The SafeLOGIC controller independently detects when safe modules have been replaced. Following a module replacement, the overall system (SafeLOGIC, openSAFETY) automatically ensures that the module is operated again using the correct parameters and that incompatible modules are rejected.

Replacing a safe ACOPOSmulti SafeMOTION inverter module can result in the following potential errors. These errors must be excluded through testing:

- Wiring errors in the motor connection
- Wiring errors in the motor holding brake connection
- Connection of the wrong encoder

Danger!

Check all safety functions that are implemented on the replaced ACOPOSmulti SafeMOTION inverter module!
Be sure to validate the entire safety function!

7.5.3 Replacing a safe encoder/motor

If a safe EnDat 2.2 FS encoder is replaced on a safe ACOPOSmulti SafeMOTION EnDat 2.2 inverter module, this will be detected as a module replacement on the SafeLOGIC controller and must be acknowledged accordingly.

The SafeLOGIC controller does not detect when a motor or encoder is replaced on the safe ACOPOSmulti SafeMOTION SinCos inverter!

After the replacement, test the safety functions configured on the affected axis.

Danger!

Check all safety functions that are implemented on the replaced ACOPOSmulti SafeMOTION inverter module!
Be sure to validate the entire safety function!

7.5.4 Firmware updates / Acknowledging updated firmware

Changes to safety-related parts of the firmware are distributed by B&R as firmware updates.
Safety-relevant firmware is only permitted to be updated by qualified personnel.
A firmware update is indicated on the SafeLOGIC controller and must be acknowledged accordingly.

Danger!

A complete functional test must be performed following any modification to the firmware.

7.5.5 Decommissioning a system

ACOPOSmulti SafeMOTION modules have a maximum mission time of 20 years.
This means that all ACOPOSmulti SafeMOTION inverter modules must be taken out of service at least one week before the expiration of this 20-year time span (starting from B&R's delivery date).

Danger!

Operating ACOPOSmulti SafeMOTION inverter modules beyond the specified mission time is not permitted!

The user must ensure that all ACOPOSmulti SafeMOTION inverter modules are replaced by new ACOPOSmulti SafeMOTION inverter modules or removed from operation before their mission time expires.

Chapter 5 • PLCopen Safety

Special function blocks that are compliant with PLCopen Safety have been implemented to ensure that SafeMOTION modules are used as efficiently as possible. These function blocks have revolutionized the development of safety applications. Because they are certified, they reduce time and costs throughout all phases of a safety application's lifecycle. From specification and implementation to testing and verification of functions, the procedure used is more like virtual wiring than programming.

Unlike "real wiring", downloading the program to the SafeLOGIC controller guarantees that an identical copy will be stored. This completely eliminates wiring errors during series production. To be sure, all options for a safe programmable controller are available to handle even more complex problems that can't be solved with "real wiring".

1 Term definitions

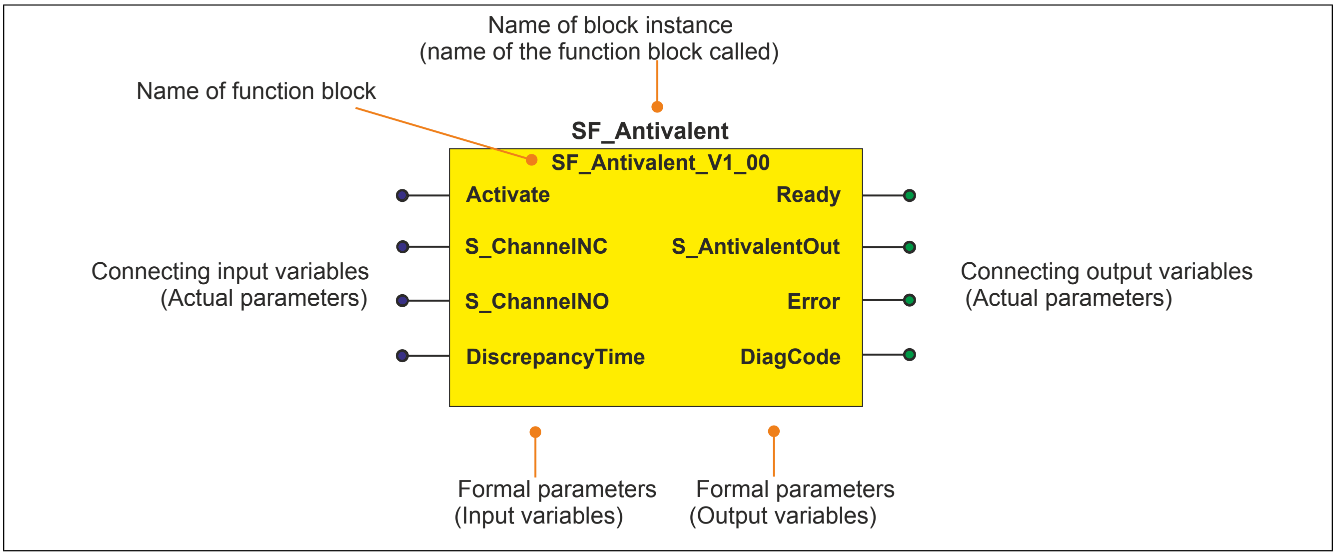


Figure 66: Function block label

When calling the function block, the actual parameters supply the formal parameters with the current values of variables or constants.

Actual parameters do not need to share the same name as the corresponding formal parameters, but they must be of the same type. A difference in data type between formal and actual parameters is reported as an error following compilation.

The name of a function block is composed of the function itself (e.g. SF_Antivalent, SF = safety function) and its version (Vx_yz). The format used to represent the version number in this document, Vx_yz, is a placeholder. For the actual version number, see the function block in use.

2 SF_SafeMC_BR

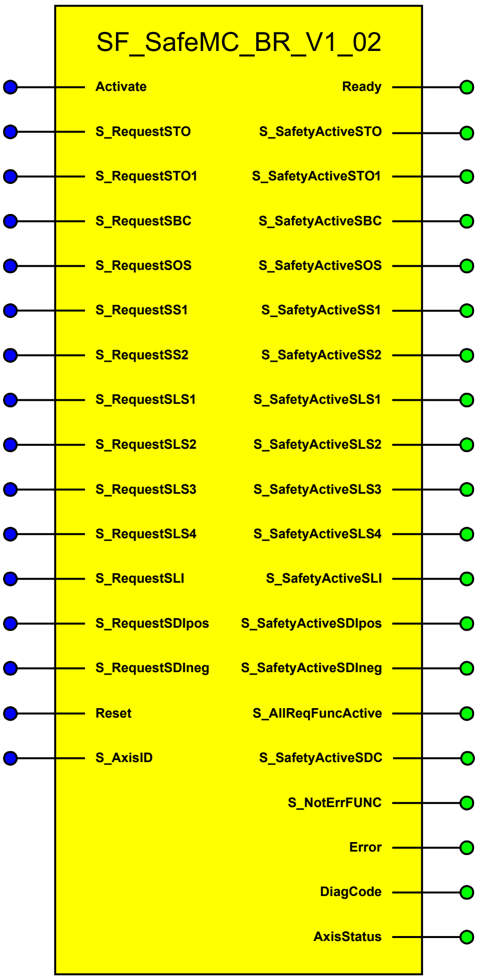


Figure 67: SF_SafeMC_BR function block

2.1 Formal parameters of the function block

In the following, the term "variable" refers to both a variable as well as a graphic connection.

Name	Type	Connection	Signal type [1)]	Initial value	Description / General function
Activate	BOOL	Variable / Constant	Status	FALSE	Enables the function block (= TRUE)
S_RequestSTO	SAFEBOOL	Variable / Constant	Status	SAFEFALSE	STO safety function request: SAFEFALSE: Safety function requested
S_RequestSTO1	SAFEBOOL	Variable / Constant	Status	SAFEFALSE	STO1 safety function request: SAFEFALSE: Safety function requested
S_RequestSBC	SAFEBOOL	Variable / Constant	Status	SAFEFALSE	SBC safety function request: SAFEFALSE: Safety function requested
S_RequestSOS	SAFEBOOL	Variable / Constant	Status	SAFEFALSE	SOS safety function request: SAFEFALSE: Safety function requested
S_RequestSS1	SAFEBOOL	Variable / Constant	Status	SAFEFALSE	SS1 safety function request: SAFEFALSE: Safety function requested
S_RequestSS2	SAFEBOOL	Variable / Constant	Status	SAFEFALSE	SS2 safety function request: SAFEFALSE: Safety function requested
S_RequestSLS1	SAFEBOOL	Variable / Constant	Status	SAFEFALSE	SLS1 safety function request: SAFEFALSE: Safety function requested
S_RequestSLS2	SAFEBOOL	Variable / Constant	Status	SAFEFALSE	SLS2 safety function request: SAFEFALSE: Safety function requested
S_RequestSLS3	SAFEBOOL	Variable / Constant	Status	SAFEFALSE	SLS3 safety function request: SAFEFALSE: Safety function requested
S_RequestSLS4	SAFEBOOL	Variable/ Constant	Status	SAFEFALSE	SLS4 safety function request: SAFEFALSE: Safety function requested
S_RequestSLI	SAFEBOOL	Variable / Constant	Status	SAFEFALSE	SLI safety function request: SAFEFALSE: Safety function requested
S_RequestSDIpos	SAFEBOOL	Variable / Constant	Status	SAFEFALSE	SDIpos safety function request: SAFEFALSE: Safety function requested
S_RequestSDIneg	SAFEBOOL	Variable / Constant	Status	SAFEFALSE	SDIneg safety function request: SAFEFALSE: Safety function requested
Reset	BOOL	Variable	Edge	FALSE	Resets error messages and the SafeMOTION module after the cause of the error has been removed
S_AxisID	SAFEINT	Constant	Status	-1	Assigns an axis to the function block

Table 161: SF_SafeMC_BR: Overview of input parameters

1) Evaluation of the input parameter signals in the function block. The signals must be controlled accordingly by the user.

Name	Type	Connection	Signal type [1)]	Initial value	Description / General function
Ready	BOOL	Variable	Status	FALSE	Indicates that the function block is enabled
S_SafetyActiveSTO	SAFEBOOL	Variable	Status	SAFEFALSE	STO safety function active (= SAFETRUE)
S_SafetyActiveSTO1	SAFEBOOL	Variable	Status	SAFEFALSE	Safety function STO1 active (= SAFETRUE)
S_SafetyActiveSBC	SAFEBOOL	Variable	Status	SAFEFALSE	SBC safety function active (= SAFETRUE)
S_SafetyActiveSOS	SAFEBOOL	Variable	Status	SAFEFALSE	SOS safety function active, no violation of a monitored limit (= SAFETRUE)
S_SafetyActiveSS1	SAFEBOOL	Variable	Status	SAFEFALSE	SS1 safety function active, deceleration monitoring completed, no violation of a monitored limit detected (= SAFETRUE)
S_SafetyActiveSS2	SAFEBOOL	Variable	Status	SAFEFALSE	SS2 safety function active, deceleration monitoring completed, no violation of a monitored limit detected (= SAFETRUE)
S_SafetyActiveSLS1	SAFEBOOL	Variable	Status	SAFEFALSE	SLS1 safety function active, deceleration monitoring completed, no violation of a monitored limit detected (= SAFETRUE)
S_SafetyActiveSLS2	SAFEBOOL	Variable	Status	SAFEFALSE	SLS2 safety function active, deceleration monitoring completed, no violation of a monitored limit detected (= SAFETRUE)
S_SafetyActiveSLS3	SAFEBOOL	Variable	Status	SAFEFALSE	SLS3 safety function active, deceleration monitoring completed, no violation of a monitored limit detected (= SAFETRUE)
S_SafetyActiveSLS4	SAFEBOOL	Variable	Status	SAFEFALSE	SLS4 safety function active, deceleration monitoring completed, no violation of a monitored limit detected (= SAFETRUE)
S_SafetyActiveSLI	SAFEBOOL	Variable	Status	SAFEFALSE	SLI safety function active, no violation of a monitored limit (= SAFETRUE)
S_SafetyActiveSDIpos	SAFEBOOL	Variable	Status	SAFEFALSE	SDIpos safety function active (= SAFETRUE)

Table 162: SF_SafeMC_BR: Overview of output parameters

Name	Type	Connection	Signal type [1]	Initial value	Description / General function
S_SafetyActiveSDIneg	SAFEBOOL	Variable	Status	SAFEFALSE	Safety function SDIneg active (= SAFETRUE)
S_AllReqFuncActive	SAFEBOOL	Variable	Status	SAFEFALSE	All requested safety functions have achieved their safe state. (= SAFETRUE)
S_SafetyActiveSDC	SAFEBOOL	Variable	Status	SAFEFALSE	Deceleration monitoring active (= SAFETRUE)
S_NotErrFUNC	SAFEBOOL	Variable	Status	SAFEFALSE	SafeMOTION module not in the FUNCTIONAL FAIL SAFE state (= SAFETRUE)
Error	BOOL	Variable	Status	FALSE	Function block error message
DiagCode	WORD	Variable	Status	16#0000	Function block diagnostic message
AxisStatus	DWORD	Variable	Status	32#00000000	Status information from axis

Table 162: SF_SafeMC_BR: Overview of output parameters

1) Output of the output parameter signals. The signals must be evaluated and/or further processed accordingly by the user.

Type	Description	Size in bits	Format option
BOOL	Bit	1	Bit string
WORD	Word	16	Bit string
SAFEBOOL	Bit	1	Bit string (signal source: safe device)
SAFEDWORD	Double word	32	Bit string (signal source: safe device)
SAFEDINT	Double integer	32	Binary number, hexadecimal number, signed decimal number (signal source: safe device)
SAFEINT	Integer	16	Binary number, hexadecimal number, signed decimal number (signal source: safe device)

Table 163: Format description of the data types

You have the option of linking a safe signal with a non-safe input parameter. To do so, use a function block for type conversion.

Caution!

You are responsible for any conversion of a non-safe input parameter to a safe signal.

2.2 SafeMOTION module parameters

Parameter	Unit	Description	Safety function
Encoder Unit System			
Number of encoder revolutions	-	Unit scale: x revolutions Any unit (mm, 1/100 mm, 1/20 inch, degree of angle, etc.) can be used for positions (and data which can result such as speed and acceleration). For this reason, the relationship between an integer multiple of this unit (units per x revolutions) and a certain number of encoder revolutions (x revolutions) has to be previously defined.	Unit system
Units per number of encoder revolutions	units	Unit scale: Units per x revolutions Any unit (mm, 1/100 mm, 1/20 inch, degree of angle, etc.) can be used for positions (and data which can result such as speed and acceleration). For this reason, the relationship between an integer multiple of this unit (units per x revolutions) and a certain number of encoder revolutions (x revolutions) has to be previously defined.	Unit system
Counting direction	Standard / Inverse	Counting direction of the position or speed Default…Encoder counter direction is equal to the counting direction of the unit system Inverse…Encoder counting direction is negative to the counting direction of the unit system	Unit system
Maximum speed to normalize the speed range	units	Maximum speed to which the displayed speed should be normalized	Unit system
Safety Deceleration Ramp			
Deceleration Ramp	[units/s²]	Slope of the deceleration ramp to be monitored	SS1, SS2, SLS
General Settings			
Safe Maximum Speed	Used / Unused	Activates the SMS safety function from the configuration	SMS
Automatic Reset at Startup (Startreset)	Used / Unused	Activates automatic reset of the function block at startup	Configuration
Channel selection for One Channel STO (STO1)	HighSide / LowSide	Selection of HighSide or LowSide IGBT in the function One Channel STO	STO1 / Configuration FUNCTIONAL FAIL SAFE
Rampmonitoring for SS1	Activated / Deactivated	Activates ramp-based monitoring (in addition to time-based monitoring) when the SS1 safety function is requested	SS1
Rampmonitoring for SS2	Activated / Deactivated	Activates ramp-based monitoring (in addition to time-based monitoring) when The SS2 safety function is requested	SS2
Rampmonitoring for SLS	Activated / Deactivated	Activates ramp-based monitoring (in addition to time-based monitoring) when the SLS safety function is requested	SLS
Early Limit Monitoring	Activated / Deactivated	Monitoring of the deceleration ramp is prematurely terminated if the target limit is reached or exceeded.	SS1, SS2, SLS
Encoder Monitoring			
Encoder Position Monitoring	Activated / Deactivated	Activates/Deactivates monitoring of the position lag error generated on the SafeMOTION module	Monitoring Encoder shaft breakage
Encoder Speed Monitoring	Activated / Deactivated	Activates/Deactivates monitoring of the speed error generated on the SafeMOTION module	Monitoring Encoder shaft breakage
Set position alive testing	Activated / Deactivated	Activates/deactivates the monitor that detects whether the set position generated on the ACOPOSmulti SafeMOTION inverter module is frozen.	Monitoring Encoder shaft breakage
Behavior of Functional Fail Safe			
SBC in Functional Fail Safe	Activated / Deactivated	The brake output is switched to 0 V when in the FUNCTIONAL FAIL SAFE state.	Configuration
Behavior of Functional Fail Safe	STO / STO1 and STO with time delay	In the FUNCTIONAL FAIL SAFE state, STO (SBC) is activated immediately or STO1 and then STO (SBC) after a delay.	Configuration
Delay time for STO in Functional Fail Safe	[µs]	Delay time between STO1 and STO (and SBC) in the FUNCTIONAL FAIL SAFE state	Configuration
Delay time until the brake engages	[µs]	Delay time before the brake engages The second enable channel is activated after this delay time if STO1 and delayed STO and SBC are configured for FUNCTIONAL FAIL SAFE.	Configuration
Safety Speed Limits			
Maximum Speed for SMS	[units/s]	Speed limit of the maximum speed	SMS
Safe Speedlimit 1 for SLS	[units/s]	Speed limit 1 for SLS	SLS
Safe Speedlimit 2 for SLS	[units/s]	Speed limit 2 for SLS	SLS
Safe Speedlimit 3 for SLS	[units/s]	Speed limit 3 for SLS	SLS
Safe Speedlimit 4 for SLS	[units/s]	Speed limit 4 for SLS	SLS
Safety Standstill and Direction Tolerances			
Speed Tolerance	[units/s]	Speed tolerance for standstill monitoring	SOS, SS2, SLI
Position Tolerance	[units]	Position tolerance for standstill and direction monitoring	SOS, SS2, SDI
Safely Limited Increments			
Safe increments	[units]	Maximum movable increments when SLI is active	SLI
SLI Off Delay	[µs]	Switch off delay of SLI	SLI
Safety Ramp Monitoring Times			
Ramp Monitoring Time for SS1 (us)	[µs]	Deceleration ramp monitoring time for SS1	SS1
Ramp Monitoring Time for SS2 (us)	[µs]	Deceleration ramp monitoring time for SS2	SS2
Ramp Monitoring Time for SLS1 (us)	[µs]	Deceleration ramp monitoring time for SLS1	SLS1

Table 164: SF_SafeMC_BR: Module parameters

Parameter	Unit	Description	Safety function
Ramp Monitoring Time for SLS2 (us)	[µs]	Deceleration ramp monitoring time for SLS2	SLS2
Ramp Monitoring Time for SLS3 (us)	[µs]	Deceleration ramp monitoring time for SLS3	SLS3
Ramp Monitoring Time for SLS4 (us)	[µs]	Deceleration ramp monitoring time for SLS4	SLS4
Safety Additional Parameters			
Delay time to start ramp monitoring (us)	[µs]	Delay time between the request for ramp-based monitoring and the start of monitoring	SS1, SS2, SLS
Delay time to start SDI (us)	[µs]	Delay time between the SDI request and activation of the safety function	SDI
Delay time to start SBC (us)	[µs]	Delay time between the SBC request and activation of the safety function	SBC
Early Limit Monitoring time (us)	[µs]	Time during which the speed must be equal to or below the target speed limit in order to prematurely end the deceleration ramp and to assume the safety function's end state	SS1, SS2, SLS
Encoder Monitoring Tolerances			
Encoder Monitoring Position Tolerance	[units]	Position lag error tolerance for shaft breakage monitoring	Monitoring Encoder shaft breakage
Encoder Monitoring Speed Tolerance	[units/s]	Speed error tolerance for encoder monitoring	Monitoring Encoder shaft breakage

Table 164: SF_SafeMC_BR: Module parameters

In a safety application, it is possible for multiple safety functions to be requested at the same time. In order to prevent this from turning into an unsafe situation, the individual safety functions are prioritized on the SafeMOTION module.

If several functions are active, then the lowest speed limit is always the value being monitored.

Information:

The following application rule must be followed in order for the safety functions to be prioritized correctly:

$\mathbf{LIM_{SOS} \leq LIM_{SLS4} \leq LIM_{SLS3} \leq LIM_{SLS2} \leq LIM_{SLS1} \leq LIM_{SMS}} < \textit{\textbf{NormSpeed}}$

If this application rule is violated, then the SafeMOTION module will switch to the FAIL SAFE state.

2.3 Integrated safety functions

See "ACOPOSmulti SafeMOTION user's manual / Safety technology / Integrated safety functions".

2.4 Fault avoidance

> **Danger!**
>
> **Validation**
>
> **Each safety function that is used must be validated separately.**
> **It is also necessary to test the entire safety application, including the interactions between individual functions.**

2.4.1 Exceeding monitored limits

The SafeMOTION module monitors configurable limits. The drive itself, however, is controlled by the standard application on the standard PLC.

The following points must be considered in order to prevent a monitored limit from being violated:

- The movement of the drive must be adapted to the requested safety function and initiated on time.
- The monitored limits must match the calculated limits and movement limitations. Make sure that the different configurations of the unit system match in the safety application and in the standard application!

> **Danger!**
>
> **Any violation of a monitored limit will cause the module to switch to the acknowledgeable FUNCTIONAL FAIL SAFE error state.**
>
> **The S_NotErrFUNC output on the function block is reset, and the drive loses all torque/power and coasts to a stop!**
>
> **Depending on the configuration, the motor holding brake will also be switched to 0 V.**
>
> **In the event of an error, a synchronous axis will no longer be synchronous.**
>
> **Check the Safety Logger in Automation Studio for detailed information about monitoring.**

2.4.2 Plausibility errors

Plausibility errors (limit values, data types, variables/constants) that occur when using the function block are detected and reported by either the function block or compiler.

This is not possible in the event of connection errors, however.

The function block does not check for the following errors:

- Actual parameter values or constants are within their valid range but incorrect for the safety function being executed.
- Actual parameters have been connected incorrectly.
- Formal input/output parameters that should have been connected have not been connected.

> **Danger!**
>
> **Ensuring proper safety function connections (sub-application) is your responsibility as the user!**
>
> **Make sure to check these connections when validating the sub-application!**

2.4.3 Sporadically changing/toggling signal levels or impermissible signals

Sporadically changing or toggling signal levels on edge-controlled formal input parameters causes the function block to interpret the signal as an edge, which results in an unintended action being triggered in the function block if error prevention measures are not taken.

Sporadically changing or toggling signal levels on status-controlled input formal parameters will cause the signal to trigger an undesired corresponding action if error prevention measures are not taken.

Impermissible signals on input formal parameters can lead to an unexpected initial movement, non-execution of a requested action or an error message.

Possible causes of these signals:

- Programming error in the application program (user error)
- Cross fault, short circuit or open line (user error, wiring error)

- Error on the standard controller

To prevent this, the following measures can be taken depending on the safety function:

- Using signals from safe devices
- Implementing additional measures for preventing a hazard if using a signal from a standard controller (e.g. executing an additional function start after a safety function has been triggered or an error has been corrected)
- Line control on the safe control system
- Suitable cabling when using non-safe signals from the standard controller
- Verifying the source code in the application program and final validation of the safety functionality

These measures can also be combined to prevent errors.

It is important to note that a signal change detected on a status-controlled formal parameter will be output as a diagnostic code.

2.4.4 Simultaneous edge change

Make sure that the **Reset** formal parameter is only connected to a signal from a manual resetting device to reduce the risk of an unexpected initial movement. This signal is based on your risk analysis.

2.4.5 Machine/System startup without performing functional testing of safety equipment

Faulty safety equipment can only be detected following functional testing. Functional testing is not supported by this function block. If additional measures are not taken, faulty safety equipment can result in errors.

Danger!

You are responsible for performing functional testing of safety equipment.
You must therefore ensure that your safety equipment undergoes validation!

Possible causes of faulty safety equipment:

- Faulty devices (hardware error)
- Cross fault, short circuit or open line (user error, wiring error)

2.5 Input parameters

2.5.1 General information about the "S_Request" inputs

The "**S_Request**" inputs are used to request the respective safety functions.

If a safety function should not be used in the safety application, then the respective input should not be connected.

> **Information:**
>
> **If a safety function is not used in the application, then the respective input must remain open.**

> **Danger!**
>
> **The safety functions that are used must be tested.**
> **A function is considered to be used if the respective input variable is connected!**

> **Information:**
>
> **At a minimum, the Activate and S_AxisID inputs must be connected. Otherwise, the SafeMOTION module will not be operated by the SafeLOGIC controller. As a result, the pulse disabling and motor holding brake output will be permanently set to 0 V, which means that the controller cannot be turned on.**

2.5.2 Activate

General function

- Enables the function block

Data type

- BOOL

Connection

- Constant or variable

Description of function

This input parameter is used to enable the function block.

- If you are activating or deactivating safe devices, link **Activate** to a variable that indicates the status (deactivated or activated) of the corresponding safe devices. This ensures that the function block does not output a triggered safety function as diagnostic information when a device is cut off.
- It is also possible to connect "Activate" to a constant (TRUE) in order to enable the function block.

TRUE

The function block is enabled.

FALSE

The function block is disabled.
All binary output parameters are set to FALSE.
Sets the DiagCode diagnostic parameter to WORD#16#0000.

If you want to control function block diagnostics as needed in your diagnostic concept whenever error messages from safe devices and/or deactivated safe devices occur, connect "Activate" to a signal that indicates the status of the safe devices that are involved with the safety function supported by the function block. Create this signal only for safe devices whose I/O signals are connected to the function block via actual parameters. This prevents triggered safety functions from being reported by inactive safe devices. This measure is only used to control diagnostics in the event of inactive safe devices.

2.5.3 S_RequestSTO

General function

- Selects/Deselects the "Safe Torque Off" (STO) safety function

Data type

- SAFEBOOL

Connection

- Constant or variable

Description of function

This input parameter is used to select or deselect the STO safety function.

TRUE

The safety function is deselected. Safe pulse disabling is not active!

FALSE

The safety function is selected. Safe pulse disabling is active! Torque/Power are switched off on the drive.

Not connected

The safety function is deactivated.

Relevant configuration parameters

- None

2.5.4 S_RequestSTO1

General function

- Selects/Deselects the "Safe Torque Off, One Channel" (STO1) safety function

Data type

- SAFEBOOL

Connection

- Constant or variable

Description of function

This input parameter is used to select or deselect the STO1 safety function.

TRUE

The safety function is deselected. Safe pulse disabling is not active!

FALSE

The safety function is selected. Depending on the configuration, the HighSide or LowSide of safe pulse disabling is active! Torque/Power are switched off on the drive.

Not connected

The safety function is deactivated.

Relevant configuration parameters

Parameter	Unit	Description	Default value
General Settings			
Channel selection for One Channel STO (STO1)	HighSide/ LowSide	Selects the HighSide or LowSide IGBT in the STO1 function	HighSide

Table 165: STO1 safety function - Parameters

2.5.5 S_RequestSBC

General function

- Selects/Deselects the "Safe Brake Control" (SBC) safety function

Data type

- SAFEBOOL

Connection

- Constant or variable

Description of function

This input parameter is used to select or deselect the SBC safety function.

TRUE

The safety function is deselected. The motor holding brake is active and can be used by the standard application.

FALSE

The safety function is selected. The motor holding brake is switched to 0 V!

Not connected

The safety function is deactivated.

Relevant configuration parameters

Parameter	Unit	Description	Default value
Safety Additional Parameters			
Delay time to start SBC (us)	[µs]	Delay time between the SBC request and activation of the safety function	0

Table 166: SBC safety function - Parameters

2.5.6 S_RequestSOS

General function

- Selects/Deselects the "Safe Operating Stop" (SOS) safety function

Data type

- SAFEBOOL

Connection

- Constant or variable

Description of function

This input parameter is used to select or deselect the SOS safety function.

TRUE

The safety function is deselected. Standstill tolerances are not being monitored.

FALSE

The safety function is selected. Standstill tolerances are being monitored.

Not connected

The safety function is deactivated.

Relevant configuration parameters

Parameter	Unit	Description	Default value
Safety Standstill and Direction Tolerances			
Speed Tolerance	[units/s]	Speed tolerance for standstill monitoring	0
Position Tolerance	[units]	Position tolerance for standstill and direction monitoring	0

Table 167: SOS safety function - Parameters

Information:

This safety function requires safe evaluation of the position and speed.
If an evaluation error is detected, then the SafeMOTION module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state.

Information:

If several safety functions are active, then the lowest speed limit is always the value being monitored.

The following application rule must be observed:
$\mathbf{LIM_{SOS} \leq LIM_{SLS4} \leq LIM_{SLS3} \leq LIM_{SLS2} \leq LIM_{SLS1} \leq LIM_{SMS} < NormSpeed}$

Failure to follow the application rule will cause the SafeMOTION module to enter the FAIL SAFE state. If this occurs, it can only be brought back to the OPERATIONAL state by modifying the safety application and completing a power off/on cycle!

2.5.7 S_RequestSS1

General function

- Selects/Deselects the "Safe Stop 1" (SS1) safety function

Data type

- SAFEBOOL

Connection

- Constant or variable

Description of function

This input parameter is used to select or deselect the SS1 safety function.

TRUE

The safety function is deselected. Safe Stop 1 is not active!

FALSE

The safety function is selected. Safe pulse disabling is activated after the end of ramp monitoring.

Not connected

The safety function is deactivated.

Relevant configuration parameters

Parameter	Unit	Description	Default value
Safety Deceleration Ramp			
Deceleration Ramp	[units/s²]	Slope of the deceleration ramp to be monitored	1073676289
General Settings			
Rampmonitoring for SS1	Activated/ Deactivated	Activates ramp-based monitoring (in addition to time-based monitoring) when the SS1 function is requested	Activated
Early Limit Monitoring	Activated/ Deactivated	Prematurely terminates monitoring of the deceleration ramp if the value falls below the lower limit for a defined amount of time	Deactivated
Safety Ramp Monitoring Times			
Ramp Monitoring Time for SS1 (us)	[µs]	Deceleration ramp monitoring time for SS1	0
Safety Additional Parameters			
Delay time to start ramp monitoring (us)	[µs]	Delay time between the request for ramp-based monitoring and the start of monitoring	0
Early Limit Monitoring time (us)	[µs]	Time during which the speed must be below the target speed limit in order to prematurely end the deceleration ramp and to assume the safety function's end state	0

Table 168: SS1 safety function - Parameters

Information:

This safety function requires safe evaluation of the position and speed.
If an evaluation error is detected, then the SafeMOTION module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state.

Information:

To use this function without safe encoder evaluation, "Ramp monitoring for SS1" and "Early Limit Monitoring" must be disabled.

Information:

If several safety functions are active, then the lowest speed limit is always the value being monitored.

The following application rule must be observed:
$LIM_{SOS} \leq LIM_{SLS4} \leq LIM_{SLS3} \leq LIM_{SLS2} \leq LIM_{SLS1} \leq LIM_{SMS} < NormSpeed$

Failure to follow the application rule will cause the SafeMOTION module to enter the FAIL SAFE state. If this occurs, it can only be brought back to the OPERATIONAL state by modifying the safety application and completing a power off/on cycle!

2.5.8 S_RequestSS2

General function

- Selects/Deselects the "Safe Stop 2" (SS2) safety function

Data type

- SAFEBOOL

Connection

- Constant or variable

Description of function

This input parameter is used to select or deselect the SS2 safety function.

TRUE

The safety function is deselected. Safe Stop 2 is not active!

FALSE

The safety function is selected. Standstill monitoring is activated after the end of ramp monitoring.

Not connected

The safety function is deactivated.

Relevant configuration parameters

Parameter	Unit	Description	Default value
Safety Deceleration Ramp			
Deceleration Ramp	[units/s²]	Slope of the deceleration ramp to be monitored	1073676289
General Settings			
Rampmonitoring for SS2	Activated/ Deactivated	Activates ramp monitoring (in addition to time-based monitoring) when the SS2 function is requested	Activated
Early Limit Monitoring	Activated/ Deactivated	Prematurely terminates monitoring of the deceleration ramp if the value falls below the lower limit for a defined amount of time	Deactivated
Safety Standstill and Direction Tolerances			
Speed Tolerance	[units/s]	Speed tolerance for standstill monitoring	0
Position Tolerance	[units]	Position tolerance for standstill and direction monitoring	0
Safety Ramp Monitoring Times			
Ramp Monitoring Time for SS2 (us)	[µs]	Deceleration ramp monitoring time for SS2	0
Safety Additional Parameters			
Delay time to start ramp monitoring (us)	[µs]	Delay time between the request for ramp-based monitoring and the start of monitoring	0
Early Limit Monitoring time (us)	[µs]	Time during which the speed must be below the target speed limit in order to prematurely end the deceleration ramp and to assume the safety function's end state	0

Table 169: SS2 safety function - Parameters

Information:

This safety function requires safe evaluation of the position and speed.
If an evaluation error is detected, then the SafeMOTION module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state.

Information:

If several safety functions are active, then the lowest speed limit is always the value being monitored.

The following application rule must be observed:
$\mathbf{LIM_{SOS} \leq LIM_{SLS4} \leq LIM_{SLS3} \leq LIM_{SLS2} \leq LIM_{SLS1} \leq LIM_{SMS} < NormSpeed}$

Failure to follow the application rule will cause the SafeMOTION module to enter the FAIL SAFE state. If this occurs, it can only be brought back to the OPERATIONAL state by modifying the safety application and completing a power off/on cycle!

2.5.9 S_RequestSLS1

General function

- Selects/Deselects the "Safely Limited Speed" safety function, Speed Limit 1

Data type

- SAFEBOOL

Connection

- Constant or variable

Description of function

This input parameter is used to select or deselect the SLS1 safety function.

TRUE

The safety function is deselected. SLS1 is not active!

FALSE

The safety function is selected. Speed limit 1 is monitored after the end of ramp monitoring.

Not connected

The safety function is deactivated.

Relevant configuration parameters

Parameter	Unit	Description	Default value
Safety Deceleration Ramp			
Deceleration Ramp	[units/s²]	Slope of the deceleration ramp to be monitored	1073676289
General Settings			
Rampmonitoring for SLS	Activated/ Deactivated	Activates ramp-based monitoring (in addition to time-based monitoring) when the SLS function is requested	Activated
Early Limit Monitoring	Activated/ Deactivated	Prematurely terminates monitoring of the deceleration ramp if the value falls below the lower limit for a defined amount of time	Deactivated
Speed Limits			
Safe Speedlimit 1 for SLS	[units/s]	Speed limit 1 for SLS	0
Safety Ramp Monitoring Times			
Ramp Monitoring Time for SLS1 (us)	[µs]	Deceleration ramp monitoring time for SLS1	0
Safety Additional Parameters			
Delay time to start ramp monitoring (us)	[µs]	Delay time between the request for ramp-based monitoring and the start of monitoring	0
Early Limit Monitoring time (us)	[µs]	Time during which the speed must be below the target speed limit in order to prematurely end the deceleration ramp and to assume the safety function's end state	0

Table 170: SLS1 safety function - Parameters

Information:

This safety function requires safe evaluation of the position and speed.
If an evaluation error is detected, then the SafeMOTION module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state.

Information:

If several safety functions are active, then the lowest speed limit is always the value being monitored.

The following application rule must be observed:
$\mathbf{LIM_{SOS} \leq LIM_{SLS4} \leq LIM_{SLS3} \leq LIM_{SLS2} \leq LIM_{SLS1} \leq LIM_{SMS} < NormSpeed}$

Failure to follow the application rule will cause the SafeMOTION module to enter the FAIL SAFE state. If this occurs, it can only be brought back to the OPERATIONAL state by modifying the safety application and completing a power off/on cycle!

2.5.10 S_RequestSLS2

General function

- Selects/Deselects the "Safely Limited Speed" safety function, Speed Limit 2

Data type

- SAFEBOOL

Connection

- Constant or variable

Description of function

This input parameter is used to select or deselect the SLS2 safety function.

TRUE

The safety function is deselected. SLS2 is not active!

FALSE

The safety function is selected. Speed limit 2 is monitored after the end of ramp monitoring.

Not connected

The safety function is deactivated.

Relevant configuration parameters

Parameter	Unit	Description	Default value
Safety Deceleration Ramp			
Deceleration Ramp	[units/s²]	Slope of the deceleration ramp to be monitored	1073676289
General settings			
Rampmonitoring for SLS	Activated/ Deactivated	Activates ramp-based monitoring (in addition to time-based monitoring) when the SLS function is requested	Activated
Early Limit Monitoring	Activated/ Deactivated	Prematurely terminates monitoring of the deceleration ramp if the value falls below the lower limit for a defined amount of time	Deactivated
Speed Limits			
Safe Speedlimit 2 for SLS	[units/s]	Speed limit 2 for SLS	0
Safety Ramp Monitoring Times			
Ramp Monitoring Time for SLS2 (us)	[µs]	Deceleration ramp monitoring time for SLS2	0
Safety Additional Parameters			
Delay time to start ramp monitoring (us)	[µs]	Delay time between the request for ramp-based monitoring and the start of monitoring	0
Early Limit Monitoring time (us)	[µs]	Time during which the speed must be below the target speed limit in order to prematurely end the deceleration ramp and to assume the safety function's end state	0

Table 171: SLS2 safety function - Parameters

Information:

This safety function requires safe evaluation of the position and speed.
If an evaluation error is detected, then the SafeMOTION module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state.

Information:

If several safety functions are active, then the lowest speed limit is always the value being monitored.

The following application rule must be observed:
$\mathbf{LIM_{SOS} \leq LIM_{SLS4} \leq LIM_{SLS3} \leq LIM_{SLS2} \leq LIM_{SLS1} \leq LIM_{SMS} < NormSpeed}$

Failure to follow the application rule will cause the SafeMOTION module to enter the FAIL SAFE state. If this occurs, it can only be brought back to the OPERATIONAL state by modifying the safety application and completing a power off/on cycle!

2.5.11 S_RequestSLS3

General function

- Selects/Deselects the "Safely Limited Speed" safety function, Speed Limit 3

Data type

- SAFEBOOL

Connection

- Constant or variable

Description of function

This input parameter is used to select or deselect the SLS3 safety function.

TRUE

The safety function is deselected. SLS3 is not active!

FALSE

The safety function is selected. Speed limit 3 is monitored after the end of ramp monitoring.

Not connected

The safety function is deactivated.

Relevant configuration parameters

Parameter	Unit	Description	Default value
Safety Deceleration Ramp			
Deceleration Ramp	[units/s²]	Slope of the deceleration ramp to be monitored	1073676289
General Settings			
Rampmonitoring for SLS	Activated/ Deactivated	Activates ramp-based monitoring (in addition to time-based monitoring) when the SLS function is requested	Activated
Early Limit Monitoring	Activated/ Deactivated	Prematurely terminates monitoring of the deceleration ramp if the value falls below the lower limit for a defined amount of time	Deactivated
Speed Limits			
Safe Speedlimit 3 for SLS	[units/s]	Speed limit 3 for SLS	0
Safety Ramp Monitoring Times			
Ramp Monitoring Time for SLS3 (us)	[µs]	Deceleration ramp monitoring time for SLS3	0
Safety Additional Parameters			
Delay time to start ramp monitoring (us)	[µs]	Delay time between the request for ramp-based monitoring and the start of monitoring	0
Early Limit Monitoring time (us)	[µs]	Time during which the speed must be below the target speed limit in order to prematurely end the deceleration ramp and to assume the safety function's end state	0

Table 172: SLS3 safety function - Parameters

Information:

**This safety function requires safe evaluation of the position and speed.
If an evaluation error is detected, then the SafeMOTION module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state.**

Information:

If several safety functions are active, then the lowest speed limit is always the value being monitored.

The following application rule must be observed:
$\mathbf{LIM_{SOS} \leq LIM_{SLS4} \leq LIM_{SLS3} \leq LIM_{SLS2} \leq LIM_{SLS1} \leq LIM_{SMS} < NormSpeed}$

Failure to follow the application rule will cause the SafeMOTION module to enter the FAIL SAFE state. If this occurs, it can only be brought back to the OPERATIONAL state by modifying the safety application and completing a power off/on cycle!

2.5.12 S_RequestSLS4

General function

- Selects/Deselects the "Safely Limited Speed" safety function, Speed Limit 4

Data type

- SAFEBOOL

Connection

- Constant or variable

Description of function

This input parameter is used to select or deselect the SLS4 safety function.

TRUE

The safety function is deselected. SLS4 is not active!

FALSE

The safety function is selected. Speed limit 4 is monitored after the end of ramp monitoring.

Not connected

The safety function is deactivated.

Relevant configuration parameters

Parameter	Unit	Description	Default value
Safety Deceleration Ramp			
Deceleration Ramp	[units/s²]	Slope of the deceleration ramp to be monitored	1073676289
General Settings			
Rampmonitoring for SLS	Activated/ Deactivated	Activates ramp-based monitoring (in addition to time-based monitoring) when the SLS function is requested	Activated
Early Limit Monitoring	Activated/ Deactivated	Prematurely terminates monitoring of the deceleration ramp if the value falls below the lower limit for a defined amount of time	Deactivated
Speed Limits			
Safe Speedlimit 4 for SLS	[units/s]	Speed limit 4 for SLS	0
Safety Ramp Monitoring Times			
Ramp Monitoring Time for SLS4 (us)	[µs]	Deceleration ramp monitoring time for SLS4	0
Safety Additional Parameters			
Delay time to start ramp monitoring (us)	[µs]	Delay time between the request for ramp-based monitoring and the start of monitoring	0
Early Limit Monitoring time (us)	[µs]	Time during which the speed must be below the target speed limit in order to prematurely end the deceleration ramp and to assume the safety function's end state	0

Table 173: SLS4 safety function - Parameters

Information:

This safety function requires safe evaluation of the position and speed.
If an evaluation error is detected, then the SafeMOTION module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state.

Information:

If several safety functions are active, then the lowest speed limit is always the value being monitored.

The following application rule must be observed:
$\mathbf{LIM_{SOS} \leq LIM_{SLS4} \leq LIM_{SLS3} \leq LIM_{SLS2} \leq LIM_{SLS1} \leq LIM_{SMS} < NormSpeed}$

Failure to follow the application rule will cause the SafeMOTION module to enter the FAIL SAFE state. If this occurs, it can only be brought back to the OPERATIONAL state by modifying the safety application and completing a power off/on cycle!

2.5.13 S_RequestSLI

General function

- Selects/Deselects the "Safely Limited Increment" safety function, SLI

Data type

- SAFEBOOL

Connection

- Constant or variable

Description of function

This input parameter is used to select or deselect the SLI safety function.

TRUE

The safety function is deselected. SLI is not active!

FALSE

The safety function is selected. A safe range of increments is monitored.

Not connected

The safety function is deactivated.

Relevant configuration parameters

Parameter	Unit	Description	Default value
Safety Standstill and Direction Tolerances			
Speed Tolerance	[units/s]	Speed tolerance for standstill monitoring	0
Safely Limited Increments			
Safe increments	[units]	Maximum movable increments when SLI is active	0
SLI Off Delay	[µs]	Switch off delay of SLI	0

Table 174: SLI safety function - Parameters

Information:

This safety function requires safe evaluation of the position and speed.
If an evaluation error is detected, then the SafeMOTION module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state.

2.5.14 S_RequestSDIpos

General function

- Selects/Deselects the "Safe Direction" safety function. Movement is allowed in the positive direction

Data type

- SAFEBOOL

Connection

- Constant or variable

Description of function

This input parameter is used to select or deselect the safety function SDI, movement is allowed in the positive direction of movement.

TRUE

The safety function is deselected. SDI is not active!

FALSE

The direction of movement is monitored after the delay time has expired. Movement is allowed in the positive direction.

Not connected

The safety function is deactivated.

Relevant configuration parameters

Parameter	Unit	Description	Default value
Safety Standstill and Direction Tolerances			
Position Tolerance	[units]	Position tolerance for standstill and direction monitoring	0
Safety Additional Parameters			
Delay time to start SDI (us)	[µs]	Delay time between the SDI request and activation of the safety function	0

Table 175: SDI safety function - Parameters

Information:

This safety function requires safe evaluation of the position and speed.
If an evaluation error is detected, then the SafeMOTION module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state.

2.5.15 S_RequestSDIneg

General function

- Selects/Deselects the "Safe Direction" safety function. Movement is allowed in the negative direction

Data type

- SAFEBOOL

Connection

- Constant or variable

Description of function

This input parameter is used to select or deselect the safety function SDI, movement is allowed in the negative direction of movement.

TRUE

The safety function is deselected. SDI is not active!

FALSE

The direction of movement is monitored after the delay time has expired. Movement is allowed in the negative direction.

Not connected

The safety function is deactivated.

Relevant configuration parameters

Parameter	Unit	Description	Default value
Safety Standstill and Direction Tolerances			
Position Tolerance	[units]	Position tolerance for standstill and direction monitoring	0
Safety Additional Parameters			
Delay time to start SDI (us)	[µs]	Delay time between the SDI request and activation of the safety function	0

Table 176: SDI safety function - Parameters

Information:

This safety function requires safe evaluation of the position and speed.
If an evaluation error is detected, then the SafeMOTION module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state.

2.5.16 Reset

General function

- **Reset** input for acknowledging the FUNCTIONAL FAIL SAFE state or for putting the SafeMOTION module into OPERATIONAL state after STARTUP

Data type

- BOOL

Connection

- Variable

Description of function

Reset input to acknowledge the FUNCTIONAL FAIL SAFE state

A positive edge triggers the reset function.

Depending on the configuration of the "Automatic Reset at Startup" parameter, a positive edge may be necessary to get the SafeMOTION module from the INIT state to the OPERATIONAL state after startup.

Relevant configuration parameters

Parameter	Unit	Description	Default value
General Settings			
Automatic Reset at Startup (Startreset)	Used / Unused	Activates automatic reset of the function block at startup	Unused

Table 177: Reset - Parameters

2.5.17 S_AxisID

General function

- This input parameter assigns a real axis to the function block.

Data type

- SAFEINT

Connection

- Constant

Description of function

The corresponding axis can be connected to the input in SafeDESIGNER using drag-and-drop.

Information:

There can only be one combination of AxisID and the SF_SafeMC_BR or SF_SafeMC_BR_Vx function block in the safety application. Otherwise, it will not be possible to compile the safety application.

2.6 Output parameters

Output parameters provide information about the state of the SafeMOTION module and the individual safety functions.

2.6.1 Ready

General function

- Message: Function block is enabled/disabled.

Data type

- BOOL

Connection

- Variable

Description of function

This output parameter indicates whether or not the function block is enabled.

TRUE

The function block is enabled (**Activate** = TRUE). The output parameters indicate the current status of the safety function.

FALSE

The function block is disabled (**Activate** = FALSE). The function block outputs are set to FALSE.

2.6.2 S_SafetyActiveSTO

General function

- Status information for the "Safe Torque Off" (STO) safety function

Data type

- SAFEBOOL

Connection

- Variable

Description of function

Indicates the functional safe state of the STO safety function

TRUE

The STO safety function is active and currently in its safe state.

FALSE

The STO safety function is not requested, the function or the SafeMOTION module is currently in an error state or the function block has not been enabled.

2.6.3 S_SafetyActiveSTO1

General function

- Status information for the "Safe Torque Off, One Channel" (STO1) safety function

Data type

- SAFEBOOL

Connection

- Variable

Description of function

Indicates the functional safe state of the STO1 safety function

TRUE

The STO1 safety function is active and currently in its safe state.

FALSE

The STO1 safety function is not requested, the function or the SafeMOTION module is currently in an error state or the function block has not been enabled.

2.6.4 S_SafetyActiveSBC

General function

- Status information for the "Safe Brake Control" (SBC) safety function

Data type

- SAFEBOOL

Connection

- Variable

Description of function

Indicates the functional safe state of the SBC safety function

TRUE

The SBC safety function is active and currently in its safe state.

FALSE

The SBC safety function is not requested, the function or the SafeMOTION module is currently in an error state or the function block has not been enabled.

2.6.5 S_SafetyActiveSOS

General function

- Status information for the "Safe Operating Stop" (SOS) safety function

Data type

- SAFEBOOL

Connection

- Variable

Description of function

Indicates the functional safe state of the SOS safety function

TRUE

The SOS safety function is active and currently in its safe state.

FALSE

The SOS safety function is not requested, the function or the SafeMOTION module is currently in an error state or the function block has not been enabled.

2.6.6 S_SafetyActiveSS1

General function

- Status information for the "Safe Stop 1" (SS1) safety function

Data type

- SAFEBOOL

Connection

- Variable

Description of function

Indicates the functional safe state of the SS1 safety function

TRUE

The SS1 safety function is active and currently in its safe state.

FALSE

The SS1 safety function is not requested, has not yet achieved its safe state, the function or the SafeMOTION module is currently in an error state or the function block has not been enabled.

2.6.7 S_SafetyActiveSS2

General function

- Status information for the "Safe Stop 2" (SS2) safety function

Data type

- SAFEBOOL

Connection

- Variable

Description of function

Indicates the functional safe state of the SS2 safety function

TRUE

The SS2 safety function is active and currently in its safe state.

FALSE

The SS2 safety function is not requested, has not yet achieved its safe state, the function or the SafeMOTION module is currently in an error state or the function block has not been enabled.

2.6.8 S_SafetyActiveSLS1

General function

- Status information for the "Safely Limited Speed" safety function, Speed Limit 1

Data type

- SAFEBOOL

Connection

- Variable

Description of function

Indicates the functional safe state of the SLS1 safety function

TRUE

The SLS1 safety function is active and currently in its safe state.

FALSE

The SLS1 safety function is not requested, has not yet achieved its safe state, the function or the SafeMOTION module is currently in an error state or the function block has not been enabled.

2.6.9 S_SafetyActiveSLS2

General function

- Status information for the "Safely Limited Speed" safety function, Speed Limit 2

Data type

- SAFEBOOL

Connection

- Variable

Description of function

Indicates the functional safe state of the SLS2 safety function

TRUE

The SLS2 safety function is active and currently in its safe state.

FALSE

The SLS2 safety function is not requested, has not yet achieved its safe state, the function or the SafeMOTION module is currently in an error state or the function block has not been enabled.

2.6.10 S_SafetyActiveSLS3

General function

- Status information for the "Safely Limited Speed" safety function, Speed Limit 3

Data type

- SAFEBOOL

Connection

- Variable

Description of function

Indicates the functional safe state of the SLS3 safety function

TRUE

The SLS3 safety function is active and currently in its safe state.

FALSE

The SLS3 safety function is not requested, has not yet achieved its safe state, the function or the SafeMOTION module is currently in an error state or the function block has not been enabled.

2.6.11 S_SafetyActiveSLS4

General function

- Status information for the "Safely Limited Speed" safety function, Speed Limit 4

Data type

- SAFEBOOL

Connection

- Variable

Description of function

Indicates the functional safe state of the SLS4 safety function

TRUE

The SLS4 safety function is active and currently in its safe state.

FALSE

The SLS4 safety function is not requested, has not yet achieved its safe state, the function or the SafeMOTION module is currently in an error state or the function block has not been enabled.

2.6.12 S_SafetyActiveSLI

General function

- Status information for the "Safely Limited Increment" safety function

Data type

- SAFEBOOL

Connection

- Variable

Description of function

Indicates the functional safe state of the SLI safety function

TRUE

The SLI safety function is active and currently in its safe state.

FALSE

The SLI safety function is not requested, the function or the SafeMOTION module is currently in an error state or the function block has not been enabled.

2.6.13 S_SafetyActiveSDIpos

General function

- Status information for the "Safe Direction" safety function. Movement is allowed in the positive direction.

Data type

- SAFEBOOL

Connection

- Variable

Description of function

Indicates the functional safe state of the SDIpos safety function

TRUE

The SDIpos safety function is active and currently in its safe state.

FALSE

The SDIpos safety function is not requested, the function or the SafeMOTION module is currently in an error state or the function block has not been enabled.

2.6.14 S_SafetyActiveSDIneg

General function

- Status information for the "Safe Direction" safety function. Movement is allowed in the negative direction.

Data type

- SAFEBOOL

Connection

- Variable

Description of function

Indicates the functional safe state of the SDIneg safety function

TRUE

The SDIneg safety function is active and currently in its safe state.

FALSE

The SDIneg safety function is not requested, the function or the SafeMOTION module is currently in an error state or the function block has not been enabled.

2.6.15 S_SafetyActiveSDC

General function

- Information about the status of ramp monitoring

Data type

- SAFEBOOL

Connection

- Variable

Description of function

This output parameter indicates the status of ramp monitoring.

TRUE

Ramp monitoring is active.

FALSE

Ramp monitoring is not active, the SafeMOTION module is currently in an error state or the function block has not been enabled.

> **Danger!**
>
> **This signal should only be used for status information.**

2.6.16 S_AllReqFuncActive

General function

- Information about the status of the requested safety functions

Data type

- SAFEBOOL

Connection

- Variable

Description of function

This output parameter specifies the status of the requested safety functions.

TRUE

All requested safety functions are currently in their functional safe state.

FALSE

One or more safety functions have not yet achieved their safe state, the SafeMOTION module is in an error state or the function block has not been enabled.

2.6.17 S_NotErrFUNC

General function

- Information about the error state of the safe SafeMOTION module

Data type

- SAFEBOOL

Connection

- Variable

Description of function

This output parameter specifies the error status of the SafeMOTION module.

TRUE

No error was found on the SafeMOTION module.

FALSE

An error was detected on the SafeMOTION module (e.g. a monitored limit was exceeded), or the function block has not been enabled.
In the event of an error, additional information about the error can be found in the Safety Logger in Automation Studio.
If the error is a functional error, then it can be acknowledged by changing the signal on the "Reset" input from FALSE to TRUE (rising edge)!

> ## Danger!
>
> **This signal should only be used for status information. It only provides information in connection with the requested safety functions.**
> **S_NotErrFUNC does not represent the functional safe state of the SafeMOTION module!**

> ## Danger!
>
> **It is your responsibility to ensure that all necessary repair measures are initiated after an error occurs since subsequent errors can result in dangerous situations!**

2.6.18 Error

General function

- Function block error message

Data type

- BOOL

Connection

- Variable

Description of function

This formal parameter indicates a pending function block error message.

TRUE

The enabled function block has detected an error. **DiagCode** indicates the error code.

FALSE

The function block is not enabled, or the enabled function block has not detected any errors. **DiagCode** indicates the status.

Danger!

It is your responsibility to ensure that all necessary repair measures are initiated after an error occurs since subsequent errors can result in dangerous situations!

In order to exit an error state (**Error** = TRUE), the signal on the **Reset** input must change from FALSE to TRUE (rising edge).

2.6.19 DiagCode

General function

- Function block diagnostic message

Data type

- WORD

Connection

- Variable

Description of function

This output parameter is used to output diagnostic and status messages specific to the function block and make them available automatically to diagnostic tools.

These diagnostic tools cannot acknowledge diagnostic messages from function blocks. This is done exclusively in the **safety** application.

The function block indicates the presence of an error message on the **DiagCode** output via the **Error** output parameter.

Diagnostic code

The diagnostic code is specified as a WORD data type. The values and meanings of these diagnostic codes are listed below.

In the event of status messages ($0xxx_{hex}$, $8xxx_{hex}$), the function block sets **Error** to FALSE.

In the event of error messages ($Cxxx_{hex}$), the function block sets **Error** to TRUE.

2.6.20 Diagnostic codes

Code (hex)	State	Description	Possible remedy
0000	IDLE	The function block is not enabled.	Enable the function block by setting **Activate** to TRUE.
8001	INIT	The function block has been enabled and the SafeMOTION module is in the INIT state. The SafeMOTION module restart inhibit is active.	Configure the "Startreset" parameter accordingly or execute a positive edge on the **Reset** input.
8002	OPERATIONAL	The SafeMOTION module is in the OPERATIONAL state. No safety function is selected. The SMS speed limit is monitored according to the configuration.	No action required
8003	WAIT FOR CONFIRMATION	The SafeMOTION module is in the internal OPERATIONAL state. At least one safety function has been requested and at least one safety function has not yet achieved its functional safe state. None of the limits currently being monitored have been violated.	No action required
8000	SAFE STATE	All requested safety functions have achieved their functional safe state. None of the limits currently being monitored have been violated.	No action required
C000	FUNCTIONAL FAIL SAFE	An error has occurred!	Check the Safety Logger in Automation Studio. It will provide detailed information about the current error. Depending on the type of error, check the standard and/or safety application. For functional errors, check the configuration of the ACOPOSmulti SafeMOTION module or replace the faulty ACOPOSmulti SafeMOTION inverter module.

Table 178: SF_SafeMC_BR(_V2, _V3): Diagnostic codes

2.6.21 AxisStatus

General function

- Diagnostic message from the function block, representation of the axis status bits in a DWORD

Data type

- DWORD

Connection

- Variable

Description of function

The **AxisStatus** output returns bit-coded information about the status of individual safety functions.
This information corresponds to a summary of the **S_xxx** outputs in a DWORD.
The individual bits have the following meaning:

Bit 0	**Bit 1**	**Bit 2**	**Bit 3**	**Bit 4**	**Bit 5**	**Bit 6**	**Bit 7**
Status STO	Status SBC	Status SOS	Status SS1	Status SS2	Status SLS1	Status SLS2	Status SLS3
Bit 8	**Bit 9**	**Bit 10**	**Bit 11**	**Bit 12**	**Bit 13**	**Bit 14**	**Bit 15**
Status SLS4	Status STO1	Status SDI pos	Status SLI	Status SDI neg	-	-	-
Bit 16	**Bit 17**	**Bit 18**	**Bit 19**	**Bit 20**	**Bit 21**	**Bit 22**	**Bit 23**
-	Status Setposition Alive Test	Status SFR	Status "All requested safety functions active"	Status SDC	Status operational	Status Not Encoder Error	Status Not Functional Error

Table 179: SF_SafeMC_BR: SafeMOTION module status bits

2.7 State machine

The state machine illustrated here is implemented on the SafeMOTION module.

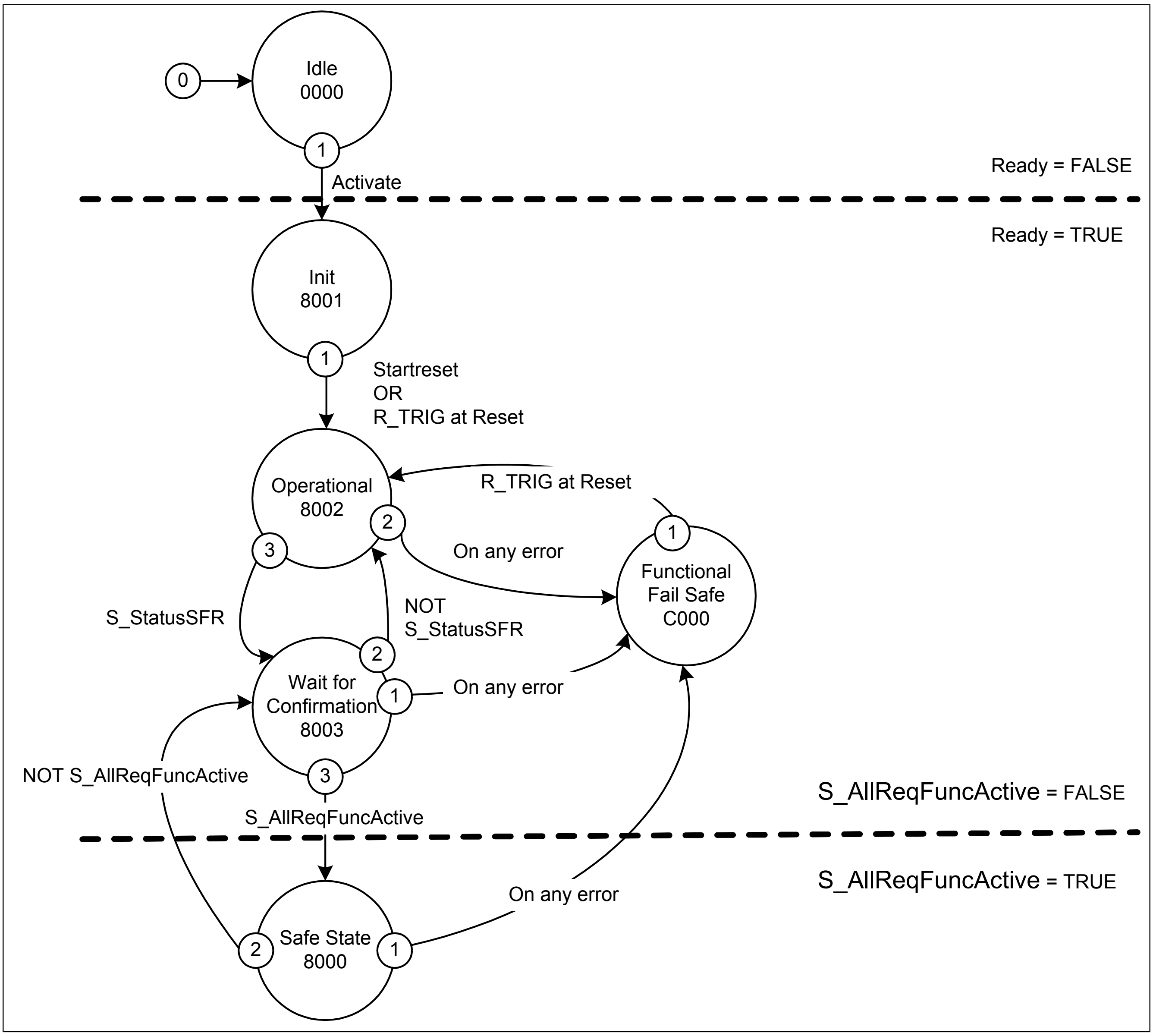


Figure 68: SF_SafeMC_BR(_V2, _V3): State machine

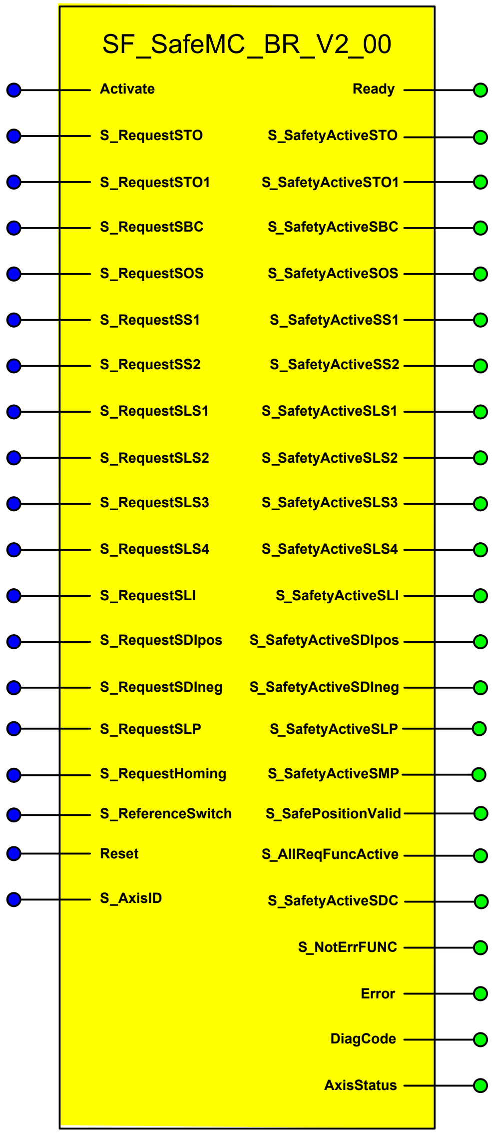
Individual states are reflected by the **DiagCode** output parameter. In this way, the function block provides a representation of the state machine on the SafeMOTION module.

2.8 Signal sequence diagram of the function block

A general signal sequence diagram of the function block cannot be specified since it depends on which safety functions are selected or deselected.

See "ACOPOSmulti SafeMOTION user's manual / Safety technology / Integrated safety functions".

3 SF_SafeMC_BR_V2



Information:

The SF_SafeMC_BR_V2_00 function block can only be used with Safety Release 1.4.

If Safety Release 1.3 is being used, then SafeDESIGNER will return an error when compiling the safety application!

3.1 Formal parameters of the function block

In the following, the term "variable" refers to both a variable as well as a graphic connection.

Name	Type	Connection	Signal type [1]	Initial value	Description / General function
Activate	BOOL	Variable / Constant	Status	FALSE	Enables the function block (= TRUE)
S_RequestSTO	SAFEBOOL	Variable / Constant	Status	SAFEFALSE	STO safety function request: SAFEFALSE: Safety function requested
S_RequestSTO1	SAFEBOOL	Variable / Constant	Status	SAFEFALSE	STO1 safety function request: SAFEFALSE: Safety function requested
S_RequestSBC	SAFEBOOL	Variable / Constant	Status	SAFEFALSE	SBC safety function request: SAFEFALSE: Safety function requested
S_RequestSOS	SAFEBOOL	Variable / Constant	Status	SAFEFALSE	SOS safety function request: SAFEFALSE: Safety function requested
S_RequestSS1	SAFEBOOL	Variable / Constant	Status	SAFEFALSE	SS1 safety function request: SAFEFALSE: Safety function requested
S_RequestSS2	SAFEBOOL	Variable / Constant	Status	SAFEFALSE	SS2 safety function request: SAFEFALSE: Safety function requested
S_RequestSLS1	SAFEBOOL	Variable / Constant	Status	SAFEFALSE	SLS1 safety function request: SAFEFALSE: Safety function requested
S_RequestSLS2	SAFEBOOL	Variable/ Constant	Status	SAFEFALSE	SLS2 safety function request: SAFEFALSE: Safety function requested
S_RequestSLS3	SAFEBOOL	Variable / Constant	Status	SAFEFALSE	SLS3 safety function request: SAFEFALSE: Safety function requested
S_RequestSLS4	SAFEBOOL	Variable / Constant	Status	SAFEFALSE	SLS4 safety function request: SAFEFALSE: Safety function requested
S_RequestSLI	SAFEBOOL	Variable / Constant	Status	SAFEFALSE	SLI safety function request: SAFEFALSE: Safety function requested
S_RequestSDIpos	SAFEBOOL	Variable / Constant	Status	SAFEFALSE	SDIpos safety function request: SAFEFALSE: Safety function requested
S_RequestSDIneg	SAFEBOOL	Variable / Constant	Status	SAFEFALSE	SDIneg safety function request: SAFEFALSE: Safety function requested
S_RequestSLP	SAFEBOOL	Variable / Constant	Status	SAFEFALSE	SLP safety function request SAFEFALSE: Safety function requested
S_RequestHoming	SAFEBOOL	Variable / Constant	Status	SAFEFALSE	Request for Safe Homing Request is made on a rising edge!
S_ReferenceSwitch	SAFEBOOL	Variable / Constant	Status	SAFEFALSE	Safe input for a reference switch
Reset	BOOL	Variable	Edge	FALSE	Resets error messages and the SafeMOTION module after the cause of the error has been removed
S_AxisID	SAFEINT	Constant	Status	-1	Assigns an axis to the function block

Table 180: SF_SafeMC_BR_V2: Overview of input parameters

1) Evaluation of the input parameter signals in the function block. The signals must be controlled accordingly by the user.

Name	Type	Connection	Signal type [1]	Initial value	Description / General function
Ready	BOOL	Variable	Status	FALSE	Indicates that the function block is enabled
S_SafetyActiveSTO	SAFEBOOL	Variable	Status	SAFEFALSE	STO safety function active (= SAFETRUE)
S_SafetyActiveSTO1	SAFEBOOL	Variable	Status	SAFEFALSE	Safety function STO1 active (= SAFETRUE)
S_SafetyActiveSBC	SAFEBOOL	Variable	Status	SAFEFALSE	SBC safety function active (= SAFETRUE)
S_SafetyActiveSOS	SAFEBOOL	Variable	Status	SAFEFALSE	SOS safety function active, no violation of a monitored limit (= SAFETRUE)
S_SafetyActiveSS1	SAFEBOOL	Variable	Status	SAFEFALSE	SS1 safety function active, deceleration monitoring completed, no violation of a monitored limit detected (= SAFETRUE)
S_SafetyActiveSS2	SAFEBOOL	Variable	Status	SAFEFALSE	SS2 safety function active, deceleration monitoring completed, no violation of a monitored limit detected (= SAFETRUE)
S_SafetyActiveSLS1	SAFEBOOL	Variable	Status	SAFEFALSE	SLS1 safety function active, deceleration monitoring completed, no violation of a monitored limit detected (= SAFETRUE)
S_SafetyActiveSLS2	SAFEBOOL	Variable	Status	SAFEFALSE	SLS2 safety function active, deceleration monitoring completed, no violation of a monitored limit detected (= SAFETRUE)
S_SafetyActiveSLS3	SAFEBOOL	Variable	Status	SAFEFALSE	SLS3 safety function active, deceleration monitoring completed, no violation of a monitored limit detected (= SAFETRUE)

Table 181: SF_SafeMC_BR_V2: Overview of output parameters

Name	Type	Connection	Signal type 1)	Initial value	Description / General function
S_SafetyActiveSLS4	SAFEBOOL	Variable	Status	SAFEFALSE	SLS4 safety function active, deceleration monitoring completed, no violation of a monitored limit detected (= SAFETRUE)
S_SafetyActiveSLI	SAFEBOOL	Variable	Status	SAFEFALSE	SLI safety function active, no violation of a monitored limit (= SAFETRUE)
S_SafetyActiveSDIpos	SAFEBOOL	Variable	Status	SAFEFALSE	SDIpos safety function active (= SAFETRUE)
S_SafetyActiveSDIneg	SAFEBOOL	Variable	Status	SAFEFALSE	Safety function SDIneg active (= SAFETRUE)
S_SafetyActiveSLP	SAFEBOOL	Variable	Status	SAFEFALSE	SLP safety function active (= SAFETRUE)
S_SafetyActiveSMP	SAFEBOOL	Variable	Status	SAFEFALSE	SMP safety function active (= SAFETRUE)
S_SafePositionValid	SAFEBOOL	Variable	Status	SAFEFALSE	Specifies whether the safe position is valid (=SAFETRUE, homing procedure has completed successfully and there are no encoder errors)
S_AllReqFuncActive	SAFEBOOL	Variable	Status	SAFEFALSE	All requested safety functions have achieved their safe state. (= SAFETRUE)
S_SafetyActiveSDC	SAFEBOOL	Variable	Status	SAFEFALSE	Deceleration monitoring active (= SAFETRUE)
S_NotErrFUNC	SAFEBOOL	Variable	Status	SAFEFALSE	SafeMOTION module not in the FUNCTIONAL FAIL SAFE state (= SAFETRUE)
Error	BOOL	Variable	Status	FALSE	Function block error message
DiagCode	WORD	Variable	Status	16#0000	Function block diagnostic message
AxisStatus	DWORD	Variable	Status	32#00000000	Status information from axis

Table 181: SF_SafeMC_BR_V2: Overview of output parameters

1) Output of the output parameter signals. The signals must be evaluated and/or further processed accordingly by the user.

Type	Description	Size in bits	Format option
BOOL	Bit	1	Bit string
WORD	Word	16	Bit string
SAFEBOOL	Bit	1	Bit string (signal source: safe device)
SAFEDWORD	Double word	32	Bit string (signal source: safe device)
SAFEDINT	Double integer	32	Binary number, hexadecimal number, signed decimal number (signal source: safe device)
SAFEINT	Integer	16	Binary number, hexadecimal number, signed decimal number (signal source: safe device)

Table 182: Format description of the data types

You have the option of linking a safe signal with a non-safe input parameter. To do so, use a function block for type conversion.

Caution!

You are responsible for any conversion of a non-safe input parameter to a safe signal.

3.2 SafeMOTION module parameters

Parameter	Unit	Description	Safety function
Encoder Unit System			
Count of physical reference system	-	Rotary encoder unit scale: x revolutions Linear encoder unit scale: x reference lengths (reference length = length of the physical reference system) Any unit (mm, 1/100 mm, 1/20 inch, degree of angle, etc.) can be used for positions (and data which can result such as speed and acceleration). For this reason, the relationship between an integer multiple of this unit (units per x revolutions / units per x reference lengths) and a certain number of x revolutions / x reference lengths has to be previously defined.	Unit system
Units per count of physical reference system [units]	units	Rotary encoder unit-scale: Units per x revolutions Linear encoder unit scale: Units per x reference lengths Any unit (mm, 1/100 mm, 1/20 inch, degree of angle, etc.) can be used for positions (and data which can result such as speed and acceleration). Therefore, the relationship between an integer multiple of this unit (units per x-revolutions / units per x-reference lengths) and a certain number of x-revolutions / x-reference lengths has to be previously defined.	Unit system
Counting direction	Standard / Inverse	Counting direction of the position or speed Default…Encoder counter direction is equal to the counting direction of the unit system Inverse…Encoder counting direction is negative to the counting direction of the unit system	Unit system
Length of physical reference system for linear encoder (nm)	nm	For linear measurement systems, the length of a physical reference system will be defined here. This value is not used for rotary encoders, where the reference system is a single revolution.	Unit system
Maximum speed to normalize the speed range (units)	units	Maximum speed to which the displayed speed should be normalized	Unit system
Maximum acceleration (rad/s² or mm/s²)	rad/s² or mm/s²	Maximum permissible encoder acceleration	Unit system
Homing			
Home Position or Home Offset (units)	units	Home position or home offset	Homing
Max. trigger speed (units/s)	units/s	Maximum permissible speed for evaluating the reference switch / reference pulse.	Homing
Homing Monitoring Time (µs)	µs	Monitoring time for the homing procedure	Homing
Mode	Direct / Reference Switch / Home Offset / Home Offset with Correction	Selects the homing mode	Homing
Edge of reference switch	Positive / Negative	Selects the switching edge for the reference switch The switch edge for the reference switch input is positive if the logical state of the reference switch changes from SAFEFALSE to SAFETRUE in the positive direction of movement.	Homing
Trigger direction	Positive / Negative	Selects the trigger direction If the homing procedure requires a movement, then this parameter specifies the direction for evaluating the reference switch / reference pulse.	Homing
Reference pulse	Used / Not Used	Selects whether or not to use a reference pulse for homing	Homing
Blocking distance (% encoder reference system)	%	Distance within which evaluation of the reference pulse will be suppressed. This is calculated starting at the configured reference switch edge and indicated as a percentage of the encoder reference system. A single revolution is used as the encoder reference system for rotary encoders.	Homing
Safety Deceleration Ramp			
Deceleration Ramp	[units/s²]	Slope of the deceleration ramp to be monitored	SS1, SS2, SLS
General Settings			
Safe Maximum Speed	Used / Unused	Activates the SMS safety function from the configuration	SMS
Automatic Reset at Startup (Startreset)	Used / Unused	Activates automatic reset of the function block at startup	Configuration
Channel selection for One Channel STO (STO1)	HighSide / LowSide	Selection of HighSide or LowSide IGBT in the function One Channel STO	STO1 / Configuration FUNCTIONAL FAIL SAFE
Rampmonitoring for SS1	Activated / Deactivated	Activates ramp-based monitoring (in addition to time-based monitoring) when the SS1 safety function is requested	SS1
Rampmonitoring for SS2	Activated / Deactivated	Activates ramp-based monitoring (in addition to time-based monitoring) when The SS2 safety function is requested	SS2
Rampmonitoring for SLS	Activated / Deactivated	Activates ramp-based monitoring (in addition to time-based monitoring) when the SLS safety function is requested	SLS
Early Limit Monitoring	Activated / Deactivated	Monitoring of the deceleration ramp is prematurely terminated if the target limit is reached or exceeded.	SS1, SS2, SLS
Safe Maximum Position	Used / Unused	Activates the SMP safety function from the configuration	SMP
Encoder Monitoring			
Encoder Position Monitoring	Activated / Deactivated	Activates/Deactivates monitoring of the position lag error generated on the SafeMOTION module	Monitoring Encoder shaft breakage
Encoder Speed Monitoring	Activated / Deactivated	Activates/Deactivates monitoring of the speed error generated on the SafeMOTION module	Monitoring Encoder shaft breakage

Table 183: SF_SafeMC_BR_V2: Module parameters

Parameter	Unit	Description	Safety function
Set position alive testing	Activated / Deactivated	Activates/deactivates the monitor that detects whether the set position generated on the ACOPOSmulti SafeMOTION inverter module is frozen.	Monitoring Encoder shaft breakage
Behavior of Functional Fail Safe			
Behavior of Functional Fail Safe	STO/ STO1 and STO with time delay	In the FUNCTIONAL FAIL SAFE state, STO (SBC) is activated immediately or STO1 and then STO (SBC) after a delay.	Configuration
Delay time for STO in Functional Fail Safe	[µs]	Delay time between STO1 and STO (and SBC) in the state FUNCTIONAL FAIL SAFE	Configuration
Delay time until the brake engages	[µs]	Delay time before the brake engages The second enable channel is activated after this delay time if STO1 and delayed STO and SBC are configured for FUNCTIONAL FAIL SAFE.	Configuration
Safety Speed Limits			
Maximum Speed for SMS	[units/s]	Speed limit of the maximum speed	SMS
Safe Speedlimit 1 for SLS	[units/s]	Speed limit 1 for SLS	SLS
Safe Speedlimit 2 for SLS	[units/s]	Speed limit 2 for SLS	SLS
Safe Speedlimit 3 for SLS	[units/s]	Speed limit 3 for SLS	SLS
Safe Speedlimit 4 for SLS	[units/s]	Speed limit 4 for SLS	SLS
Safety Position Limits			
Safe Lower Position Limit for SMP (units)	[units]	Lower position limit for the machine's full range of movement	SMP
Safe Upper Position Limit for SMP (units)	[units]	Upper position limit for the machine's full range of movement	SMP
Safe Lower Position Limit for SLP (units)	[units]	Lower position limit for the monitoring range	SLP
Safe Upper Position Limit for SLP (units)	[units]	Upper position limit for the monitoring range	SLP
Safety Standstill and Direction Tolerances			
Speed Tolerance	[units/s]	Speed tolerance for standstill monitoring	SOS, SS2, SLI, SMP, SLP
Position Tolerance	[units]	Position tolerance for standstill and direction monitoring	SOS, SS2, SDI, SMP, SLP
Safely Limited Increments			
Safe increments	[units]	Maximum movable increments when SLI is active	SLI
SLI Off Delay	[µs]	Switch off delay of SLI	SLI
Safety Ramp Monitoring Times			
Ramp Monitoring Time for SS1 (us)	[µs]	Deceleration ramp monitoring time for SS1	SS1
Ramp Monitoring Time for SS2 (us)	[µs]	Deceleration ramp monitoring time for SS2	SS2
Ramp Monitoring Time for SLS1 (us)	[µs]	Deceleration ramp monitoring time for SLS1	SLS1
Ramp Monitoring Time for SLS2 (us)	[µs]	Deceleration ramp monitoring time for SLS2	SLS2
Ramp Monitoring Time for SLS3 (us)	[µs]	Deceleration ramp monitoring time for SLS3	SLS3
Ramp Monitoring Time for SLS4 (us)	[µs]	Deceleration ramp monitoring time for SLS4	SLS4
Safety Additional Parameters			
Delay time to start ramp monitoring (us)	[µs]	Delay time between the request for ramp-based monitoring and the start of monitoring	SS1, SS2, SLS
Delay time to start SDI (us)	[µs]	Delay time between the SDI request and activation of the safety function	SDI
Delay time to start SBC (us)	[µs]	Delay time between the SBC request and activation of the safety function	SBC
Delay time to start SLP (us)	[µs]	Delay time between the SLP request and start of monitoring	SLP
Early Limit Monitoring time (us)	[µs]	Time during which the speed must be equal to or below the target speed limit in order to prematurely end the deceleration ramp and to assume the safety function's end state	SS1, SS2, SLS
Encoder Monitoring Tolerances			
Encoder Monitoring Position Tolerance	[units]	Position lag error tolerance for shaft breakage monitoring	Monitoring Encoder shaft breakage
Encoder Monitoring Speed Tolerance	[units/s]	Speed error tolerance for encoder monitoring	Monitoring Encoder shaft breakage

Table 183: SF_SafeMC_BR_V2: Module parameters

In a safety application, it is possible for multiple safety functions to be requested at the same time. In order to prevent this from turning into an unsafe situation, the individual safety functions are prioritized on the SafeMOTION module.

If several functions are active at the same time, then the lowest speed limit is always the value being monitored.

Information:

The following application rule must be followed in order for the safety functions to be prioritized correctly:

$LIM_{SOS} \leq LIM_{SLS4} \leq LIM_{SLS3} \leq LIM_{SLS2} \leq LIM_{SLS1} \leq LIM_{SMS} < NormSpeed$

or

$LIM_{SMP,NEG} \leq LIM_{SLP,NEG} \leq LIM_{SLP,POS} \leq LIM_{SMP,POS}$

If the application rule is violated, then the SafeMOTION module will switch to the FAIL SAFE state.

3.3 Integrated safety functions

See "ACOPOSmulti SafeMOTION user's manual / Safety technology / Integrated safety functions".

3.4 Safe encoder connection monitoring

3.4.1 Encoder mounting with proof of fatigue strength

To prevent errors caused by encoder slippage or shaft breakage, the mechanical mounting of the encoder requires proof of fatigue strength.

This proof and the corresponding mounting guidelines can be provided either by the manufacturer of the measuring instrument or by the manufacturer of the machine.

> **Danger!**
>
> **To ensure safe operation up to and including the motor shaft, any errors in the connection between the motor shaft and encoder must be identified and prevented.**

> **Danger!**
>
> **Proof of fatigue strength for the encoder's mechanical mounting is to be dimensioned to the maximum rotor acceleration. This acceleration value must not be exceeded in the worst case. The maximum acceleration is monitored on the SafeMOTION module and can be configured using the "Maximum acceleration" parameter.**

> **Danger!**
>
> **Mechanical tolerances in the encoder mounting must be taken into account when calculating the residual distance. This residual movement must be taken into account by the safety functions.**

> **Danger!**
>
> **To ensure safe operation up to and including the motor shaft, any errors in the connection between the motor shaft and encoder must be identified and prevented.**
> **There are specific guidelines that must be followed when installing a functional safety encoder.**
> **The motor manufacturer must ensure that these specifications are adhered to.**

> **Danger!**
>
> **The frictional connection between the cone-shaped shaft of the rotor and measuring instrument can be dimensioned for maximum rotor acceleration in accordance with the mounting instructions provided by the encoder manufacturer. This acceleration value must not be exceeded in the worst case. The maximum acceleration is monitored on the SafeMOTION module and can be configured using the "*Maximum acceleration*" parameter.**

> **Danger!**
>
> **If the terminal screw for the coupling ring becomes loose on installed measuring instruments, then the form-fit pin will be the only thing holding the encoder to the motor housing. A movement in accordance with the mounting tolerances is possible. The encoder is not able to register this movement. This residual movement must be taken into account by the safety functions.**

3.4.2 Encoder mounting without proof of fatigue strength - Safe lag error monitoring

If "Encoder Monitoring" is activated in the SafeMOTION module, in some applications the proof of fatigue strength for the mechanical mounting of the encoder is not required.

The following safety-related restrictions must be taken into account!

> **Danger!**
>
> **Only safety functions in which no safe absolute position is monitored are permitted to be used (STO, SBC, SOS, SS1, SS2, SLS, SMS, SLI, SDI, SLA, SBT (only available for ACOPOSmulti SafeMOTION SinCos) and Safe Speed).**

Danger!

The application must meet the following requirements for safety-related monitoring of the encoder-motor connection:

- **Encoder connection monitoring can only be used for encoders that are integrated in position control.**
- **Encoder connection monitoring can only be used for drive systems with synchronous motors.**
- **The encoder must be protected against shearing in standstill (e.g. with encasement in the motor housing)!**
- **Monitoring for position lag errors, speed errors and position setpoints change (Alive Testing) must be enabled in the safety application, and sufficiently strict limits must be monitored!**
- **The Safe Position, SLP and/or SMP safety functions must not be used!**
- **Safe monitoring can only be guaranteed when closed-loop control is enabled.**

Danger!

- **An electrical offset of <90° will not be detected sufficiently.**
- **There is no way to monitor the encoder connection if the setpoint remains constant.**
- **An encoder connection error or an error in encoder evaluation is always assumed as the cause for the lag error.**
- **The error reaction in the standard application to a position lag error or speed error is disabled by the SafeMOTION module (overridden). When lag errors occur, only the error responses STO or STO1 with an induction stop are possible.**

Danger!

Note that an error can result in a forward movement. The maximum angle of rotation φ of the motor shaft during this forward movement depends on the motor being used.

For permanently excited synchronous motors, φ = 360°/2p (for B&R standard motors, p=3 so the angle is 60°). For three-phase induction motors, there is a relatively small angle of rotation (between 5° and 15°).

The maximum speed of the forward movement can be calculated as follows:

$$n_{Jolt} = \frac{1}{2\pi}\sqrt{\frac{6a_{max}}{p_z}}\left[\frac{U}{s}\right]$$

with maximum acceleration $a_{max} = \frac{M_{max}}{J}\left[\frac{rad}{s^2}\right]$ **and number of motor pole pairs** p_z

Danger!

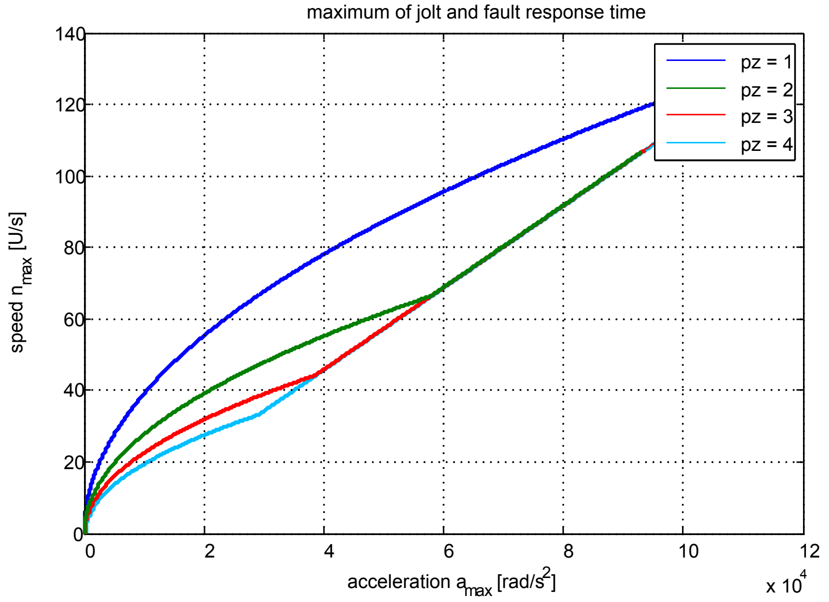
When considering the worst-case scenario for a safety function, the highest value of the maximum speed of the forward movement n_{Jolt} **and the speed must be used as maximum speed due to the maximum error response time** $n_{T_{worstcase}}$**.**

$$n_{max} = max(n_{Jolt}, n_{T_{worstcase}}) = max\left(\frac{1}{2\pi}\sqrt{\frac{6a_{max}}{p_z}}, \frac{T_{worstcase}}{2\pi}\cdot a_{max}\right)$$

with maximum error response time $T_{worstcase} = 7.2[ms]$

The maximum speed n_{max} **resulting from this must be considered together with the speed when the safety function** n_{LIM} **is violated in order to determine the maximum possible speed** $n_{worstcase}$ **at the time of coasting to a stop!**

$$n_{worstcase} = n_{LIM} + n_{max}$$



Information:

In order to check the plausibility of setpoint selection after each power on, the axis must be moved by at least twice the configured lag error limit before the first request of a safety function, which requires a safe encoder evaluation, or at least within 15 min.
If this is not done, then the SafeMOTION module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state. The S_NotErrFUNC output on the function block is reset, and the drive loses all torque/power and coasts to a stop!
In the event of an error, a synchronous axis will no longer be synchronous.

Danger!

Situations involving external forces (e.g. hanging loads) can result in dangerous movements!
If this poses a safety risk, then the user must implement the necessary equipment to eliminate the risk (e.g. mechanical brakes)! This equipment must correspond to the required safety level!

Information:

A 24-hour timeout begins after successfully checking the plausibility of the setpoint.
The timeout is reset any time the position setpoint changes by more than twice the position lag error tolerance.
If the position setpoint does not change during 24 hours of continuous controller operation, then the SafeMOTION module will switch to the acknowledgeable FUNCTIONAL FAIL SAFE error state. The S_NotErrFUNC output on the function block is reset, and the drive loses all torque/power and coasts to a stop! In the event of an error, a synchronous axis will no longer be synchronous.

The following parameters are relevant for safe monitoring of the encoder-motor shaft connection (Encoder Monitoring):

Parameter	Unit	Description	Default value
Encoder Unit System			
Maximum acceleration [rad/s² or mm/s²]	[rad/s² or mm/s²]	Maximum permissible encoder acceleration	100000
Encoder Monitoring			
Encoder Position Monitoring	Activated/ Deactivated	Activates/Deactivates the monitoring of the position lag error generated on the SafeMOTION module	Activated
Encoder Speed Monitoring	Activated/ Deactivated	Activates/Deactivates the monitoring of the speed error generated on the SafeMOTION module	Activated
Set position alive testing	Activated/ Deactivated	Activates/Deactivates the monitor that detects whether the position setpoint generated on the ACOPOSmulti SafeMOTION inverter module is frozen	Activated
Encoder Monitoring Tolerances			
Encoder Monitoring Position Tolerance	[units]	Position lag error tolerance for shaft breakage monitoring	0
Encoder Monitoring Speed Tolerance	[units/s]	Speed error tolerance for encoder monitoring	0

Table 184: Encoder Monitoring safety function - Parameters

Danger!

The machine manufacturer is responsible for determining whether or not the application is suited for safe encoder connection monitoring if there is no mechanical mechanism for detecting encoder shaft breakage.
The machine manufacturer is responsible for ensuring that the safe encoder monitoring has been configured correctly!

Danger!

Encoder connection monitoring can only be used in a safety-related capacity if the aforementioned requirements for the application have been fulfilled!

3.4.2.1 Activating monitoring

The following parameters must be set to "Activated" in SafeDESIGNER in order to enable safe encoder connection monitoring:

- "Encoder Position Monitoring" = Activated
- "Encoder Speed Monitoring" = Activated
- "Set position alive testing" = Activated

Danger!

In order to ensure safety-related monitoring of the encoder/motor connection, all three parameters "Encoder Position Monitoring", "Encoder Speed Monitoring" and "Set Position Alive Testing" must be set to "Activated"!
If this is not the case, then the monitoring system cannot be used for safety purposes and a mechanical solution for detecting errors must be implemented!

3.4.2.2 Configuration rule for position lag error tolerance

The position lag error tolerance must be set large enough to ensure availability. This can be done by first measuring the position lag error under the highest influence of disturbance variables and at maximum acceleration and then setting the position lag error tolerance accordingly higher.

Danger!

The position lag error tolerance cannot be higher than half of one pole length!

If the safety function is activated, the size of the position lag error tolerance value affects how long it will take to look for errors and therefore also the error response time and estimation of the residual distance.

This must be taken into account by the machine manufacturer in the risk analysis!

Information:

Due to rounding errors, a reserve of 1 unit should be taken into account with the parameter "Encoder Monitoring Position Tolerance".

3.4.2.3 Configuration rule for speed error tolerance

The speed error tolerance must be set large enough to ensure availability.
This can be done by first measuring the speed error under the highest influence of disturbance variables and reference variables (e.g. at maximum acceleration) and then setting the speed error tolerance accordingly higher.

Danger!

When the safety function is enabled, the size of the speed error tolerance value affects how long it will take to look for errors and therefore also the error response time and estimation of the residual distance.

This must be taken into account by the machine manufacturer in the risk analysis!

Information:

Due to rounding errors, a reserve of 1 unit/s should be taken into account with the "Encoder monitoring speed tolerance" parameter.

3.5 Fault avoidance

> **Danger!**
>
> **Validation**
>
> **Each safety function that is used must be validated separately.**
> **It is also necessary to test the entire safety application, including the interactions between individual functions.**

3.5.1 Exceeding monitored limits

The SafeMOTION module monitors configurable limits. The drive itself, however, is controlled by the standard application on the standard PLC.

The following points must be considered in order to prevent a monitored limit from being violated:

- The movement of the drive must be adapted to the requested safety function and initiated on time.
- The monitored limits must match the calculated limits and movement limitations. Make sure that the different configurations of the unit system match in the safety application and in the standard application!

> **Danger!**
>
> **Any violation of a monitored limit will cause the module to switch to the acknowledgeable FUNCTIONAL FAIL SAFE error state.**
>
> **The S_NotErrFUNC output on the function block is reset, and the drive loses all torque/power and coasts to a stop!**
>
> **Depending on the configuration, the motor holding brake will also be switched to 0 V.**
>
> **In the event of an error, a synchronous axis will no longer be synchronous.**
>
> **Check the Safety Logger in Automation Studio for detailed information about monitoring.**

3.5.2 Plausibility errors

Plausibility errors (limit values, data types, variables/constants) that occur when using the function block are detected and reported by either the function block or compiler.

This is not possible in the event of connection errors, however.

The function block does not check for the following errors:

- Actual parameter values or constants are within their valid range but incorrect for the safety function being executed.
- Actual parameters have been connected incorrectly.
- Formal input/output parameters that should have been connected have not been connected.

> **Danger!**
>
> **Ensuring proper safety function connections (sub-application) is your responsibility as the user!**
>
> **Make sure to check these connections when validating the sub-application!**

3.5.3 Sporadically changing/toggling signal levels or impermissible signals

Sporadically changing or toggling signal levels on edge-controlled formal input parameters causes the function block to interpret the signal as an edge, which results in an unintended action being triggered in the function block if error prevention measures are not taken.

Sporadically changing or toggling signal levels on status-controlled input formal parameters will cause the signal to trigger an undesired corresponding action if error prevention measures are not taken.

Impermissible signals on input formal parameters can lead to an unexpected initial movement, non-execution of a requested action or an error message.

Possible causes of these signals:

- Programming error in the application program (user error)
- Cross fault, short circuit or open line (user error, wiring error)

- Error on the standard controller

To prevent this, the following measures can be taken depending on the safety function:

- Using signals from safe devices
- Implementing additional measures for preventing a hazard if using a signal from a standard controller (e.g. executing an additional function start after a safety function has been triggered or an error has been corrected)
- Line control on the safe control system
- Suitable cabling when using non-safe signals from the standard controller
- Verifying the source code in the application program and final validation of the safety functionality

These measures can also be combined to prevent errors.

It is important to note that a signal change detected on a status-controlled formal parameter will be output as a diagnostic code.

3.5.4 Simultaneous edge change

Make sure that the **Reset** formal parameter is only connected to a signal from a manual resetting device to reduce the risk of an unexpected initial movement. This signal is based on your risk analysis.

3.5.5 Machine/System startup without performing functional testing of safety equipment

Faulty safety equipment can only be detected following functional testing. Functional testing is not supported by this function block. If additional measures are not taken, faulty safety equipment can result in errors.

> **Danger!**
>
> **You are responsible for performing functional testing of safety equipment.**
> **You must therefore ensure that your safety equipment undergoes validation!**

Possible causes of faulty safety equipment:

- Faulty devices (hardware error)
- Cross fault, short circuit or open line (user error, wiring error)

3.6 Input parameters

Information:

For detailed information on the individual safety functions, see "ACOPOSmulti SafeMOTION user's manual/ Chapter: Safety technology / Integrated safety functions".

3.6.1 General information about the "S_Request" inputs

The "**S_Request**" inputs are used to request the respective safety functions.

If a safety function should not be used in the safety application, then the respective input should not be connected.

Information:

If a safety function is not used in the application, then the respective input must remain open.

Danger!

The safety functions that are used must be tested.
A function is considered to be used if the respective input variable is connected!

Information:

At a minimum, the Activate and S_AxisID inputs must be connected. Otherwise, the SafeMOTION module will not be operated by the SafeLOGIC controller. As a result, the pulse disabling and motor holding brake output will be permanently set to 0 V, which means that the controller cannot be turned on.

3.6.2 Activate

General function

- Enables the function block

Data type

- BOOL

Connection

- Constant or variable

Description of function

This input parameter is used to enable the function block.

- If you are activating or deactivating safe devices, link **Activate** to a variable that indicates the status (deactivated or activated) of the corresponding safe devices. This ensures that the function block does not output a triggered safety function as diagnostic information when a device is cut off.
- It is also possible to connect "Activate" to a constant (TRUE) in order to enable the function block.

TRUE

The function block is enabled.

FALSE

The function block is disabled.
All binary output parameters are set to FALSE.
Sets the DiagCode diagnostic parameter to WORD#16#0000.

If you want to control function block diagnostics as needed in your diagnostic concept whenever error messages from safe devices and/or deactivated safe devices occur, connect "Activate" to a signal that indicates the status of the safe devices that are involved with the safety function supported by the function block. Create this signal only for safe devices whose I/O signals are connected to the function block via actual parameters. This prevents triggered safety functions from being reported by inactive safe devices. This measure is only used to control diagnostics in the event of inactive safe devices.

3.6.3 S_RequestSTO

General function

- Selects/Deselects the "Safe Torque Off" (STO) safety function

Data type

- SAFEBOOL

Connection

- Constant or variable

Description of function

This input parameter is used to select or deselect the STO safety function.

TRUE

The safety function is deselected. Safe pulse disabling is not active!

FALSE

The safety function is selected. Safe pulse disabling is active! Torque/Power are switched off on the drive.

Not connected

The safety function is deactivated.

Relevant configuration parameters

- None

3.6.4 S_RequestSTO1

General function

- Selects/Deselects the "Safe Torque Off, One Channel" (STO1) safety function

Data type

- SAFEBOOL

Connection

- Constant or variable

Description of function

This input parameter is used to select or deselect the STO1 safety function.

TRUE

The safety function is deselected. Safe pulse disabling is not active!

FALSE

The safety function is selected. Depending on the configuration, the HighSide or LowSide of safe pulse disabling is active! Torque/Power are switched off on the drive.

Not connected

The safety function is deactivated.

Relevant configuration parameters

Parameter	Unit	Description	Default value
General Settings			
Channel selection for One Channel STO (STO1)	HighSide/ LowSide	Selects the HighSide or LowSide IGBT in the STO1 function	HighSide

Table 185: STO1 safety function - Parameters

3.6.5 S_RequestSBC

General function

- Selects/Deselects the "Safe Brake Control" (SBC) safety function

Data type

- SAFEBOOL

Connection

- Constant or variable

Description of function

This input parameter is used to select or deselect the SBC safety function.

TRUE

The safety function is deselected. The motor holding brake is active and can be used by the standard application.

FALSE

The safety function is selected. The motor holding brake is switched to 0 V!

Not connected

The safety function is deactivated.

Relevant configuration parameters

Parameter	Unit	Description	Default value
Safety Additional Parameters			
Delay time to start SBC (us)	[µs]	Delay time between the SBC request and activation of the safety function	0

Table 186: SBC safety function - Parameters

3.6.6 S_RequestSOS

General function

- Selects/Deselects the "Safe Operating Stop" (SOS) safety function

Data type

- SAFEBOOL

Connection

- Constant or variable

Description of function

This input parameter is used to select or deselect the SOS safety function.

TRUE

The safety function is deselected. Standstill tolerances are not being monitored.

FALSE

The safety function is selected. Standstill tolerances are being monitored.

Not connected

The safety function is deactivated.

Relevant configuration parameters

Parameter	Unit	Description	Default value
Safety Standstill and Direction Tolerances			
Speed Tolerance	[units/s]	Speed tolerance for standstill monitoring	0
Position Tolerance	[units]	Position tolerance for standstill and direction monitoring	0

Table 187: SOS safety function - Parameters

Information:

This safety function requires safe evaluation of the position and speed.
If an evaluation error is detected, then the SafeMOTION module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state.

Information:

If several safety functions are active, then the lowest speed limit is always the value being monitored.

The following application rule must be observed:
$\mathbf{LIM_{SOS} \leq LIM_{SLS4} \leq LIM_{SLS3} \leq LIM_{SLS2} \leq LIM_{SLS1} \leq LIM_{SMS} < NormSpeed}$

Failure to follow the application rule will cause the SafeMOTION module to enter the FAIL SAFE state. If this occurs, it can only be brought back to the OPERATIONAL state by modifying the safety application and completing a power off/on cycle!

3.6.7 S_RequestSS1

General function

- Selects/Deselects the "Safe Stop 1" (SS1) safety function

Data type

- SAFEBOOL

Connection

- Constant or variable

Description of function

This input parameter is used to select or deselect the SS1 safety function.

TRUE

The safety function is deselected. Safe Stop 1 is not active!

FALSE

The safety function is selected. Safe pulse disabling is activated after the end of ramp monitoring.

Not connected

The safety function is deactivated.

Relevant configuration parameters

Parameter	Unit	Description	Default value
Safety Deceleration Ramp			
Deceleration Ramp	[units/s²]	Slope of the deceleration ramp to be monitored	1073676289
General Settings			
Rampmonitoring for SS1	Activated/ Deactivated	Activates ramp-based monitoring (in addition to time-based monitoring) when the SS1 function is requested	Activated
Early Limit Monitoring	Activated/ Deactivated	Prematurely terminates monitoring of the deceleration ramp if the value falls below the lower limit for a defined amount of time	Deactivated
Safety Ramp Monitoring Times			
Ramp Monitoring Time for SS1 (us)	[µs]	Deceleration ramp monitoring time for SS1	0
Safety Additional Parameters			
Delay time to start ramp monitoring (us)	[µs]	Delay time between the request for ramp-based monitoring and the start of monitoring	0
Early Limit Monitoring time (us)	[µs]	Time during which the speed must be below the target speed limit in order to prematurely end the deceleration ramp and to assume the safety function's end state	0

Table 188: SS1 safety function - Parameters

Information:

This safety function requires safe evaluation of the position and speed.
If an evaluation error is detected, then the SafeMOTION module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state.

Information:

To use this function without safe encoder evaluation, "Ramp monitoring for SS1" and "Early Limit Monitoring" must be disabled.

Information:

If several safety functions are active, then the lowest speed limit is always the value being monitored.

The following application rule must be observed:
$LIM_{SOS} \leq LIM_{SLS4} \leq LIM_{SLS3} \leq LIM_{SLS2} \leq LIM_{SLS1} \leq LIM_{SMS}$ < NormSpeed

Failure to follow the application rule will cause the SafeMOTION module to enter the FAIL SAFE state. If this occurs, it can only be brought back to the OPERATIONAL state by modifying the safety application and completing a power off/on cycle!

3.6.8 S_RequestSS2

General function

- Selects/Deselects the "Safe Stop 2" (SS2) safety function

Data type

- SAFEBOOL

Connection

- Constant or variable

Description of function

This input parameter is used to select or deselect the SS2 safety function.

TRUE

The safety function is deselected. Safe Stop 2 is not active!

FALSE

The safety function is selected. Standstill monitoring is activated after the end of ramp monitoring.

Not connected

The safety function is deactivated.

Relevant configuration parameters

Parameter	Unit	Description	Default value
Safety Deceleration Ramp			
Deceleration Ramp	[units/s²]	Slope of the deceleration ramp to be monitored	1073676289
General Settings			
Rampmonitoring for SS2	Activated/ Deactivated	Activates ramp monitoring (in addition to time-based monitoring) when the SS2 function is requested	Activated
Early Limit Monitoring	Activated/ Deactivated	Prematurely terminates monitoring of the deceleration ramp if the value falls below the lower limit for a defined amount of time	Deactivated
Safety Standstill and Direction Tolerances			
Speed Tolerance	[units/s]	Speed tolerance for standstill monitoring	0
Position Tolerance	[units]	Position tolerance for standstill and direction monitoring	0
Safety Ramp Monitoring Times			
Ramp Monitoring Time for SS2 (us)	[µs]	Deceleration ramp monitoring time for SS2	0
Safety Additional Parameters			
Delay time to start ramp monitoring (us)	[µs]	Delay time between the request for ramp-based monitoring and the start of monitoring	0
Early Limit Monitoring time (us)	[µs]	Time during which the speed must be below the target speed limit in order to prematurely end the deceleration ramp and to assume the safety function's end state	0

Table 189: SS2 safety function - Parameters

Information:

This safety function requires safe evaluation of the position and speed.
If an evaluation error is detected, then the SafeMOTION module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state.

Information:

If several safety functions are active, then the lowest speed limit is always the value being monitored.

The following application rule must be observed:
$\mathbf{LIM_{SOS} \leq LIM_{SLS4} \leq LIM_{SLS3} \leq LIM_{SLS2} \leq LIM_{SLS1} \leq LIM_{SMS} < NormSpeed}$

Failure to follow the application rule will cause the SafeMOTION module to enter the FAIL SAFE state. If this occurs, it can only be brought back to the OPERATIONAL state by modifying the safety application and completing a power off/on cycle!

3.6.9 S_RequestSLS1

General function

- Selects/Deselects the "Safely Limited Speed" safety function, Speed Limit 1

Data type

- SAFEBOOL

Connection

- Constant or variable

Description of function

This input parameter is used to select or deselect the SLS1 safety function.

TRUE

The safety function is deselected. SLS1 is not active!

FALSE

The safety function is selected. Speed limit 1 is monitored after the end of ramp monitoring.

Not connected

The safety function is deactivated.

Relevant configuration parameters

Parameter	Unit	Description	Default value
Safety Deceleration Ramp			
Deceleration Ramp	[units/s²]	Slope of the deceleration ramp to be monitored	1073676289
General Settings			
Rampmonitoring for SLS	Activated/ Deactivated	Activates ramp-based monitoring (in addition to time-based monitoring) when the SLS function is requested	Activated
Early Limit Monitoring	Activated/ Deactivated	Prematurely terminates monitoring of the deceleration ramp if the value falls below the lower limit for a defined amount of time	Deactivated
Speed Limits			
Safe Speedlimit 1 for SLS	[units/s]	Speed limit 1 for SLS	0
Safety Ramp Monitoring Times			
Ramp Monitoring Time for SLS1 (us)	[µs]	Deceleration ramp monitoring time for SLS1	0
Safety Additional Parameters			
Delay time to start ramp monitoring (us)	[µs]	Delay time between the request for ramp-based monitoring and the start of monitoring	0
Early Limit Monitoring time (us)	[µs]	Time during which the speed must be below the target speed limit in order to prematurely end the deceleration ramp and to assume the safety function's end state	0

Table 190: SLS1 safety function - Parameters

Information:

This safety function requires safe evaluation of the position and speed.
If an evaluation error is detected, then the SafeMOTION module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state.

Information:

If several safety functions are active, then the lowest speed limit is always the value being monitored.

The following application rule must be observed:
$LIM_{SOS} \leq LIM_{SLS4} \leq LIM_{SLS3} \leq LIM_{SLS2} \leq LIM_{SLS1} \leq LIM_{SMS} < NormSpeed$

Failure to follow the application rule will cause the SafeMOTION module to enter the FAIL SAFE state. If this occurs, it can only be brought back to the OPERATIONAL state by modifying the safety application and completing a power off/on cycle!

3.6.10 S_RequestSLS2

General function

- Selects/Deselects the "Safely Limited Speed" safety function, Speed Limit 2

Data type

- SAFEBOOL

Connection

- Constant or variable

Description of function

This input parameter is used to select or deselect the SLS2 safety function.

TRUE

The safety function is deselected. SLS2 is not active!

FALSE

The safety function is selected. Speed limit 2 is monitored after the end of ramp monitoring.

Not connected

The safety function is deactivated.

Relevant configuration parameters

Parameter	Unit	Description	Default value
Safety Deceleration Ramp			
Deceleration Ramp	[units/s²]	Slope of the deceleration ramp to be monitored	1073676289
General settings			
Rampmonitoring for SLS	Activated/ Deactivated	Activates ramp-based monitoring (in addition to time-based monitoring) when the SLS function is requested	Activated
Early Limit Monitoring	Activated/ Deactivated	Prematurely terminates monitoring of the deceleration ramp if the value falls below the lower limit for a defined amount of time	Deactivated
Speed Limits			
Safe Speedlimit 2 for SLS	[units/s]	Speed limit 2 for SLS	0
Safety Ramp Monitoring Times			
Ramp Monitoring Time for SLS2 (us)	[µs]	Deceleration ramp monitoring time for SLS2	0
Safety Additional Parameters			
Delay time to start ramp monitoring (us)	[µs]	Delay time between the request for ramp-based monitoring and the start of monitoring	0
Early Limit Monitoring time (us)	[µs]	Time during which the speed must be below the target speed limit in order to prematurely end the deceleration ramp and to assume the safety function's end state	0

Table 191: SLS2 safety function - Parameters

Information:

This safety function requires safe evaluation of the position and speed.
If an evaluation error is detected, then the SafeMOTION module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state.

Information:

If several safety functions are active, then the lowest speed limit is always the value being monitored.

The following application rule must be observed:
$\mathbf{LIM_{SOS} \leq LIM_{SLS4} \leq LIM_{SLS3} \leq LIM_{SLS2} \leq LIM_{SLS1} \leq LIM_{SMS} < NormSpeed}$

Failure to follow the application rule will cause the SafeMOTION module to enter the FAIL SAFE state. If this occurs, it can only be brought back to the OPERATIONAL state by modifying the safety application and completing a power off/on cycle!

3.6.11 S_RequestSLS3

General function

- Selects/Deselects the "Safely Limited Speed" safety function, Speed Limit 3

Data type

- SAFEBOOL

Connection

- Constant or variable

Description of function

This input parameter is used to select or deselect the SLS3 safety function.

TRUE

The safety function is deselected. SLS3 is not active!

FALSE

The safety function is selected. Speed limit 3 is monitored after the end of ramp monitoring.

Not connected

The safety function is deactivated.

Relevant configuration parameters

Parameter	Unit	Description	Default value
Safety Deceleration Ramp			
Deceleration Ramp	[units/s²]	Slope of the deceleration ramp to be monitored	1073676289
General Settings			
Rampmonitoring for SLS	Activated/ Deactivated	Activates ramp-based monitoring (in addition to time-based monitoring) when the SLS function is requested	Activated
Early Limit Monitoring	Activated/ Deactivated	Prematurely terminates monitoring of the deceleration ramp if the value falls below the lower limit for a defined amount of time	Deactivated
Speed Limits			
Safe Speedlimit 3 for SLS	[units/s]	Speed limit 3 for SLS	0
Safety Ramp Monitoring Times			
Ramp Monitoring Time for SLS3 (us)	[µs]	Deceleration ramp monitoring time for SLS3	0
Safety Additional Parameters			
Delay time to start ramp monitoring (us)	[µs]	Delay time between the request for ramp-based monitoring and the start of monitoring	0
Early Limit Monitoring time (us)	[µs]	Time during which the speed must be below the target speed limit in order to prematurely end the deceleration ramp and to assume the safety function's end state	0

Table 192: SLS3 safety function - Parameters

Information:

This safety function requires safe evaluation of the position and speed.
If an evaluation error is detected, then the SafeMOTION module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state.

Information:

If several safety functions are active, then the lowest speed limit is always the value being monitored.

The following application rule must be observed:
$\mathbf{LIM_{SOS} \leq LIM_{SLS4} \leq LIM_{SLS3} \leq LIM_{SLS2} \leq LIM_{SLS1} \leq LIM_{SMS} < NormSpeed}$

Failure to follow the application rule will cause the SafeMOTION module to enter the FAIL SAFE state. If this occurs, it can only be brought back to the OPERATIONAL state by modifying the safety application and completing a power off/on cycle!

3.6.12 S_RequestSLS4

General function

- Selects/Deselects the "Safely Limited Speed" safety function, Speed Limit 4

Data type

- SAFEBOOL

Connection

- Constant or variable

Description of function

This input parameter is used to select or deselect the SLS4 safety function.

TRUE

The safety function is deselected. SLS4 is not active!

FALSE

The safety function is selected. Speed limit 4 is monitored after the end of ramp monitoring.

Not connected

The safety function is deactivated.

Relevant configuration parameters

Parameter	Unit	Description	Default value
Safety Deceleration Ramp			
Deceleration Ramp	[units/s²]	Slope of the deceleration ramp to be monitored	1073676289
General Settings			
Rampmonitoring for SLS	Activated/ Deactivated	Activates ramp-based monitoring (in addition to time-based monitoring) when the SLS function is requested	Activated
Early Limit Monitoring	Activated/ Deactivated	Prematurely terminates monitoring of the deceleration ramp if the value falls below the lower limit for a defined amount of time	Deactivated
Speed Limits			
Safe Speedlimit 4 for SLS	[units/s]	Speed limit 4 for SLS	0
Safety Ramp Monitoring Times			
Ramp Monitoring Time for SLS4 (us)	[µs]	Deceleration ramp monitoring time for SLS4	0
Safety Additional Parameters			
Delay time to start ramp monitoring (us)	[µs]	Delay time between the request for ramp-based monitoring and the start of monitoring	0
Early Limit Monitoring time (us)	[µs]	Time during which the speed must be below the target speed limit in order to prematurely end the deceleration ramp and to assume the safety function's end state	0

Table 193: SLS4 safety function - Parameters

Information:

This safety function requires safe evaluation of the position and speed.
If an evaluation error is detected, then the SafeMOTION module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state.

Information:

If several safety functions are active, then the lowest speed limit is always the value being monitored.

The following application rule must be observed:
$\mathbf{LIM_{SOS} \leq LIM_{SLS4} \leq LIM_{SLS3} \leq LIM_{SLS2} \leq LIM_{SLS1} \leq LIM_{SMS} < NormSpeed}$

Failure to follow the application rule will cause the SafeMOTION module to enter the FAIL SAFE state. If this occurs, it can only be brought back to the OPERATIONAL state by modifying the safety application and completing a power off/on cycle!

3.6.13 S_RequestSLI

General function

- Selects/Deselects the "Safely Limited Increment" safety function, SLI

Data type

- SAFEBOOL

Connection

- Constant or variable

Description of function

This input parameter is used to select or deselect the SLI safety function.

TRUE

The safety function is deselected. SLI is not active!

FALSE

The safety function is selected. A safe range of increments is monitored.

Not connected

The safety function is deactivated.

Relevant configuration parameters

Parameter	Unit	Description	Default value
Safety Standstill and Direction Tolerances			
Speed Tolerance	[units/s]	Speed tolerance for standstill monitoring	0
Safely Limited Increments			
Safe increments	[units]	Maximum movable increments when SLI is active	0
SLI Off Delay	[µs]	Switch off delay of SLI	0

Table 194: SLI safety function - Parameters

Information:

This safety function requires safe evaluation of the position and speed.
If an evaluation error is detected, then the SafeMOTION module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state.

3.6.14 S_RequestSDIpos

General function

- Selects/Deselects the "Safe Direction" safety function. Movement is allowed in the positive direction

Data type

- SAFEBOOL

Connection

- Constant or variable

Description of function

This input parameter is used to select or deselect the safety function SDI, movement is allowed in the positive direction of movement.

TRUE

The safety function is deselected. SDI is not active!

FALSE

The direction of movement is monitored after the delay time has expired. Movement is allowed in the positive direction.

Not connected

The safety function is deactivated.

Relevant configuration parameters

Parameter	Unit	Description	Default value
Safety Standstill and Direction Tolerances			
Position Tolerance	[units]	Position tolerance for standstill and direction monitoring	0
Safety Additional Parameters			
Delay time to start SDI (us)	[µs]	Delay time between the SDI request and activation of the safety function	0

Table 195: SDI safety function - Parameters

Information:

This safety function requires safe evaluation of the position and speed.
If an evaluation error is detected, then the SafeMOTION module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state.

3.6.15 S_RequestSDIneg

General function

- Selects/Deselects the "Safe Direction" safety function. Movement is allowed in the negative direction

Data type

- SAFEBOOL

Connection

- Constant or variable

Description of function

This input parameter is used to select or deselect the safety function SDI, movement is allowed in the negative direction of movement.

TRUE

The safety function is deselected. SDI is not active!

FALSE

The direction of movement is monitored after the delay time has expired. Movement is allowed in the negative direction.

Not connected

The safety function is deactivated.

Relevant configuration parameters

Parameter	Unit	Description	Default value
Safety Standstill and Direction Tolerances			
Position Tolerance	[units]	Position tolerance for standstill and direction monitoring	0
Safety Additional Parameters			
Delay time to start SDI (us)	[µs]	Delay time between the SDI request and activation of the safety function	0

Table 196: SDI safety function - Parameters

Information:

This safety function requires safe evaluation of the position and speed.
If an evaluation error is detected, then the SafeMOTION module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state.

3.6.16 S_RequestSLP

General function

- Selects/Deselects the "Safely Limited Position" (SLP) safety function

Data type

- SAFEBOOL

Connection

- Constant or variable

Description of function

This input parameter is used to select or deselect the SLP safety function.

TRUE

The safety function is deselected. SLP is not active!

FALSE

The configured position window will be safety-monitored after "Delay time to start SLP (us)".

Not connected

The safety function is deactivated.

Relevant configuration parameters

Parameter	Unit	Description	Default value
Safety Deceleration Ramp			
Deceleration Ramp	[units/s²]	Slope of the deceleration ramp to be monitored	1073676289
Safety Position Limits			
Safe Lower Position Limit for SLP (units)	[units]	Lower position limit for the monitoring range	0
Safe Upper Position Limit for SLP (units)	[units]	Upper position limit for the monitoring range	0
Safety Standstill and Direction Tolerances			
Speed Tolerance	[units/s]	Speed tolerance for standstill monitoring	0
Position Tolerance	[units]	Position tolerance for standstill and direction monitoring	0
Safety Additional Parameters			
Delay time to start SLP (us)	[µs]	Delay time between the SLP request and start of monitoring	0

Table 197: SLP safety function - Parameters

Information:

This safety function requires safe evaluation of the position and speed.
If an evaluation error is detected, then the SafeMOTION module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state.

Information:

The following application rule must be observed:
$\mathbf{LIM_{SMP,NEG} \leq LIM_{SLP,NEG} \leq LIM_{SLP,POS} \leq LIM_{SMP,POS}}$
Failure to follow the application rule will cause the SafeMOTION module to enter the FAIL SAFE state. If this occurs, it can only be brought back to the OPERATIONAL state by modifying the safety application and completing a power off/on cycle!

Information:

Safe homing of the axis must be completed prior to using this safety function.
If a homing procedure is not completed successfully or the S_SafePositionValid status changes, then the request for the SLP safety function causes the module to switch to the acknowledgeable FUNCTIONAL FAIL SAFE error state.
The drive loses all torque/power and coasts to a stop! In the event of an error, a synchronous axis will no longer be synchronous. The output of the S_NotErrFUNC function block is reset.

3.6.17 S_RequestHoming

General function

- Selects/Deselects the "Safe Homing" safety function

Data type

- SAFEBOOL

Connection

- Constant or variable

Description of function

This input parameter is used to start a "Safe Homing" procedure. A rising edge of the input starts the safety function.

Rising edge: Change from FALSE to TRUE

Starts "Safe Homing".

Falling edge: Change from TRUE to FALSE

If still active, the homing procedure will be terminated by the falling edge. This state transition has no effect if the homing procedure has already been completed.

Not connected

The safety function is deactivated.

Relevant configuration parameters

Parameter	Unit	Description	Default value
Homing			
Home Position or Home Offset (units)	[units]	Home position or home offset	0
Max. trigger speed (units/s)	[units/s]	Maximum permissible speed for evaluating the reference switch / reference pulse.	0
Homing Monitoring Time (µs)	[µs]	Monitoring time for the homing procedure	0
Mode	Direct / Reference Switch / *Home Offset /* *Home Offset with Correction*	Selects the homing mode *The modes "Home Offset" and "Home Offset with Correction" are only available for the ACOPOSmulti SafeMOTION EnDat 2.2!*	Direct
Edge of reference switch	Positive / Negative	Selects the switching edge for reference switch The switching edge for the reference switch input is positive if the logical state of the reference switch changes from SAFEFALSE to SAFETRUE in the positive direction of movement.	Positive
Trigger direction	Positive / Negative	Selects the trigger direction If the homing procedure requires a movement, then this parameter specifies the direction for evaluating the reference switch / reference pulse.	Positive
Reference pulse	*Used /* *Not Used*	*Selects whether or not to use a reference pulse for homing* *This parameter is only available for the ACOPOSmulti SafeMOTION EnDat 2.2.*	*Not Used*
Remanent safe position	*Used /* *Not Used*	*Selects whether or not to use the remanent safe position* *This parameter is only available for the ACOPOSmulti SafeMOTION EnDat 2.2.*	*Not Used*
Blocking distance (% encoder reference system)	*%*	*Distance within which evaluation of the reference pulse will be suppressed.* *This is calculated starting at the configured reference switch edge and indicated as a percentage of the encoder reference system. A single revolution is used as the encoder reference system for rotary encoders.* *This parameter is only available for the ACOPOSmulti SafeMOTION EnDat 2.2.*	*0*

Table 198: "Safe Homing" safety function - Parameters

Information:

This safety function requires safe evaluation of the position and speed.
If an evaluation error is detected, then the SafeMOTION module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state.

Information:

The Safe Homing function is needed in order to implement the safety functions SLP and SMP and for using the safe position.
The S_SafePositionValid status will remain set to SAFEFALSE until safe homing has been performed!

3.6.18 S_ReferenceSwitch

General function

- Reference switch input for the "Safe Homing" safety function

Data type

- SAFEBOOL

Connection

- Constant or variable

Description of function

This input parameter serves as a reference switch input for the "Safe Homing" safety function and is only evaluated in the "Reference Switch" homing mode.
The status of a safe reference switch that was read into the safety application via a safe input module (X20SIxxxx), for example, should be linked to the input.

Not connected

The reference switch is not being used!

Information:

If "Reference Switch" homing mode is configured and the reference switch input S_ReferenceSwitch is not wired on the function block, then the SafeMOTION module will switch to the FAIL SAFE state. The only way to exit the FAIL SAFE state is to complete a power off/on cycle and modify the safety application!

Information:

The S_ReferenceSwitch input is only evaluated in "Reference Switch" homing mode.
The input is ignored in other homing modes!

3.6.19 Reset

General function

- **Reset** input for acknowledging the FUNCTIONAL FAIL SAFE state or for putting the SafeMOTION module into OPERATIONAL state after STARTUP

Data type

- BOOL

Connection

- Variable

Description of function

Reset input to acknowledge the FUNCTIONAL FAIL SAFE state

A positive edge triggers the reset function.

Depending on the configuration of the "Automatic Reset at Startup" parameter, a positive edge may be necessary to get the SafeMOTION module from the INIT state to the OPERATIONAL state after startup.

Relevant configuration parameters

Parameter	Unit	Description	Default value
General Settings			
Automatic Reset at Startup (Startreset)	Used / Unused	Activates automatic reset of the function block at startup	Unused

Table 199: Reset - Parameters

3.6.20 S_AxisID

General function

- This input parameter assigns a real axis to the function block.

Data type

- SAFEINT

Connection

- Constant

Description of function

The corresponding axis can be connected to the input in SafeDESIGNER using drag-and-drop.

Information:

There can only be one combination of AxisID and the SF_SafeMC_BR or SF_SafeMC_BR_Vx function block in the safety application. Otherwise, it will not be possible to compile the safety application.

3.7 Output parameters

Output parameters provide information about the state of the SafeMOTION module and the individual safety functions.

3.7.1 Ready

General function

- Message: Function block is enabled/disabled.

Data type

- BOOL

Connection

- Variable

Description of function

This output parameter indicates whether or not the function block is enabled.

TRUE

The function block is enabled (**Activate** = TRUE). The output parameters indicate the current status of the safety function.

FALSE

The function block is disabled (**Activate** = FALSE). The function block outputs are set to FALSE.

3.7.2 S_SafetyActiveSTO

General function

- Status information for the "Safe Torque Off" (STO) safety function

Data type

- SAFEBOOL

Connection

- Variable

Description of function

Indicates the functional safe state of the STO safety function

TRUE

The STO safety function is active and currently in its safe state.

FALSE

The STO safety function is not requested, the function or the SafeMOTION module is currently in an error state or the function block has not been enabled.

3.7.3 S_SafetyActiveSTO1

General function

- Status information for the "Safe Torque Off, One Channel" (STO1) safety function

Data type

- SAFEBOOL

Connection

- Variable

Description of function

Indicates the functional safe state of the STO1 safety function

TRUE

The STO1 safety function is active and currently in its safe state.

FALSE

The STO1 safety function is not requested, the function or the SafeMOTION module is currently in an error state or the function block has not been enabled.

3.7.4 S_SafetyActiveSBC

General function

- Status information for the "Safe Brake Control" (SBC) safety function

Data type

- SAFEBOOL

Connection

- Variable

Description of function

Indicates the functional safe state of the SBC safety function

TRUE

The SBC safety function is active and currently in its safe state.

FALSE

The SBC safety function is not requested, the function or the SafeMOTION module is currently in an error state or the function block has not been enabled.

3.7.5 S_SafetyActiveSOS

General function

- Status information for the "Safe Operating Stop" (SOS) safety function

Data type

- SAFEBOOL

Connection

- Variable

Description of function

Indicates the functional safe state of the SOS safety function

TRUE

The SOS safety function is active and currently in its safe state.

FALSE

The SOS safety function is not requested, the function or the SafeMOTION module is currently in an error state or the function block has not been enabled.

3.7.6 S_SafetyActiveSS1

General function

- Status information for the "Safe Stop 1" (SS1) safety function

Data type

- SAFEBOOL

Connection

- Variable

Description of function

Indicates the functional safe state of the SS1 safety function

TRUE

The SS1 safety function is active and currently in its safe state.

FALSE

The SS1 safety function is not requested, has not yet achieved its safe state, the function or the SafeMOTION module is currently in an error state or the function block has not been enabled.

3.7.7 S_SafetyActiveSS2

General function

- Status information for the "Safe Stop 2" (SS2) safety function

Data type

- SAFEBOOL

Connection

- Variable

Description of function

Indicates the functional safe state of the SS2 safety function

TRUE

The SS2 safety function is active and currently in its safe state.

FALSE

The SS2 safety function is not requested, has not yet achieved its safe state, the function or the SafeMOTION module is currently in an error state or the function block has not been enabled.

3.7.8 S_SafetyActiveSLS1

General function

- Status information for the "Safely Limited Speed" safety function, Speed Limit 1

Data type

- SAFEBOOL

Connection

- Variable

Description of function

Indicates the functional safe state of the SLS1 safety function

TRUE

The SLS1 safety function is active and currently in its safe state.

FALSE

The SLS1 safety function is not requested, has not yet achieved its safe state, the function or the SafeMOTION module is currently in an error state or the function block has not been enabled.

3.7.9 S_SafetyActiveSLS2

General function

- Status information for the "Safely Limited Speed" safety function, Speed Limit 2

Data type

- SAFEBOOL

Connection

- Variable

Description of function

Indicates the functional safe state of the SLS2 safety function

TRUE

The SLS2 safety function is active and currently in its safe state.

FALSE

The SLS2 safety function is not requested, has not yet achieved its safe state, the function or the SafeMOTION module is currently in an error state or the function block has not been enabled.

3.7.10 S_SafetyActiveSLS3

General function

- Status information for the "Safely Limited Speed" safety function, Speed Limit 3

Data type

- SAFEBOOL

Connection

- Variable

Description of function

Indicates the functional safe state of the SLS3 safety function

TRUE

The SLS3 safety function is active and currently in its safe state.

FALSE

The SLS3 safety function is not requested, has not yet achieved its safe state, the function or the SafeMOTION module is currently in an error state or the function block has not been enabled.

3.7.11 S_SafetyActiveSLS4

General function

- Status information for the "Safely Limited Speed" safety function, Speed Limit 4

Data type

- SAFEBOOL

Connection

- Variable

Description of function

Indicates the functional safe state of the SLS4 safety function

TRUE

The SLS4 safety function is active and currently in its safe state.

FALSE

The SLS4 safety function is not requested, has not yet achieved its safe state, the function or the SafeMOTION module is currently in an error state or the function block has not been enabled.

3.7.12 S_SafetyActiveSLI

General function

- Status information for the "Safely Limited Increment" safety function

Data type

- SAFEBOOL

Connection

- Variable

Description of function

Indicates the functional safe state of the SLI safety function

TRUE

The SLI safety function is active and currently in its safe state.

FALSE

The SLI safety function is not requested, the function or the SafeMOTION module is currently in an error state or the function block has not been enabled.

3.7.13 S_SafetyActiveSDIpos

General function

- Status information for the "Safe Direction" safety function. Movement is allowed in the positive direction.

Data type

- SAFEBOOL

Connection

- Variable

Description of function

Indicates the functional safe state of the SDIpos safety function

TRUE

The SDIpos safety function is active and currently in its safe state.

FALSE

The SDIpos safety function is not requested, the function or the SafeMOTION module is currently in an error state or the function block has not been enabled.

3.7.14 S_SafetyActiveSDIneg

General function

- Status information for the "Safe Direction" safety function. Movement is allowed in the negative direction.

Data type

- SAFEBOOL

Connection

- Variable

Description of function

Indicates the functional safe state of the SDIneg safety function

TRUE

The SDIneg safety function is active and currently in its safe state.

FALSE

The SDIneg safety function is not requested, the function or the SafeMOTION module is currently in an error state or the function block has not been enabled.

3.7.15 S_SafetyActiveSLP

General function

- Status information for the "Safely Limited Position" (SLP) safety function

Data type

- SAFEBOOL

Connection

- Variable

Description of function

Indicates the functional safe state of the SLP safety function

TRUE

The SLP safety function is active and currently in its safe state.

FALSE

The SLP safety function is not requested, the function or the SafeMOTION module is currently in an error state or the function block has not been enabled.

3.7.16 S_SafetyActiveSMP

General function

- Status information for the "Safe Maximum Position" (SMP) safety function

Data type

- SAFEBOOL

Connection

- Variable

Description of function

Indicates the functional safe state of the SMP safety function

TRUE

The SMP safety function is active and currently in its safe state.

FALSE

Monitoring of the SMP position limits is not active. Monitoring is not active because the ACOPOSmulti SafeMOTION inverter module has not yet been homed, the function or the SafeMOTION module is in an error state or the function block has not been enabled.

3.7.17 S_SafePositionValid

General function

- Status information for the "Safe Homing" safety function and the safe position

Data type

- SAFEBOOL

Connection

- Variable

Description of function

This output parameter specifies whether or not safe homing of the axis has been completed and whether or not the position signal is valid.

TRUE

The axis has been safely homed, and the safe position is valid.

FALSE

The axis has not yet been safely homed, the axis encoder signal contains errors, the SafeMOTION module is in an error state or the function block has not been enabled.
The safe position is invalid!

> **Danger!**
>
> **This signal should only be used for status information.**
>
> **S_SafePositionValid does not represent the functional safe state of the SafeMOTION module!**

> **Danger!**
>
> **The value of the S_SafePosition output parameter is only valid if the S_SafePositionValid output parameter is SAFETRUE. Otherwise, it is invalid and is not permitted to be used further.**

3.7.18 S_SafetyActiveSDC

General function

- Information about the status of ramp monitoring

Data type

- SAFEBOOL

Connection

- Variable

Description of function

This output parameter indicates the status of ramp monitoring.

TRUE

Ramp monitoring is active.

FALSE

Ramp monitoring is not active, the SafeMOTION module is currently in an error state or the function block has not been enabled.

Danger!

This signal should only be used for status information.

3.7.19 S_AllReqFuncActive

General function

- Information about the status of the requested safety functions

Data type

- SAFEBOOL

Connection

- Variable

Description of function

This output parameter specifies the status of the requested safety functions.

TRUE

All requested safety functions are currently in their functional safe state.

FALSE

One or more safety functions have not yet achieved their safe state, the SafeMOTION module is in an error state or the function block has not been enabled.

3.7.20 S_NotErrFUNC

General function

- Information about the error state of the safe SafeMOTION module

Data type

- SAFEBOOL

Connection

- Variable

Description of function

This output parameter specifies the error status of the SafeMOTION module.

TRUE

No error was found on the SafeMOTION module.

FALSE

An error was detected on the SafeMOTION module (e.g. a monitored limit was exceeded), or the function block has not been enabled.
In the event of an error, additional information about the error can be found in the Safety Logger in Automation Studio.
If the error is a functional error, then it can be acknowledged by changing the signal on the "Reset" input from FALSE to TRUE (rising edge)!

Danger!

This signal should only be used for status information. It only provides information in connection with the requested safety functions.
S_NotErrFUNC does not represent the functional safe state of the SafeMOTION module!

Danger!

It is your responsibility to ensure that all necessary repair measures are initiated after an error occurs since subsequent errors can result in dangerous situations!

3.7.21 Error

General function

- Function block error message

Data type

- BOOL

Connection

- Variable

Description of function

This formal parameter indicates a pending function block error message.

TRUE

The enabled function block has detected an error. **DiagCode** indicates the error code.

FALSE

The function block is not enabled, or the enabled function block has not detected any errors. **DiagCode** indicates the status.

> ## Danger!
> **It is your responsibility to ensure that all necessary repair measures are initiated after an error occurs since subsequent errors can result in dangerous situations!**

In order to exit an error state (**Error** = TRUE), the signal on the **Reset** input must change from FALSE to TRUE (rising edge).

3.7.22 DiagCode

General function

- Function block diagnostic message

Data type

- WORD

Connection

- Variable

Description of function

This output parameter is used to output diagnostic and status messages specific to the function block and make them available automatically to diagnostic tools.

These diagnostic tools cannot acknowledge diagnostic messages from function blocks. This is done exclusively in the **safety** application.

The function block indicates the presence of an error message on the **DiagCode** output via the **Error** output parameter.

Diagnostic code

The diagnostic code is specified as a WORD data type. The values and meanings of these diagnostic codes are listed below.

In the event of status messages ($0xxx_{hex}$, $8xxx_{hex}$), the function block sets **Error** to FALSE.

In the event of error messages ($Cxxx_{hex}$), the function block sets **Error** to TRUE.

3.7.23 Diagnostic codes

Code (hex)	State	Description	Possible remedy
0000	IDLE	The function block is not enabled.	Enable the function block by setting **Activate** to TRUE.
8001	INIT	The function block has been enabled and the SafeMOTION module is in the INIT state. The SafeMOTION module restart inhibit is active.	Configure the "Startreset" parameter accordingly or execute a positive edge on the **Reset** input.
8002	OPERATIONAL	The SafeMOTION module is in the OPERATIONAL state. No safety function is selected. The SMS speed limit is monitored according to the configuration.	No action required
8003	WAIT FOR CONFIRMATION	The SafeMOTION module is in the internal OPERATIONAL state. At least one safety function has been requested and at least one safety function has not yet achieved its functional safe state. None of the limits currently being monitored have been violated.	No action required
8000	SAFE STATE	All requested safety functions have achieved their functional safe state. None of the limits currently being monitored have been violated.	No action required
C000	FUNCTIONAL FAIL SAFE	An error has occurred!	Check the Safety Logger in Automation Studio. It will provide detailed information about the current error. Depending on the type of error, check the standard and/or safety application. For functional errors, check the configuration of the ACOPOSmulti SafeMOTION module or replace the faulty ACOPOSmulti SafeMOTION inverter module.

Table 200: SF_SafeMC_BR(_V2, _V3): Diagnostic codes

3.7.24 AxisStatus

General function

- Diagnostic message from the function block, representation of the axis status bits in a DWORD

Data type

- DWORD

Connection

- Variable

Description of function

The **AxisStatus** output returns bit-coded information about the status of individual safety functions.
This information is equal to a summary of the **S_xxx** outputs in a DWORD.
The individual bits have the following meaning:

Bit 0	**Bit 1**	**Bit 2**	**Bit 3**	**Bit 4**	**Bit 5**	**Bit 6**	**Bit 7**
Status STO	Status SBC	Status SOS	Status SS1	Status SS2	Status SLS1	Status SLS2	Status SLS3
Bit 8	**Bit 9**	**Bit 10**	**Bit 11**	**Bit 12**	**Bit 13**	**Bit 14**	**Bit 15**
Status SLS4	Status STO1	Status SDI pos	Status SLI	Status SDI neg	Status SLP	Status SMP	Status PositionValid
Bit 16	**Bit 17**	**Bit 18**	**Bit 19**	**Bit 20**	**Bit 21**	**Bit 22**	**Bit 23**
-	Status Setposition Alive Test	Status SFR	Status "All requested safety functions active"	Status SDC	Status operational	Status Not Encoder Error	Status Not Functional Error

Table 201: SF_SafeMC_BR_V2: SafeMOTION module status bits

3.8 State machine

The state machine illustrated here is implemented on the SafeMOTION module.

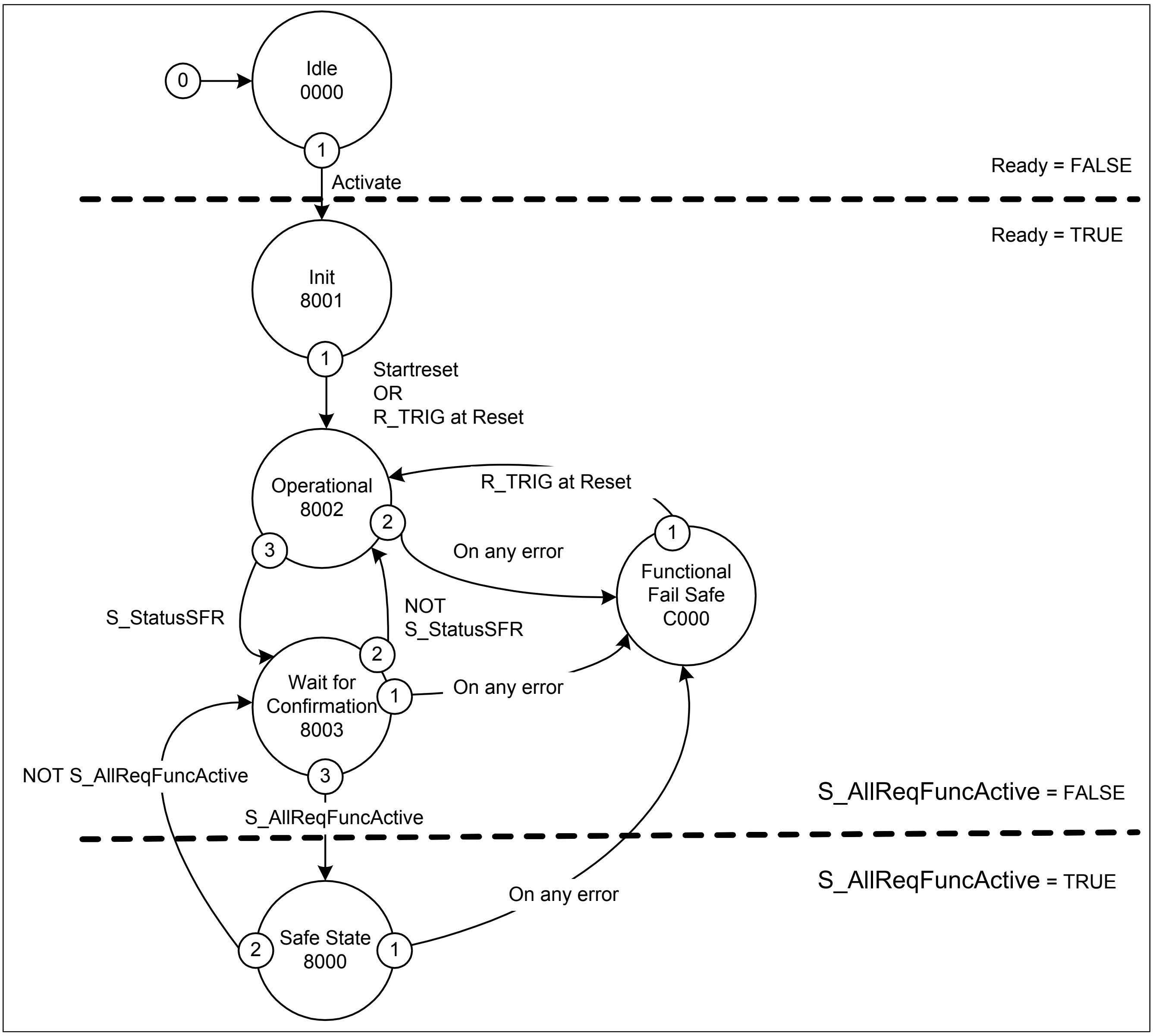


Figure 69: SF_SafeMC_BR(_V2, _V3): State machine

Individual states are reflected by the **DiagCode** output parameter. In this way, the function block provides a representation of the state machine on the SafeMOTION module.

3.9 Signal sequence diagram of the function block

A general signal sequence diagram of the function block cannot be specified since it depends on which safety functions are selected or deselected.

See "ACOPOSmulti SafeMOTION user's manual / Safety technology / Integrated safety functions".

4 SF_SafeMC_BR_V3

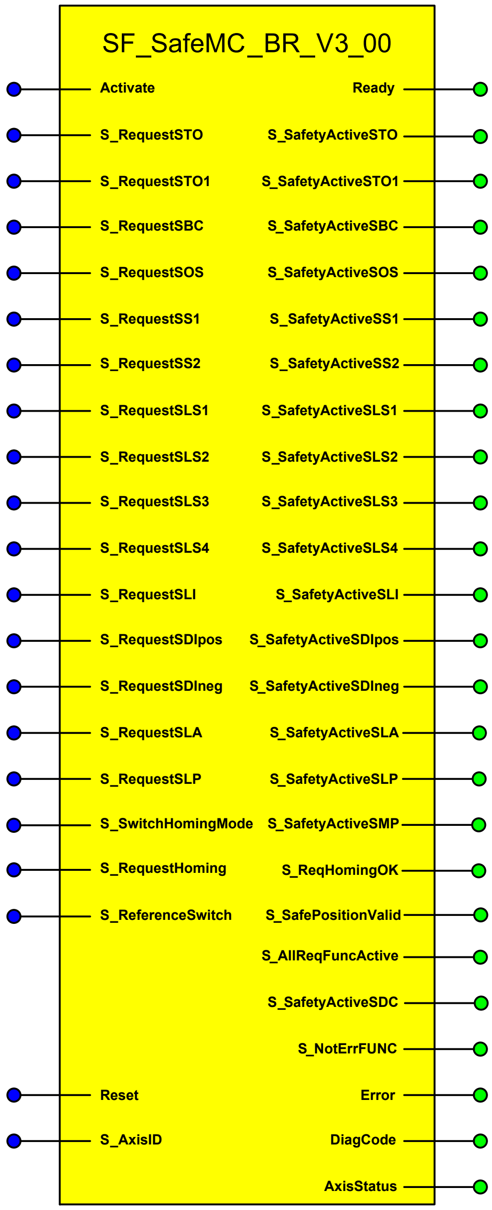


Figure 70: SF_SafeMC_BR_V3 function block

Information:

The SF_SafeMC_BR_V3_00 function block can only be used with Safety Release 1.9.

If a previous Safety Release is being used, then SafeDESIGNER will return an error when compiling the safety application!

4.1 Formal parameters of the function block

In the following, the term "variable" refers to both a variable as well as a graphic connection.

Name	Type	Connection	Signal type [1]	Initial value	Description / General function
Activate	BOOL	Variable/ Constant	Status	FALSE	Enables the function block (= TRUE)
S_RequestSTO	SAFEBOOL	Variable/ Constant	Status	SAFEFALSE	STO safety function request: SAFEFALSE: Safety function requested
S_RequestSTO1	SAFEBOOL	Variable/ Constant	Status	SAFEFALSE	STO1 safety function request: SAFEFALSE: Safety function requested
S_RequestSBC	SAFEBOOL	Variable/ Constant	Status	SAFEFALSE	SBC safety function request: SAFEFALSE: Safety function requested
S_RequestSOS	SAFEBOOL	Variable/ Constant	Status	SAFEFALSE	SOS safety function request: SAFEFALSE: Safety function requested
S_RequestSS1	SAFEBOOL	Variable/ Constant	Status	SAFEFALSE	SS1 safety function request: SAFEFALSE: Safety function requested
S_RequestSS2	SAFEBOOL	Variable/ Constant	Status	SAFEFALSE	SS2 safety function request: SAFEFALSE: Safety function requested
S_RequestSLS1	SAFEBOOL	Variable/ Constant	Status	SAFEFALSE	SLS1 safety function request: SAFEFALSE: Safety function requested
S_RequestSLS2	SAFEBOOL	Variable/ Constant	Status	SAFEFALSE	SLS2 safety function request: SAFEFALSE: Safety function requested
S_RequestSLS3	SAFEBOOL	Variable/ Constant	Status	SAFEFALSE	SLS3 safety function request: SAFEFALSE: Safety function requested
S_RequestSLS4	SAFEBOOL	Variable/ Constant	Status	SAFEFALSE	SLS4 safety function request: SAFEFALSE: Safety function requested
S_RequestSLI	SAFEBOOL	Variable/ Constant	Status	SAFEFALSE	SLI safety function request: SAFEFALSE: Safety function requested
S_RequestSDIpos	SAFEBOOL	Variable/ Constant	Status	SAFEFALSE	SDIpos safety function request: SAFEFALSE: Safety function requested
S_RequestSDIneg	SAFEBOOL	Variable/ Constant	Status	SAFEFALSE	SDIneg safety function request: SAFEFALSE: Safety function requested
S_RequestSLA	SAFEBOOL	Variable/ Constant	Status	SAFEFALSE	SLA safety function request SAFEFALSE: Safety function requested
S_RequestSLP	SAFEBOOL	Variable/ Constant	Status	SAFEFALSE	SLP safety function request SAFEFALSE: Safety function requested
S_SwitchHomingMode	SAFEBOOL	Variable/ Constant	Status	SAFEFALSE	Homing with RSP enabled. SAFEFALSE: Homing with RSP disabled.
S_RequestHoming	SAFEBOOL	Variable/ Constant	Status	SAFEFALSE	Request for Safe Homing Request is made on a rising edge!
S_ReferenceSwitch	SAFEBOOL	Variable/ Constant	Status	SAFEFALSE	Safe input for a reference switch
Reset	BOOL	Variable	Edge	FALSE	Resets error messages and the SafeMOTION module after the cause of the error has been removed
S_AxisID	SAFEINT	Constant	Status	-1	Assigns an axis to the function block

Table 202: SF_SafeMC_BR_V3: Overview of input parameters

1) Evaluation of the input parameter signals in the function block. The signals must be controlled accordingly by the user.

Name	Type	Connection	Signal type [1]	Initial value	Description / General function
Ready	BOOL	Variable	Status	FALSE	Indicates that the function block is enabled
S_SafetyActiveSTO	SAFEBOOL	Variable	Status	SAFEFALSE	STO safety function active (= SAFETRUE)
S_SafetyActiveSTO1	SAFEBOOL	Variable	Status	SAFEFALSE	Safety function STO1 active (= SAFETRUE)
S_SafetyActiveSBC	SAFEBOOL	Variable	Status	SAFEFALSE	SBC safety function active (= SAFETRUE)
S_SafetyActiveSOS	SAFEBOOL	Variable	Status	SAFEFALSE	SOS safety function active, no violation of a monitored limit (= SAFETRUE)
S_SafetyActiveSS1	SAFEBOOL	Variable	Status	SAFEFALSE	SS1 safety function active, deceleration monitoring completed, no violation of a monitored limit detected (= SAFETRUE)
S_SafetyActiveSS2	SAFEBOOL	Variable	Status	SAFEFALSE	SS2 safety function active, deceleration monitoring completed, no violation of a monitored limit detected (= SAFETRUE)
S_SafetyActiveSLS1	SAFEBOOL	Variable	Status	SAFEFALSE	SLS1 safety function active, deceleration monitoring completed, no violation of a monitored limit detected (= SAFETRUE)
S_SafetyActiveSLS2	SAFEBOOL	Variable	Status	SAFEFALSE	SLS2 safety function active, deceleration monitoring completed, no violation of a monitored limit detected (= SAFETRUE)

Table 203: SF_SafeMC_BR_V3: Overview of output parameters

Name	Type	Connection	Signal type 1)	Initial value	Description / General function
S_SafetyActiveSLS3	SAFEBOOL	Variable	Status	SAFEFALSE	SLS3 safety function active, deceleration monitoring completed, no violation of a monitored limit detected (= SAFETRUE)
S_SafetyActiveSLS4	SAFEBOOL	Variable	Status	SAFEFALSE	SLS4 safety function active, deceleration monitoring completed, no violation of a monitored limit detected (= SAFETRUE)
S_SafetyActiveSLI	SAFEBOOL	Variable	Status	SAFEFALSE	SLI safety function active, no violation of a monitored limit (= SAFETRUE)
S_SafetyActiveSDIpos	SAFEBOOL	Variable	Status	SAFEFALSE	SDIpos safety function active (= SAFETRUE)
S_SafetyActiveSDIneg	SAFEBOOL	Variable	Status	SAFEFALSE	Safety function SDIneg active (= SAFETRUE)
S_SafetyActiveSLA	SAFEBOOL	Variable	Status	SAFEFALSE	SLA safety function is active, no violation of a monitored limit (= SAFETRUE)
S_SafetyActiveSLP	SAFEBOOL	Variable	Status	SAFEFALSE	SLP safety function active (= SAFETRUE)
S_SafetyActiveSMP	SAFEBOOL	Variable	Status	SAFEFALSE	SMP safety function active (= SAFETRUE)
S_ReqHomingOK	SAFEBOOL	Variable	Status	SAFEFALSE	Feedback for referencing in SafeDESIGNER (=SAFETRUE, safe position is valid and request for safe homing is SAFETRUE)
S_SafePositionValid	SAFEBOOL	Variable	Status	SAFEFALSE	Specifies whether the safe position is valid (=SAFETRUE, homing procedure has completed successfully and there are no encoder errors)
S_AllReqFuncActive	SAFEBOOL	Variable	Status	SAFEFALSE	All requested safety functions have achieved their safe state. (= SAFETRUE)
S_SafetyActiveSDC	SAFEBOOL	Variable	Status	SAFEFALSE	Deceleration monitoring active (= SAFETRUE)
S_NotErrFUNC	SAFEBOOL	Variable	Status	SAFEFALSE	SafeMOTION module not in the FUNCTIONAL FAIL SAFE state (= SAFETRUE)
Error	BOOL	Variable	Status	FALSE	Function block error message
DiagCode	WORD	Variable	Status	16#0000	Function block diagnostic message
AxisStatus	DWORD	Variable	Status	32#00000000	Status information from axis

Table 203: SF_SafeMC_BR_V3: Overview of output parameters

1) Output of the output parameter signals. The signals must be evaluated and/or further processed accordingly by the user.

Type	Description	Size in bits	Format option
BOOL	Bit	1	Bit string
WORD	Word	16	Bit string
SAFEBOOL	Bit	1	Bit string (signal source: safe device)
SAFEDWORD	Double word	32	Bit string (signal source: safe device)
SAFEDINT	Double integer	32	Binary number, hexadecimal number, signed decimal number (signal source: safe device)
SAFEINT	Integer	16	Binary number, hexadecimal number, signed decimal number (signal source: safe device)

Table 204: Format description of the data types

You have the option of linking a safe signal with a non-safe input parameter. To do so, use a function block for type conversion.

Caution!

You are responsible for any conversion of a non-safe input parameter to a safe signal.

4.2 SafeMOTION module parameters

Parameter	Unit	Description	Safety function
Additional Parameter			
Activate safe machine options	Deactivated/ Activated	Activates/Deactivates the "Safe machine options" function	Safe machine options
Encoder Unit System			
Count of physical reference system	-	Rotary encoder unit scale: x revolutions Linear encoder unit scale: x reference lengths (reference length = length of the physical reference system) Any unit (mm, 1/100 mm, 1/20 inch, degree of angle, etc.) can be used for positions (and data which can result such as speed and acceleration). For this reason, the relationship between an integer multiple of this unit (units per x revolutions / units per x reference lengths) and a certain number of x revolutions / x reference lengths has to be previously defined.	Unit system
Units per count of physical reference system [units]	units	Rotary encoder unit-scale: Units per x revolutions Linear encoder unit scale: Units per x reference lengths Any unit (mm, 1/100 mm, 1/20 inch, degree of angle, etc.) can be used for positions (and data which can result such as speed and acceleration). Therefore, the relationship between an integer multiple of this unit (units per x-revolutions / units per x-reference lengths) and a certain number of x-revolutions / x-reference lengths has to be previously defined.	Unit system
Counting direction	Standard / Inverse	Counting direction of the position or speed Default…Encoder counter direction is equal to the counting direction of the unit system Inverse…Encoder counting direction is negative to the counting direction of the unit system	Unit system
Length of physical reference system for linear encoder (nm)	nm	For linear measurement systems, the length of a physical reference system will be defined here. This value is not used for rotary encoders, where the reference system is a single revolution.	Unit system
Maximum speed to normalize the speed range (units)	units	Maximum speed to which the displayed speed should be normalized	Unit system
Maximum acceleration (rad/s² or mm/s²)	rad/s² or mm/s²	Maximum permissible encoder acceleration	Unit system
Homing			
Home Position or Home Offset (units)	units	Home position or home offset	Homing
Max. trigger speed (units/s)	units/s	Maximum permissible speed for evaluating the reference switch / reference pulse.	Homing
Homing Monitoring Time (µs)	µs	Monitoring time for the homing procedure	Homing
Mode	Direct / Reference Switch / Home Offset / Home Offset with Correction	Selects the homing mode	Homing
Edge of reference switch	Positive / Negative	Selects the switching edge for the reference switch The switch edge for the reference switch input is positive if the logical state of the reference switch changes from SAFEFALSE to SAFETRUE in the positive direction of movement.	Homing
Trigger direction	Positive / Negative	Selects the trigger direction If the homing procedure requires a movement, then this parameter specifies the direction for evaluating the reference switch / reference pulse.	Homing
Reference pulse	Used / Not Used	Selects whether or not to use a reference pulse for homing	Homing
Blocking distance (% encoder reference system)	%	Distance within which evaluation of the reference pulse will be suppressed. This is calculated starting at the configured reference switch edge and indicated as a percentage of the encoder reference system. A single revolution is used as the encoder reference system for rotary encoders.	Homing
Safety Deceleration Ramp			
Deceleration Ramp	[units/s²]	Slope of the deceleration ramp to be monitored	SS1, SS2, SLS
General Settings			
Safe Maximum Speed	Used / Unused	Activates the SMS safety function from the configuration	SMS
Automatic Reset at Startup (Startreset)	Used / Unused	Activates automatic reset of the function block at startup	Configuration
Channel selection for One Channel STO (STO1)	HighSide / LowSide	Selection of HighSide or LowSide IGBT in the function One Channel STO	STO1 / Configuration FUNCTIONAL FAIL SAFE
Rampmonitoring for SS1	Activated / Deactivated	Activates ramp-based monitoring (in addition to time-based monitoring) when the SS1 safety function is requested	SS1
Rampmonitoring for SS2	Activated / Deactivated	Activates ramp-based monitoring (in addition to time-based monitoring) when The SS2 safety function is requested	SS2
Rampmonitoring for SLS	Activated / Deactivated	Activates ramp-based monitoring (in addition to time-based monitoring) when the SLS safety function is requested	SLS
Early Limit Monitoring	Activated / Deactivated	Monitoring of the deceleration ramp is prematurely terminated if the target limit is reached or exceeded.	SS1, SS2, SLS
Safe Maximum Position	Used / Unused	Activates the SMP safety function from the configuration	SMP
Encoder Monitoring			
Encoder Position Monitoring	Activated / Deactivated	Activates/deactivates the monitoring of the position lag error generated on the SafeMOTION module	Monitoring Encoder shaft breakage

Table 205: SF_SafeMC_BR_V3: Module parameters

Parameter	Unit	Description	Safety function
Encoder Speed Monitoring	Activated / Deactivated	Activates/Deactivates monitoring of the speed error generated on the SafeMOTION module	Monitoring Encoder shaft breakage
Set position alive testing	Activated / Deactivated	Activates/deactivates the monitor that detects whether the set position generated on the ACOPOSmulti SafeMOTION inverter module is frozen.	Monitoring Encoder shaft breakage
Behavior of Functional Fail Safe			
Behavior of Functional Fail Safe	STO/ STO1 and STO with time delay	In the FUNCTIONAL FAIL SAFE state, STO (SBC) is activated immediately or STO1 and then STO (SBC) after a delay.	Configuration
Safely Limited Acceleration			
Safe acceleration limit for SLA (units/s²) in positive direction	[units/s²]	Limit for acceleration in the positive direction of movement	SLA
Safe deceleration limit for SLA (units/s²) in positive direction	[units/s²]	Limit for deceleration in the positive direction of movement	SLA
Safe acceleration limit for SLA (units/s²) in negative direction	[units/s²]	Limit for acceleration in the negative direction of movement	SLA
Safe deceleration limit for SLA (units/s²) in negative direction	[units/s²]	Limit for deceleration in the negative direction of movement	SLA
Safety Speed Limits			
Maximum Speed for SMS	[units/s]	Speed limit of the maximum speed	SMS
Safe Speedlimit 1 for SLS	[units/s]	Speed limit 1 for SLS	SLS
Safe Speedlimit 2 for SLS	[units/s]	Speed limit 2 for SLS	SLS
Safe Speedlimit 3 for SLS	[units/s]	Speed limit 3 for SLS	SLS
Safe Speedlimit 4 for SLS	[units/s]	Speed limit 4 for SLS	SLS
Safety Position Limits			
Safe Lower Position Limit for SMP (units)	[units]	Lower position limit for the machine's full range of movement	SMP
Safe Upper Position Limit for SMP (units)	[units]	Upper position limit for the machine's full range of movement	SMP
Safe Lower Position Limit for SLP (units)	[units]	Lower position limit for the monitoring range	SLP
Safe Upper Position Limit for SLP (units)	[units]	Upper position limit for the monitoring range	SLP
Safety Standstill and Direction Tolerances			
Speed Tolerance	[units/s]	Speed tolerance for standstill monitoring	SOS, SS2, SLI, SMP, SLP
Position Tolerance	[units]	Position tolerance for standstill and direction monitoring	SOS, SS2, SDI, SMP, SLP
Safely Limited Increments			
Safe increments	[units]	Maximum movable increments when SLI is active	SLI
SLI Off Delay	[µs]	Switch off delay of SLI	SLI
Safety Ramp Monitoring Times			
Ramp Monitoring Time for SS1 (us)	[µs]	Deceleration ramp monitoring time for SS1	SS1
Ramp Monitoring Time for SS2 (us)	[µs]	Deceleration ramp monitoring time for SS2	SS2
Ramp Monitoring Time for SLS1 (us)	[µs]	Deceleration ramp monitoring time for SLS1	SLS1
Ramp Monitoring Time for SLS2 (us)	[µs]	Deceleration ramp monitoring time for SLS2	SLS2
Ramp Monitoring Time for SLS3 (us)	[µs]	Deceleration ramp monitoring time for SLS3	SLS3
Ramp Monitoring Time for SLS4 (us)	[µs]	Deceleration ramp monitoring time for SLS4	SLS4
Safety Additional Parameters			
Delay time to start ramp monitoring (us)	[µs]	Delay time between the request for ramp-based monitoring and the start of monitoring	SS1, SS2, SLS
Delay time to start SDI (us)	[µs]	Delay time between the SDI request and activation of the safety function	SDI
Delay time to start SBC (us)	[µs]	Delay time between the SBC request and activation of the safety function	SBC
Delay time to start SLP (us)	[µs]	Delay time between the SLP request and start of monitoring	SLP
Delay time to start SLA (us)	[µs]	Delay time between the SLA request and start of monitoring	SLA
Early Limit Monitoring time (us)	[µs]	Time during which the speed must be equal to or below the target speed limit in order to prematurely end the deceleration ramp and to assume the safety function's end state	SS1, SS2, SLS
Encoder Monitoring Tolerances			
Encoder Monitoring Position Tolerance	[units]	Position lag error tolerance for shaft breakage monitoring	Monitoring Encoder shaft breakage
Encoder Monitoring Speed Tolerance	[units/s]	Speed error tolerance for encoder monitoring	Monitoring Encoder shaft breakage

Table 205: SF_SafeMC_BR_V3: Module parameters

In a safety application, it is possible for multiple safety functions to be requested at the same time. In order to prevent this from turning into an unsafe situation, the individual safety functions are prioritized on the SafeMOTION module.

If several functions are active at the same time, then the lowest speed limit is always the value being monitored.

Information:

The following application rule must be followed in order for the safety functions to be prioritized correctly:

$LIM_{SOS} \leq LIM_{SLS4} \leq LIM_{SLS3} \leq LIM_{SLS2} \leq LIM_{SLS1} \leq LIM_{SMS}$ <NormSpeed

or

$LIM_{SMP,NEG} \leq LIM_{SLP,NEG} \leq LIM_{SLP,POS} \leq LIM_{SMP,POS}$

If the application rule is violated, then the SafeMOTION module will switch to the FAIL SAFE state.

4.3 Integrated safety functions

See "ACOPOSmulti SafeMOTION user's manual / Safety technology / Integrated safety functions".

4.4 Safe encoder connection monitoring

4.4.1 Encoder mounting with proof of fatigue strength

To prevent errors caused by encoder slippage or shaft breakage, the mechanical mounting of the encoder requires proof of fatigue strength.

This proof and the corresponding mounting guidelines can be provided either by the manufacturer of the measuring instrument or by the manufacturer of the machine.

> **Danger!**
>
> **To ensure safe operation up to and including the motor shaft, any errors in the connection between the motor shaft and encoder must be identified and prevented.**

> **Danger!**
>
> **Proof of fatigue strength for the encoder's mechanical mounting is to be dimensioned to the maximum rotor acceleration. This acceleration value must not be exceeded in the worst case. The maximum acceleration is monitored on the SafeMOTION module and can be configured using the "Maximum acceleration" parameter.**

> **Danger!**
>
> **Mechanical tolerances in the encoder mounting must be taken into account when calculating the residual distance. This residual movement must be taken into account by the safety functions.**

> **Danger!**
>
> **To ensure safe operation up to and including the motor shaft, any errors in the connection between the motor shaft and encoder must be identified and prevented.**
> **There are specific guidelines that must be followed when installing a functional safety encoder.**
> **The motor manufacturer must ensure that these specifications are adhered to.**

> **Danger!**
>
> **The frictional connection between the cone-shaped shaft of the rotor and measuring instrument can be dimensioned for maximum rotor acceleration in accordance with the mounting instructions provided by the encoder manufacturer. This acceleration value must not be exceeded in the worst case. The maximum acceleration is monitored on the SafeMOTION module and can be configured using the "*Maximum acceleration*" parameter.**

> **Danger!**
>
> **If the terminal screw for the coupling ring becomes loose on installed measuring instruments, then the form-fit pin will be the only thing holding the encoder to the motor housing. A movement in accordance with the mounting tolerances is possible. The encoder is not able to register this movement. This residual movement must be taken into account by the safety functions.**

4.4.2 Encoder mounting without proof of fatigue strength - Safe lag error monitoring

If "Encoder Monitoring" is activated in the SafeMOTION module, in some applications the proof of fatigue strength for the mechanical mounting of the encoder is not required.

The following safety-related restrictions must be taken into account!

> **Danger!**
>
> **Only safety functions in which no safe absolute position is monitored are permitted to be used (STO, SBC, SOS, SS1, SS2, SLS, SMS, SLI, SDI, SLA, SBT (only available for ACOPOSmulti SafeMOTION SinCos) and Safe Speed).**

Danger!

The application must meet the following requirements for safety-related monitoring of the encoder-motor connection:

- **Encoder connection monitoring can only be used for encoders that are integrated in position control.**
- **Encoder connection monitoring can only be used for drive systems with synchronous motors.**
- **The encoder must be protected against shearing in standstill (e.g. with encasement in the motor housing)!**
- **Monitoring for position lag errors, speed errors and position setpoints change (Alive Testing) must be enabled in the safety application, and sufficiently strict limits must be monitored!**
- **The Safe Position, SLP and/or SMP safety functions must not be used!**
- **Safe monitoring can only be guaranteed when closed-loop control is enabled.**

Danger!

- **An electrical offset of <90° will not be detected sufficiently.**
- **There is no way to monitor the encoder connection if the setpoint remains constant.**
- **An encoder connection error or an error in encoder evaluation is always assumed as the cause for the lag error.**
- **The error reaction in the standard application to a position lag error or speed error is disabled by the SafeMOTION module (overridden). When lag errors occur, only the error responses STO or STO1 with an induction stop are possible.**

Danger!

Note that an error can result in a forward movement. The maximum angle of rotation φ of the motor shaft during this forward movement depends on the motor being used.

For permanently excited synchronous motors, φ = 360°/2p (for B&R standard motors, p=3 so the angle is 60°). For three-phase induction motors, there is a relatively small angle of rotation (between 5° and 15°).

The maximum speed of the forward movement can be calculated as follows:

$$n_{Jolt} = \frac{1}{2\pi}\sqrt{\frac{6a_{max}}{p_z}}\left[\frac{U}{s}\right]$$

with maximum acceleration $a_{max} = \frac{M_{max}}{J}\left[\frac{rad}{s^2}\right]$ **and number of motor pole pairs** p_z

Danger!

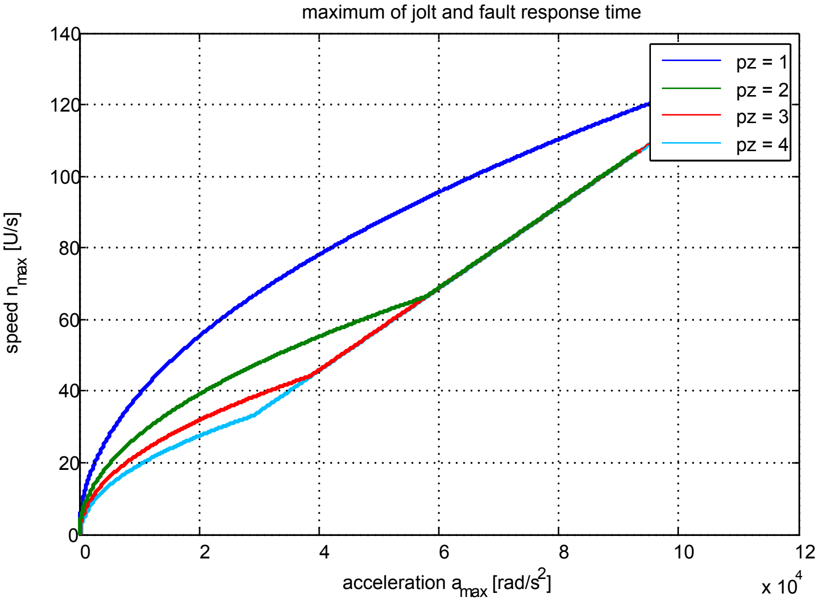
When considering the worst-case scenario for a safety function, the highest value of the maximum speed of the forward movement n_{Jolt} **and the speed must be used as maximum speed due to the maximum error response time** $n_{T_{worstcase}}$**.**

$$n_{max} = max(n_{Jolt}, n_{T_{worstcase}}) = max\left(\frac{1}{2\pi}\sqrt{\frac{6a_{max}}{p_z}}, \frac{T_{worstcase}}{2\pi} \cdot a_{max}\right)$$

with maximum error response time $T_{worstcase} = 7.2[ms]$

The maximum speed n_{max} **resulting from this must be considered together with the speed when the safety function** n_{LIM} **is violated in order to determine the maximum possible speed** $n_{worstcase}$ **at the time of coasting to a stop!**

$$n_{worstcase} = n_{LIM} + n_{max}$$



Information:

In order to check the plausibility of setpoint selection after each power on, the axis must be moved by at least twice the configured lag error limit before the first request of a safety function, which requires a safe encoder evaluation, or at least within 15 min.
If this is not done, then the SafeMOTION module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state. The S_NotErrFUNC output on the function block is reset, and the drive loses all torque/power and coasts to a stop!
In the event of an error, a synchronous axis will no longer be synchronous.

Danger!

Situations involving external forces (e.g. hanging loads) can result in dangerous movements!
If this poses a safety risk, then the user must implement the necessary equipment to eliminate the risk (e.g. mechanical brakes)! This equipment must correspond to the required safety level!

Information:

A 24-hour timeout begins after successfully checking the plausibility of the setpoint.
The timeout is reset any time the position setpoint changes by more than twice the position lag error tolerance.
If the position setpoint does not change during 24 hours of continuous controller operation, then the SafeMOTION module will switch to the acknowledgeable FUNCTIONAL FAIL SAFE error state. The S_NotErrFUNC output on the function block is reset, and the drive loses all torque/power and coasts to a stop! In the event of an error, a synchronous axis will no longer be synchronous.

The following parameters are relevant for safe monitoring of the encoder-motor shaft connection (Encoder Monitoring):

Parameter	Unit	Description	Default value
Encoder Unit System			
Maximum acceleration [rad/s² or mm/s²]	[rad/s² or mm/s²]	Maximum permissible encoder acceleration	100000
Encoder Monitoring			
Encoder Position Monitoring	Activated/ Deactivated	Activates/Deactivates the monitoring of the position lag error generated on the SafeMOTION module	Activated
Encoder Speed Monitoring	Activated/ Deactivated	Activates/Deactivates the monitoring of the speed error generated on the SafeMOTION module	Activated
Set position alive testing	Activated/ Deactivated	Activates/Deactivates the monitor that detects whether the position setpoint generated on the ACOPOSmulti SafeMOTION inverter module is frozen	Activated
Encoder Monitoring Tolerances			
Encoder Monitoring Position Tolerance	[units]	Position lag error tolerance for shaft breakage monitoring	0
Encoder Monitoring Speed Tolerance	[units/s]	Speed error tolerance for encoder monitoring	0

Table 206: Encoder Monitoring safety function - Parameters

Danger!

The machine manufacturer is responsible for determining whether or not the application is suited for safe encoder connection monitoring if there is no mechanical mechanism for detecting encoder shaft breakage.
The machine manufacturer is responsible for ensuring that the safe encoder monitoring has been configured correctly!

Danger!

Encoder connection monitoring can only be used in a safety-related capacity if the aforementioned requirements for the application have been fulfilled!

4.4.2.1 Activating monitoring

The following parameters must be set to "Activated" in SafeDESIGNER in order to enable safe encoder connection monitoring:

- "Encoder Position Monitoring" = Activated
- "Encoder Speed Monitoring" = Activated
- "Set position alive testing" = Activated

Danger!

In order to ensure safety-related monitoring of the encoder/motor connection, all three parameters "Encoder Position Monitoring", "Encoder Speed Monitoring" and "Set Position Alive Testing" must be set to "Activated"!
If this is not the case, then the monitoring system cannot be used for safety purposes and a mechanical solution for detecting errors must be implemented!

4.4.2.2 Configuration rule for position lag error tolerance

The position lag error tolerance must be set large enough to ensure availability. This can be done by first measuring the position lag error under the highest influence of disturbance variables and at maximum acceleration and then setting the position lag error tolerance accordingly higher.

Danger!

The position lag error tolerance cannot be higher than half of one pole length!

If the safety function is activated, the size of the position lag error tolerance value affects how long it will take to look for errors and therefore also the error response time and estimation of the residual distance.

This must be taken into account by the machine manufacturer in the risk analysis!

Information:

Due to rounding errors, a reserve of 1 unit should be taken into account with the parameter "Encoder Monitoring Position Tolerance".

4.4.2.3 Configuration rule for speed error tolerance

The speed error tolerance must be set large enough to ensure availability.
This can be done by first measuring the speed error under the highest influence of disturbance variables and reference variables (e.g. at maximum acceleration) and then setting the speed error tolerance accordingly higher.

Danger!

When the safety function is enabled, the size of the speed error tolerance value affects how long it will take to look for errors and therefore also the error response time and estimation of the residual distance.

This must be taken into account by the machine manufacturer in the risk analysis!

Information:

Due to rounding errors, a reserve of 1 unit/s should be taken into account with the "Encoder monitoring speed tolerance" parameter.

4.5 Fault avoidance

Danger!

Validation

Each safety function that is used must be validated separately.
It is also necessary to test the entire safety application, including the interactions between individual functions.

4.5.1 Exceeding monitored limits

The SafeMOTION module monitors configurable limits. The drive itself, however, is controlled by the standard application on the standard PLC.

The following points must be considered in order to prevent a monitored limit from being violated:

- The movement of the drive must be adapted to the requested safety function and initiated on time.
- The monitored limits must match the calculated limits and movement limitations. Make sure that the different configurations of the unit system match in the safety application and in the standard application!

Danger!

Any violation of a monitored limit will cause the module to switch to the acknowledgeable FUNCTIONAL FAIL SAFE error state.

The S_NotErrFUNC output on the function block is reset, and the drive loses all torque/power and coasts to a stop!

Depending on the configuration, the motor holding brake will also be switched to 0 V.

In the event of an error, a synchronous axis will no longer be synchronous.

Check the Safety Logger in Automation Studio for detailed information about monitoring.

4.5.2 Plausibility errors

Plausibility errors (limit values, data types, variables/constants) that occur when using the function block are detected and reported by either the function block or compiler.

This is not possible in the event of connection errors, however.

The function block does not check for the following errors:

- Actual parameter values or constants are within their valid range but incorrect for the safety function being executed.
- Actual parameters have been connected incorrectly.
- Formal input/output parameters that should have been connected have not been connected.

Danger!

Ensuring proper safety function connections (sub-application) is your responsibility as the user!

Make sure to check these connections when validating the sub-application!

4.5.3 Sporadically changing/toggling signal levels or impermissible signals

Sporadically changing or toggling signal levels on edge-controlled formal input parameters causes the function block to interpret the signal as an edge, which results in an unintended action being triggered in the function block if error prevention measures are not taken.

Sporadically changing or toggling signal levels on status-controlled input formal parameters will cause the signal to trigger an undesired corresponding action if error prevention measures are not taken.

Impermissible signals on input formal parameters can lead to an unexpected initial movement, non-execution of a requested action or an error message.

Possible causes of these signals:

- Programming error in the application program (user error)
- Cross fault, short circuit or open line (user error, wiring error)

- Error on the standard controller

To prevent this, the following measures can be taken depending on the safety function:

- Using signals from safe devices
- Implementing additional measures for preventing a hazard if using a signal from a standard controller (e.g. executing an additional function start after a safety function has been triggered or an error has been corrected)
- Line control on the safe control system
- Suitable cabling when using non-safe signals from the standard controller
- Verifying the source code in the application program and final validation of the safety functionality

These measures can also be combined to prevent errors.

It is important to note that a signal change detected on a status-controlled formal parameter will be output as a diagnostic code.

4.5.4 Simultaneous edge change

Make sure that the **Reset** formal parameter is only connected to a signal from a manual resetting device to reduce the risk of an unexpected initial movement. This signal is based on your risk analysis.

4.5.5 Machine/System startup without performing functional testing of safety equipment

Faulty safety equipment can only be detected following functional testing. Functional testing is not supported by this function block. If additional measures are not taken, faulty safety equipment can result in errors.

> ## Danger!
>
> **You are responsible for performing functional testing of safety equipment.**
> **You must therefore ensure that your safety equipment undergoes validation!**

Possible causes of faulty safety equipment:

- Faulty devices (hardware error)
- Cross fault, short circuit or open line (user error, wiring error)

4.6 Input parameters

Information:

For detailed information on the individual safety functions, see "ACOPOSmulti SafeMOTION user's manual/ Chapter: Safety technology / Integrated safety functions".

4.6.1 General information about the "S_Request" inputs

The "**S_Request**" inputs are used to request the respective safety functions.

If a safety function should not be used in the safety application, then the respective input should not be connected.

Information:

If a safety function is not used in the application, then the respective input must remain open.

Danger!

The safety functions that are used must be tested.
A function is considered to be used if the respective input variable is connected!

Information:

At a minimum, the Activate and S_AxisID inputs must be connected. Otherwise, the SafeMOTION module will not be operated by the SafeLOGIC controller. As a result, the pulse disabling and motor holding brake output will be permanently set to 0 V, which means that the controller cannot be turned on.

4.6.2 Activate

General function

- Enables the function block

Data type

- BOOL

Connection

- Constant or variable

Description of function

This input parameter is used to enable the function block.

- If you are activating or deactivating safe devices, link **Activate** to a variable that indicates the status (deactivated or activated) of the corresponding safe devices. This ensures that the function block does not output a triggered safety function as diagnostic information when a device is cut off.
- It is also possible to connect "Activate" to a constant (TRUE) in order to enable the function block.

TRUE

The function block is enabled.

FALSE

The function block is disabled.
All binary output parameters are set to FALSE.
Sets the DiagCode diagnostic parameter to WORD#16#0000.

If you want to control function block diagnostics as needed in your diagnostic concept whenever error messages from safe devices and/or deactivated safe devices occur, connect "Activate" to a signal that indicates the status of the safe devices that are involved with the safety function supported by the function block. Create this signal only for safe devices whose I/O signals are connected to the function block via actual parameters. This prevents triggered safety functions from being reported by inactive safe devices. This measure is only used to control diagnostics in the event of inactive safe devices.

4.6.3 S_RequestSTO

General function

- Selects/Deselects the "Safe Torque Off" (STO) safety function

Data type

- SAFEBOOL

Connection

- Constant or variable

Description of function

This input parameter is used to select or deselect the STO safety function.

TRUE

The safety function is deselected. Safe pulse disabling is not active!

FALSE

The safety function is selected. Safe pulse disabling is active! Torque/Power are switched off on the drive.

Not connected

The safety function is deactivated.

Relevant configuration parameters

- None

4.6.4 S_RequestSTO1

General function

- Selects/Deselects the "Safe Torque Off, One Channel" (STO1) safety function

Data type

- SAFEBOOL

Connection

- Constant or variable

Description of function

This input parameter is used to select or deselect the STO1 safety function.

TRUE

The safety function is deselected. Safe pulse disabling is not active!

FALSE

The safety function is selected. Depending on the configuration, the HighSide or LowSide of safe pulse disabling is active! Torque/Power are switched off on the drive.

Not connected

The safety function is deactivated.

Relevant configuration parameters

Parameter	Unit	Description	Default value
General Settings			
Channel selection for One Channel STO (STO1)	HighSide/ LowSide	Selects the HighSide or LowSide IGBT in the STO1 function	HighSide

Table 207: STO1 safety function - Parameters

4.6.5 S_RequestSBC

General function

- Selects/Deselects the "Safe Brake Control" (SBC) safety function

Data type

- SAFEBOOL

Connection

- Constant or variable

Description of function

This input parameter is used to select or deselect the SBC safety function.

TRUE

The safety function is deselected. The motor holding brake is active and can be used by the standard application.

FALSE

The safety function is selected. The motor holding brake is switched to 0 V!

Not connected

The safety function is deactivated.

Relevant configuration parameters

Parameter	Unit	Description	Default value
Safety Additional Parameters			
Delay time to start SBC (us)	[µs]	Delay time between the SBC request and activation of the safety function	0

Table 208: SBC safety function - Parameters

4.6.6 S_RequestSOS

General function

- Selects/Deselects the "Safe Operating Stop" (SOS) safety function

Data type

- SAFEBOOL

Connection

- Constant or variable

Description of function

This input parameter is used to select or deselect the SOS safety function.

TRUE

The safety function is deselected. Standstill tolerances are not being monitored.

FALSE

The safety function is selected. Standstill tolerances are being monitored.

Not connected

The safety function is deactivated.

Relevant configuration parameters

Parameter	Unit	Description	Default value
Safety Standstill and Direction Tolerances			
Speed Tolerance	[units/s]	Speed tolerance for standstill monitoring	0
Position Tolerance	[units]	Position tolerance for standstill and direction monitoring	0

Table 209: SOS safety function - Parameters

Information:

This safety function requires safe evaluation of the position and speed.
If an evaluation error is detected, then the SafeMOTION module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state.

Information:

If several safety functions are active, then the lowest speed limit is always the value being monitored.

The following application rule must be observed:
$\mathbf{LIM_{SOS} \leq LIM_{SLS4} \leq LIM_{SLS3} \leq LIM_{SLS2} \leq LIM_{SLS1} \leq LIM_{SMS} < NormSpeed}$

Failure to follow the application rule will cause the SafeMOTION module to enter the FAIL SAFE state. If this occurs, it can only be brought back to the OPERATIONAL state by modifying the safety application and completing a power off/on cycle!

4.6.7 S_RequestSS1

General function

- Selects/Deselects the "Safe Stop 1" (SS1) safety function

Data type

- SAFEBOOL

Connection

- Constant or variable

Description of function

This input parameter is used to select or deselect the SS1 safety function.

TRUE

The safety function is deselected. Safe Stop 1 is not active!

FALSE

The safety function is selected. Safe pulse disabling is activated after the end of ramp monitoring.

Not connected

The safety function is deactivated.

Relevant configuration parameters

Parameter	Unit	Description	Default value
Safety Deceleration Ramp			
Deceleration Ramp	[units/s²]	Slope of the deceleration ramp to be monitored	1073676289
General Settings			
Rampmonitoring for SS1	Activated/ Deactivated	Activates ramp-based monitoring (in addition to time-based monitoring) when the SS1 function is requested	Activated
Early Limit Monitoring	Activated/ Deactivated	Prematurely terminates monitoring of the deceleration ramp if the value falls below the lower limit for a defined amount of time	Deactivated
Safety Ramp Monitoring Times			
Ramp Monitoring Time for SS1 (us)	[µs]	Deceleration ramp monitoring time for SS1	0
Safety Additional Parameters			
Delay time to start ramp monitoring (us)	[µs]	Delay time between the request for ramp-based monitoring and the start of monitoring	0
Early Limit Monitoring time (us)	[µs]	Time during which the speed must be below the target speed limit in order to prematurely end the deceleration ramp and to assume the safety function's end state	0

Table 210: SS1 safety function - Parameters

Information:

This safety function requires safe evaluation of the position and speed.
If an evaluation error is detected, then the SafeMOTION module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state.

Information:

To use this function without safe encoder evaluation, "Ramp monitoring for SS1" and "Early Limit Monitoring" must be disabled.

Information:

If several safety functions are active, then the lowest speed limit is always the value being monitored.

The following application rule must be observed:
$LIM_{SOS} \leq LIM_{SLS4} \leq LIM_{SLS3} \leq LIM_{SLS2} \leq LIM_{SLS1} \leq LIM_{SMS} <$ NormSpeed

Failure to follow the application rule will cause the SafeMOTION module to enter the FAIL SAFE state. If this occurs, it can only be brought back to the OPERATIONAL state by modifying the safety application and completing a power off/on cycle!

4.6.8 S_RequestSS2

General function

- Selects/Deselects the "Safe Stop 2" (SS2) safety function

Data type

- SAFEBOOL

Connection

- Constant or variable

Description of function

This input parameter is used to select or deselect the SS2 safety function.

TRUE

The safety function is deselected. Safe Stop 2 is not active!

FALSE

The safety function is selected. Standstill monitoring is activated after the end of ramp monitoring.

Not connected

The safety function is deactivated.

Relevant configuration parameters

Parameter	Unit	Description	Default value
Safety Deceleration Ramp			
Deceleration Ramp	[units/s²]	Slope of the deceleration ramp to be monitored	1073676289
General Settings			
Rampmonitoring for SS2	Activated/ Deactivated	Activates ramp monitoring (in addition to time-based monitoring) when the SS2 function is requested	Activated
Early Limit Monitoring	Activated/ Deactivated	Prematurely terminates monitoring of the deceleration ramp if the value falls below the lower limit for a defined amount of time	Deactivated
Safety Standstill and Direction Tolerances			
Speed Tolerance	[units/s]	Speed tolerance for standstill monitoring	0
Position Tolerance	[units]	Position tolerance for standstill and direction monitoring	0
Safety Ramp Monitoring Times			
Ramp Monitoring Time for SS2 (us)	[µs]	Deceleration ramp monitoring time for SS2	0
Safety Additional Parameters			
Delay time to start ramp monitoring (us)	[µs]	Delay time between the request for ramp-based monitoring and the start of monitoring	0
Early Limit Monitoring time (us)	[µs]	Time during which the speed must be below the target speed limit in order to prematurely end the deceleration ramp and to assume the safety function's end state	0

Table 211: SS2 safety function - Parameters

Information:

**This safety function requires safe evaluation of the position and speed.
If an evaluation error is detected, then the SafeMOTION module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state.**

Information:

If several safety functions are active, then the lowest speed limit is always the value being monitored.

The following application rule must be observed:
$\mathbf{LIM_{SOS} \leq LIM_{SLS4} \leq LIM_{SLS3} \leq LIM_{SLS2} \leq LIM_{SLS1} \leq LIM_{SMS} < NormSpeed}$

Failure to follow the application rule will cause the SafeMOTION module to enter the FAIL SAFE state. If this occurs, it can only be brought back to the OPERATIONAL state by modifying the safety application and completing a power off/on cycle!

4.6.9 S_RequestSLS1

General function

- Selects/Deselects the "Safely Limited Speed" safety function, Speed Limit 1

Data type

- SAFEBOOL

Connection

- Constant or variable

Description of function

This input parameter is used to select or deselect the SLS1 safety function.

TRUE

The safety function is deselected. SLS1 is not active!

FALSE

The safety function is selected. Speed limit 1 is monitored after the end of ramp monitoring.

Not connected

The safety function is deactivated.

Relevant configuration parameters

Parameter	Unit	Description	Default value
Safety Deceleration Ramp			
Deceleration Ramp	[units/s²]	Slope of the deceleration ramp to be monitored	1073676289
General Settings			
Rampmonitoring for SLS	Activated/ Deactivated	Activates ramp-based monitoring (in addition to time-based monitoring) when the SLS function is requested	Activated
Early Limit Monitoring	Activated/ Deactivated	Prematurely terminates monitoring of the deceleration ramp if the value falls below the lower limit for a defined amount of time	Deactivated
Speed Limits			
Safe Speedlimit 1 for SLS	[units/s]	Speed limit 1 for SLS	0
Safety Ramp Monitoring Times			
Ramp Monitoring Time for SLS1 (us)	[µs]	Deceleration ramp monitoring time for SLS1	0
Safety Additional Parameters			
Delay time to start ramp monitoring (us)	[µs]	Delay time between the request for ramp-based monitoring and the start of monitoring	0
Early Limit Monitoring time (us)	[µs]	Time during which the speed must be below the target speed limit in order to prematurely end the deceleration ramp and to assume the safety function's end state	0

Table 212: SLS1 safety function - Parameters

Information:

This safety function requires safe evaluation of the position and speed.
If an evaluation error is detected, then the SafeMOTION module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state.

Information:

If several safety functions are active, then the lowest speed limit is always the value being monitored.

The following application rule must be observed:
$LIM_{SOS} \leq LIM_{SLS4} \leq LIM_{SLS3} \leq LIM_{SLS2} \leq LIM_{SLS1} \leq LIM_{SMS}$ < NormSpeed

Failure to follow the application rule will cause the SafeMOTION module to enter the FAIL SAFE state. If this occurs, it can only be brought back to the OPERATIONAL state by modifying the safety application and completing a power off/on cycle!

4.6.10 S_RequestSLS2

General function

- Selects/Deselects the "Safely Limited Speed" safety function, Speed Limit 2

Data type

- SAFEBOOL

Connection

- Constant or variable

Description of function

This input parameter is used to select or deselect the SLS2 safety function.

TRUE

The safety function is deselected. SLS2 is not active!

FALSE

The safety function is selected. Speed limit 2 is monitored after the end of ramp monitoring.

Not connected

The safety function is deactivated.

Relevant configuration parameters

Parameter	Unit	Description	Default value
Safety Deceleration Ramp			
Deceleration Ramp	[units/s²]	Slope of the deceleration ramp to be monitored	1073676289
General settings			
Rampmonitoring for SLS	Activated/ Deactivated	Activates ramp-based monitoring (in addition to time-based monitoring) when the SLS function is requested	Activated
Early Limit Monitoring	Activated/ Deactivated	Prematurely terminates monitoring of the deceleration ramp if the value falls below the lower limit for a defined amount of time	Deactivated
Speed Limits			
Safe Speedlimit 2 for SLS	[units/s]	Speed limit 2 for SLS	0
Safety Ramp Monitoring Times			
Ramp Monitoring Time for SLS2 (us)	[µs]	Deceleration ramp monitoring time for SLS2	0
Safety Additional Parameters			
Delay time to start ramp monitoring (us)	[µs]	Delay time between the request for ramp-based monitoring and the start of monitoring	0
Early Limit Monitoring time (us)	[µs]	Time during which the speed must be below the target speed limit in order to prematurely end the deceleration ramp and to assume the safety function's end state	0

Table 213: SLS2 safety function - Parameters

Information:

This safety function requires safe evaluation of the position and speed.
If an evaluation error is detected, then the SafeMOTION module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state.

Information:

If several safety functions are active, then the lowest speed limit is always the value being monitored.

The following application rule must be observed:
$LIM_{SOS} \leq LIM_{SLS4} \leq LIM_{SLS3} \leq LIM_{SLS2} \leq LIM_{SLS1} \leq LIM_{SMS} <$ NormSpeed

Failure to follow the application rule will cause the SafeMOTION module to enter the FAIL SAFE state. If this occurs, it can only be brought back to the OPERATIONAL state by modifying the safety application and completing a power off/on cycle!

4.6.11 S_RequestSLS3

General function

- Selects/Deselects the "Safely Limited Speed" safety function, Speed Limit 3

Data type

- SAFEBOOL

Connection

- Constant or variable

Description of function

This input parameter is used to select or deselect the SLS3 safety function.

TRUE

The safety function is deselected. SLS3 is not active!

FALSE

The safety function is selected. Speed limit 3 is monitored after the end of ramp monitoring.

Not connected

The safety function is deactivated.

Relevant configuration parameters

Parameter	Unit	Description	Default value
Safety Deceleration Ramp			
Deceleration Ramp	[units/s²]	Slope of the deceleration ramp to be monitored	1073676289
General Settings			
Rampmonitoring for SLS	Activated/ Deactivated	Activates ramp-based monitoring (in addition to time-based monitoring) when the SLS function is requested	Activated
Early Limit Monitoring	Activated/ Deactivated	Prematurely terminates monitoring of the deceleration ramp if the value falls below the lower limit for a defined amount of time	Deactivated
Speed Limits			
Safe Speedlimit 3 for SLS	[units/s]	Speed limit 3 for SLS	0
Safety Ramp Monitoring Times			
Ramp Monitoring Time for SLS3 (us)	[µs]	Deceleration ramp monitoring time for SLS3	0
Safety Additional Parameters			
Delay time to start ramp monitoring (us)	[µs]	Delay time between the request for ramp-based monitoring and the start of monitoring	0
Early Limit Monitoring time (us)	[µs]	Time during which the speed must be below the target speed limit in order to prematurely end the deceleration ramp and to assume the safety function's end state	0

Table 214: SLS3 safety function - Parameters

Information:

This safety function requires safe evaluation of the position and speed.
If an evaluation error is detected, then the SafeMOTION module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state.

Information:

If several safety functions are active, then the lowest speed limit is always the value being monitored.

The following application rule must be observed:
$\mathbf{LIM_{SOS} \leq LIM_{SLS4} \leq LIM_{SLS3} \leq LIM_{SLS2} \leq LIM_{SLS1} \leq LIM_{SMS} < NormSpeed}$

Failure to follow the application rule will cause the SafeMOTION module to enter the FAIL SAFE state. If this occurs, it can only be brought back to the OPERATIONAL state by modifying the safety application and completing a power off/on cycle!

4.6.12 S_RequestSLS4

General function

- Selects/Deselects the "Safely Limited Speed" safety function, Speed Limit 4

Data type

- SAFEBOOL

Connection

- Constant or variable

Description of function

This input parameter is used to select or deselect the SLS4 safety function.

TRUE

The safety function is deselected. SLS4 is not active!

FALSE

The safety function is selected. Speed limit 4 is monitored after the end of ramp monitoring.

Not connected

The safety function is deactivated.

Relevant configuration parameters

Parameter	Unit	Description	Default value
Safety Deceleration Ramp			
Deceleration Ramp	[units/s²]	Slope of the deceleration ramp to be monitored	1073676289
General Settings			
Rampmonitoring for SLS	Activated/ Deactivated	Activates ramp-based monitoring (in addition to time-based monitoring) when the SLS function is requested	Activated
Early Limit Monitoring	Activated/ Deactivated	Prematurely terminates monitoring of the deceleration ramp if the value falls below the lower limit for a defined amount of time	Deactivated
Speed Limits			
Safe Speedlimit 4 for SLS	[units/s]	Speed limit 4 for SLS	0
Safety Ramp Monitoring Times			
Ramp Monitoring Time for SLS4 (us)	[µs]	Deceleration ramp monitoring time for SLS4	0
Safety Additional Parameters			
Delay time to start ramp monitoring (us)	[µs]	Delay time between the request for ramp-based monitoring and the start of monitoring	0
Early Limit Monitoring time (us)	[µs]	Time during which the speed must be below the target speed limit in order to prematurely end the deceleration ramp and to assume the safety function's end state	0

Table 215: SLS4 safety function - Parameters

Information:

This safety function requires safe evaluation of the position and speed.
If an evaluation error is detected, then the SafeMOTION module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state.

Information:

If several safety functions are active, then the lowest speed limit is always the value being monitored.

The following application rule must be observed:
$\mathbf{LIM_{SOS} \leq LIM_{SLS4} \leq LIM_{SLS3} \leq LIM_{SLS2} \leq LIM_{SLS1} \leq LIM_{SMS} < NormSpeed}$

Failure to follow the application rule will cause the SafeMOTION module to enter the FAIL SAFE state. If this occurs, it can only be brought back to the OPERATIONAL state by modifying the safety application and completing a power off/on cycle!

4.6.13 S_RequestSLI

General function

- Selects/Deselects the "Safely Limited Increment" safety function, SLI

Data type

- SAFEBOOL

Connection

- Constant or variable

Description of function

This input parameter is used to select or deselect the SLI safety function.

TRUE

The safety function is deselected. SLI is not active!

FALSE

The safety function is selected. A safe range of increments is monitored.

Not connected

The safety function is deactivated.

Relevant configuration parameters

Parameter	Unit	Description	Default value
Safety Standstill and Direction Tolerances			
Speed Tolerance	[units/s]	Speed tolerance for standstill monitoring	0
Safely Limited Increments			
Safe increments	[units]	Maximum movable increments when SLI is active	0
SLI Off Delay	[µs]	Switch off delay of SLI	0

Table 216: SLI safety function - Parameters

Information:

This safety function requires safe evaluation of the position and speed.
If an evaluation error is detected, then the SafeMOTION module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state.

4.6.14 S_RequestSDIpos

General function

- Selects/Deselects the "Safe Direction" safety function. Movement is allowed in the positive direction

Data type

- SAFEBOOL

Connection

- Constant or variable

Description of function

This input parameter is used to select or deselect the safety function SDI, movement is allowed in the positive direction of movement.

TRUE

The safety function is deselected. SDI is not active!

FALSE

The direction of movement is monitored after the delay time has expired. Movement is allowed in the positive direction.

Not connected

The safety function is deactivated.

Relevant configuration parameters

Parameter	Unit	Description	Default value
Safety Standstill and Direction Tolerances			
Position Tolerance	[units]	Position tolerance for standstill and direction monitoring	0
Safety Additional Parameters			
Delay time to start SDI (us)	[µs]	Delay time between the SDI request and activation of the safety function	0

Table 217: SDI safety function - Parameters

Information:

This safety function requires safe evaluation of the position and speed.
If an evaluation error is detected, then the SafeMOTION module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state.

4.6.15 S_RequestSDIneg

General function

- Selects/Deselects the "Safe Direction" safety function. Movement is allowed in the negative direction

Data type

- SAFEBOOL

Connection

- Constant or variable

Description of function

This input parameter is used to select or deselect the safety function SDI, movement is allowed in the negative direction of movement.

TRUE

The safety function is deselected. SDI is not active!

FALSE

The direction of movement is monitored after the delay time has expired. Movement is allowed in the negative direction.

Not connected

The safety function is deactivated.

Relevant configuration parameters

Parameter	Unit	Description	Default value
Safety Standstill and Direction Tolerances			
Position Tolerance	[units]	Position tolerance for standstill and direction monitoring	0
Safety Additional Parameters			
Delay time to start SDI (us)	[µs]	Delay time between the SDI request and activation of the safety function	0

Table 218: SDI safety function - Parameters

Information:

This safety function requires safe evaluation of the position and speed.
If an evaluation error is detected, then the SafeMOTION module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state.

4.6.16 S_RequestSLA

General function

- Selects/Deselects the "Safely Limited Acceleration" (SLA) safety function

Data type

- SAFEBOOL

Connection

- Constant or variable

Description of function

This input parameter is used to select or deselect the SLA safety function.

TRUE

The safety function is deselected. SLA is not active!

FALSE

The safety function is selected. A safe limit value for acceleration/deceleration is monitored with respect to the direction of movement.

Not connected

The safety function is deactivated.

Relevant configuration parameters

Parameter	Unit	Description	Default value
Safe acceleration limit for SLA (units/s²) in positive direction	[units/s²]	Limit for acceleration in the positive direction of movement	0
Safe deceleration limit for SLA (units/s²) in positive direction	[units/s²]	Limit for deceleration in the positive direction of movement	0
Safe acceleration limit for SLA (units/s²) in negative direction	[units/s²]	Limit for acceleration in the negative direction of movement	0
Safe deceleration limit for SLA (units/s²) in negative direction	[units/s²]	Limit for deceleration in the negative direction of movement	0
Safety Standstill and Direction Tolerances			
Speed tolerance (unit/s)	[units/s]	Speed tolerance for standstill monitoring	0
Safety Additional Parameters			
Delay time to start SLA (µs)	[µs]	Delay time between the SLA request and activation of the safety function	0

Table 219: SLA safety function - Parameters

Information:

This safety function requires safe evaluation of the position and speed.
If an evaluation error is detected, then the SafeMOTION module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state.

4.6.17 S_RequestSLP

General function

- Selects/Deselects the "Safely Limited Position" (SLP) safety function

Data type

- SAFEBOOL

Connection

- Constant or variable

Description of function

This input parameter is used to select or deselect the SLP safety function.

TRUE

The safety function is deselected. SLP is not active!

FALSE

The configured position window will be safety-monitored after "Delay time to start SLP (us)".

Not connected

The safety function is deactivated.

Relevant configuration parameters

Parameter	Unit	Description	Default value
Safety Deceleration Ramp			
Deceleration Ramp	[units/s²]	Slope of the deceleration ramp to be monitored	1073676289
Safety Position Limits			
Safe Lower Position Limit for SLP (units)	[units]	Lower position limit for the monitoring range	0
Safe Upper Position Limit for SLP (units)	[units]	Upper position limit for the monitoring range	0
Safety Standstill and Direction Tolerances			
Speed Tolerance	[units/s]	Speed tolerance for standstill monitoring	0
Position Tolerance	[units]	Position tolerance for standstill and direction monitoring	0
Safety Additional Parameters			
Delay time to start SLP (us)	[µs]	Delay time between the SLP request and start of monitoring	0

Table 220: SLP safety function - Parameters

Information:

This safety function requires safe evaluation of the position and speed.
If an evaluation error is detected, then the SafeMOTION module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state.

Information:

The following application rule must be observed:
$\mathbf{LIM_{SMP,NEG} \leq LIM_{SLP,NEG} \leq LIM_{SLP,POS} \leq LIM_{SMP,POS}}$
Failure to follow the application rule will cause the SafeMOTION module to enter the FAIL SAFE state. If this occurs, it can only be brought back to the OPERATIONAL state by modifying the safety application and completing a power off/on cycle!

Information:

Safe homing of the axis must be completed prior to using this safety function.
If a homing procedure is not completed successfully or the S_SafePositionValid status changes, then the request for the SLP safety function causes the module to switch to the acknowledgeable FUNCTIONAL FAIL SAFE error state.
The drive loses all torque/power and coasts to a stop! In the event of an error, a synchronous axis will no longer be synchronous. The output of the S_NotErrFUNC function block is reset.

4.6.18 S_SwitchHomingMode

General function

- This input is used by the "Remanent Safe Position" safety function and enables a homing procedure that confirms the remanent safe position.

Data type

- SAFEBOOL

Connection

- Variable

Description of function

This input parameter is used to switch between homing with RSP and the configured homing mode.

TRUE

When a homing command is given (i.e. rising edge of the **S_RequestHoming** input), then homing mode "Homing with RSP" is used.

FALSE

When a homing command is given (i.e. rising edge of the **S_RequestHoming** input), then the configured homing mode is used.

Relevant configuration parameters

Parameter	Unit	Description	Default value
Homing			
Remanent safe position	*Used / Not used*	*Selects whether or not to use the remanent safe position* *Parameter is only available with ACOPOSmulti SafeMOTION EnDat 2.2.*	*Not Used*
Safety Standstill and Direction Tolerances			
Speed Tolerance	[units/s]	Speed tolerance for standstill monitoring	0
Position Tolerance	[units]	Position tolerance for standstill and direction monitoring	0

Table 221: RSP safety function - Parameters

4.6.19 S_RequestHoming

General function

- Selects/Deselects the "Safe Homing" safety function

Data type

- SAFEBOOL

Connection

- Constant or variable

Description of function

This input parameter is used to start a "Safe Homing" procedure. A rising edge of the input starts the safety function.

Rising edge: Change from FALSE to TRUE

Starts "Safe Homing".

Falling edge: Change from TRUE to FALSE

If still active, the homing procedure will be terminated by the falling edge. This state transition has no effect if the homing procedure has already been completed.

Not connected

The safety function is deactivated.

Relevant configuration parameters

Parameter	Unit	Description	Default value
Homing			
Home Position or Home Offset (units)	[units]	Home position or home offset	0
Max. trigger speed (units/s)	[units/s]	Maximum permissible speed for evaluating the reference switch / reference pulse.	0
Homing Monitoring Time (µs)	[µs]	Monitoring time for the homing procedure	0
Mode	Direct / Reference Switch / *Home Offset /* *Home Offset with Correction*	Selects the homing mode *The modes "Home Offset" and "Home Offset with Correction" are only available for the ACOPOSmulti SafeMOTION EnDat 2.2!*	Direct
Edge of reference switch	Positive / Negative	Selects the switching edge for reference switch The switching edge for the reference switch input is positive if the logical state of the reference switch changes from SAFEFALSE to SAFETRUE in the positive direction of movement.	Positive
Trigger direction	Positive / Negative	Selects the trigger direction If the homing procedure requires a movement, then this parameter specifies the direction for evaluating the reference switch / reference pulse.	Positive
Reference pulse	*Used /* *Not Used*	*Selects whether or not to use a reference pulse for homing* *This parameter is only available for the ACOPOSmulti SafeMOTION EnDat 2.2.*	*Not Used*
Remanent safe position	*Used /* *Not Used*	*Selects whether or not to use the remanent safe position* *This parameter is only available for the ACOPOSmulti SafeMOTION EnDat 2.2.*	*Not Used*
Blocking distance (% encoder reference system)	*%*	*Distance within which evaluation of the reference pulse will be suppressed.* *This is calculated starting at the configured reference switch edge and indicated as a percentage of the encoder reference system. A single revolution is used as the encoder reference system for rotary encoders.* *This parameter is only available for the ACOPOSmulti SafeMOTION EnDat 2.2.*	*0*

Table 222: "Safe Homing" safety function - Parameters

Information:

This safety function requires safe evaluation of the position and speed.
If an evaluation error is detected, then the SafeMOTION module switches to the acknowledgeable FUNCTIONAL FAIL SAFE error state.

Information:

The Safe Homing function is needed in order to implement the safety functions SLP and SMP and for using the safe position.
The S_SafePositionValid status will remain set to SAFEFALSE until safe homing has been performed!

4.6.20 S_ReferenceSwitch

General function

- Reference switch input for the "Safe Homing" safety function

Data type

- SAFEBOOL

Connection

- Constant or variable

Description of function

This input parameter serves as a reference switch input for the "Safe Homing" safety function and is only evaluated in the "Reference Switch" homing mode.
The status of a safe reference switch that was read into the safety application via a safe input module (X20SIxxxx), for example, should be linked to the input.

Not connected

The reference switch is not being used!

> **Information:**
>
> **If "Reference Switch" homing mode is configured and the reference switch input S_ReferenceSwitch is not wired on the function block, then the SafeMOTION module will switch to the FAIL SAFE state. The only way to exit the FAIL SAFE state is to complete a power off/on cycle and modify the safety application!**

> **Information:**
>
> **The S_ReferenceSwitch input is only evaluated in "Reference Switch" homing mode.
> The input is ignored in other homing modes!**

4.6.21 Reset

General function

- **Reset** input for acknowledging the FUNCTIONAL FAIL SAFE state or for putting the SafeMOTION module into OPERATIONAL state after STARTUP

Data type

- BOOL

Connection

- Variable

Description of function

Reset input to acknowledge the FUNCTIONAL FAIL SAFE state

A positive edge triggers the reset function.

Depending on the configuration of the "Automatic Reset at Startup" parameter, a positive edge may be necessary to get the SafeMOTION module from the INIT state to the OPERATIONAL state after startup.

Relevant configuration parameters

Parameter	Unit	Description	Default value
General Settings			
Automatic Reset at Startup (Startreset)	Used / Unused	Activates automatic reset of the function block at startup	Unused

Table 223: Reset - Parameters

4.6.22 S_AxisID

General function

- This input parameter assigns a real axis to the function block.

Data type

- SAFEINT

Connection

- Constant

Description of function

The corresponding axis can be connected to the input in SafeDESIGNER using drag-and-drop.

Information:

There can only be one combination of AxisID and the SF_SafeMC_BR or SF_SafeMC_BR_Vx function block in the safety application. Otherwise, it will not be possible to compile the safety application.

4.7 Output parameters

Output parameters provide information about the state of the SafeMOTION module and the individual safety functions.

4.7.1 Ready

General function

- Message: Function block is enabled/disabled.

Data type

- BOOL

Connection

- Variable

Description of function

This output parameter indicates whether or not the function block is enabled.

TRUE

The function block is enabled (**Activate** = TRUE). The output parameters indicate the current status of the safety function.

FALSE

The function block is disabled (**Activate** = FALSE). The function block outputs are set to FALSE.

4.7.2 S_SafetyActiveSTO

General function

- Status information for the "Safe Torque Off" (STO) safety function

Data type

- SAFEBOOL

Connection

- Variable

Description of function

Indicates the functional safe state of the STO safety function

TRUE

The STO safety function is active and currently in its safe state.

FALSE

The STO safety function is not requested, the function or the SafeMOTION module is currently in an error state or the function block has not been enabled.

4.7.3 S_SafetyActiveSTO1

General function

- Status information for the "Safe Torque Off, One Channel" (STO1) safety function

Data type

- SAFEBOOL

Connection

- Variable

Description of function

Indicates the functional safe state of the STO1 safety function

TRUE

The STO1 safety function is active and currently in its safe state.

FALSE

The STO1 safety function is not requested, the function or the SafeMOTION module is currently in an error state or the function block has not been enabled.

4.7.4 S_SafetyActiveSBC

General function

- Status information for the "Safe Brake Control" (SBC) safety function

Data type

- SAFEBOOL

Connection

- Variable

Description of function

Indicates the functional safe state of the SBC safety function

TRUE

The SBC safety function is active and currently in its safe state.

FALSE

The SBC safety function is not requested, the function or the SafeMOTION module is currently in an error state or the function block has not been enabled.

4.7.5 S_SafetyActiveSOS

General function

- Status information for the "Safe Operating Stop" (SOS) safety function

Data type

- SAFEBOOL

Connection

- Variable

Description of function

Indicates the functional safe state of the SOS safety function

TRUE

The SOS safety function is active and currently in its safe state.

FALSE

The SOS safety function is not requested, the function or the SafeMOTION module is currently in an error state or the function block has not been enabled.

4.7.6 S_SafetyActiveSS1

General function

- Status information for the "Safe Stop 1" (SS1) safety function

Data type

- SAFEBOOL

Connection

- Variable

Description of function

Indicates the functional safe state of the SS1 safety function

TRUE

The SS1 safety function is active and currently in its safe state.

FALSE

The SS1 safety function is not requested, has not yet achieved its safe state, the function or the SafeMOTION module is currently in an error state or the function block has not been enabled.

4.7.7 S_SafetyActiveSS2

General function

- Status information for the "Safe Stop 2" (SS2) safety function

Data type

- SAFEBOOL

Connection

- Variable

Description of function

Indicates the functional safe state of the SS2 safety function

TRUE

The SS2 safety function is active and currently in its safe state.

FALSE

The SS2 safety function is not requested, has not yet achieved its safe state, the function or the SafeMOTION module is currently in an error state or the function block has not been enabled.

4.7.8 S_SafetyActiveSLS1

General function

- Status information for the "Safely Limited Speed" safety function, Speed Limit 1

Data type

- SAFEBOOL

Connection

- Variable

Description of function

Indicates the functional safe state of the SLS1 safety function

TRUE

The SLS1 safety function is active and currently in its safe state.

FALSE

The SLS1 safety function is not requested, has not yet achieved its safe state, the function or the SafeMOTION module is currently in an error state or the function block has not been enabled.

4.7.9 S_SafetyActiveSLS2

General function

- Status information for the "Safely Limited Speed" safety function, Speed Limit 2

Data type

- SAFEBOOL

Connection

- Variable

Description of function

Indicates the functional safe state of the SLS2 safety function

TRUE

The SLS2 safety function is active and currently in its safe state.

FALSE

The SLS2 safety function is not requested, has not yet achieved its safe state, the function or the SafeMOTION module is currently in an error state or the function block has not been enabled.

4.7.10 S_SafetyActiveSLS3

General function

- Status information for the "Safely Limited Speed" safety function, Speed Limit 3

Data type

- SAFEBOOL

Connection

- Variable

Description of function

Indicates the functional safe state of the SLS3 safety function

TRUE

The SLS3 safety function is active and currently in its safe state.

FALSE

The SLS3 safety function is not requested, has not yet achieved its safe state, the function or the SafeMOTION module is currently in an error state or the function block has not been enabled.

4.7.11 S_SafetyActiveSLS4

General function

- Status information for the "Safely Limited Speed" safety function, Speed Limit 4

Data type

- SAFEBOOL

Connection

- Variable

Description of function

Indicates the functional safe state of the SLS4 safety function

TRUE

The SLS4 safety function is active and currently in its safe state.

FALSE

The SLS4 safety function is not requested, has not yet achieved its safe state, the function or the SafeMOTION module is currently in an error state or the function block has not been enabled.

4.7.12 S_SafetyActiveSLI

General function

- Status information for the "Safely Limited Increment" safety function

Data type

- SAFEBOOL

Connection

- Variable

Description of function

Indicates the functional safe state of the SLI safety function

TRUE

The SLI safety function is active and currently in its safe state.

FALSE

The SLI safety function is not requested, the function or the SafeMOTION module is currently in an error state or the function block has not been enabled.

4.7.13 S_SafetyActiveSDIpos

General function

- Status information for the "Safe Direction" safety function. Movement is allowed in the positive direction.

Data type

- SAFEBOOL

Connection

- Variable

Description of function

Indicates the functional safe state of the SDIpos safety function

TRUE

The SDIpos safety function is active and currently in its safe state.

FALSE

The SDIpos safety function is not requested, the function or the SafeMOTION module is currently in an error state or the function block has not been enabled.

4.7.14 S_SafetyActiveSDIneg

General function

- Status information for the "Safe Direction" safety function. Movement is allowed in the negative direction.

Data type

- SAFEBOOL

Connection

- Variable

Description of function

Indicates the functional safe state of the SDIneg safety function

TRUE

The SDIneg safety function is active and currently in its safe state.

FALSE

The SDIneg safety function is not requested, the function or the SafeMOTION module is currently in an error state or the function block has not been enabled.

4.7.15 S_SafetyActiveSLA

General function

- Status information for the "Safely Limited Acceleration" (SLA) safety function

Data type

- SAFEBOOL

Connection

- Variable

Description of function

Indicates the functional safe state of the SLA safety function

TRUE

The SLA safety function is active and currently in its safe state.

FALSE

The SLA safety function is not requested, the function or the SafeMOTION module is currently in an error state or the function block has not been enabled.

4.7.16 S_SafetyActiveSLP

General function

- Status information for the "Safely Limited Position" (SLP) safety function

Data type

- SAFEBOOL

Connection

- Variable

Description of function

Indicates the functional safe state of the SLP safety function

TRUE

The SLP safety function is active and currently in its safe state.

FALSE

The SLP safety function is not requested, the function or the SafeMOTION module is currently in an error state or the function block has not been enabled.

4.7.17 S_SafetyActiveSMP

General function

- Status information for the "Safe Maximum Position" (SMP) safety function

Data type

- SAFEBOOL

Connection

- Variable

Description of function

Indicates the functional safe state of the SMP safety function

TRUE

The SMP safety function is active and currently in its safe state.

FALSE

Monitoring of the SMP position limits is not active. Monitoring is not active because the ACOPOSmulti SafeMOTION inverter module has not yet been homed, the function or the SafeMOTION module is in an error state or the function block has not been enabled.

4.7.18 S_ReqHominOK

General function

- Feedback for homing in SafeDESIGNER

Data type

- SAFEBOOL

Connection

- Variable

Description of function

This status is set to provide feedback in the event that homing is requested when already in a homed state (**S_RequestHoming** and **S_SafePositionValid** are set).

TRUE

The input for homing is set (**S_RequestHoming** = SAFETRUE), and the safe position is valid (**S_SafePositionValid** = SAFETRUE).

FALSE

The input for homing is not set or the safe position is not valid.

4.7.19 S_SafePositionValid

General function

- Status information for the "Safe Homing" safety function and the safe position

Data type

- SAFEBOOL

Connection

- Variable

Description of function

This output parameter specifies whether or not safe homing of the axis has been completed and whether or not the position signal is valid.

TRUE

The axis has been safely homed, and the safe position is valid.

FALSE

The axis has not yet been safely homed, the axis encoder signal contains errors, the SafeMOTION module is in an error state or the function block has not been enabled.
The safe position is invalid!

Danger!

This signal should only be used for status information.

S_SafePositionValid does not represent the functional safe state of the SafeMOTION module!

Danger!

The value of the S_SafePosition output parameter is only valid if the S_SafePositionValid output parameter is SAFETRUE. Otherwise, it is invalid and is not permitted to be used further.

4.7.20 S_SafetyActiveSDC

General function

- Information about the status of ramp monitoring

Data type

- SAFEBOOL

Connection

- Variable

Description of function

This output parameter indicates the status of ramp monitoring.

TRUE

Ramp monitoring is active.

FALSE

Ramp monitoring is not active, the SafeMOTION module is currently in an error state or the function block has not been enabled.

> ## Danger!
> **This signal should only be used for status information.**

4.7.21 S_AllReqFuncActive

General function

- Information about the status of the requested safety functions

Data type

- SAFEBOOL

Connection

- Variable

Description of function

This output parameter specifies the status of the requested safety functions.

TRUE

All requested safety functions are currently in their functional safe state.

FALSE

One or more safety functions have not yet achieved their safe state, the SafeMOTION module is in an error state or the function block has not been enabled.

4.7.22 S_NotErrFUNC

General function

- Information about the error state of the safe SafeMOTION module

Data type

- SAFEBOOL

Connection

- Variable

Description of function

This output parameter specifies the error status of the SafeMOTION module.

TRUE

No error was found on the SafeMOTION module.

FALSE

An error was detected on the SafeMOTION module (e.g. a monitored limit was exceeded), or the function block has not been enabled.
In the event of an error, additional information about the error can be found in the Safety Logger in Automation Studio.
If the error is a functional error, then it can be acknowledged by changing the signal on the "Reset" input from FALSE to TRUE (rising edge)!

Danger!

This signal should only be used for status information. It only provides information in connection with the requested safety functions.
S_NotErrFUNC does not represent the functional safe state of the SafeMOTION module!

Danger!

It is your responsibility to ensure that all necessary repair measures are initiated after an error occurs since subsequent errors can result in dangerous situations!

4.7.23 Error

General function

- Function block error message

Data type

- BOOL

Connection

- Variable

Description of function

This formal parameter indicates a pending function block error message.

TRUE

The enabled function block has detected an error. **DiagCode** indicates the error code.

FALSE

The function block is not enabled, or the enabled function block has not detected any errors. **DiagCode** indicates the status.

Danger!

It is your responsibility to ensure that all necessary repair measures are initiated after an error occurs since subsequent errors can result in dangerous situations!

In order to exit an error state (**Error** = TRUE), the signal on the **Reset** input must change from FALSE to TRUE (rising edge).

4.7.24 DiagCode

General function

- Function block diagnostic message

Data type

- WORD

Connection

- Variable

Description of function

This output parameter is used to output diagnostic and status messages specific to the function block and make them available automatically to diagnostic tools.

These diagnostic tools cannot acknowledge diagnostic messages from function blocks. This is done exclusively in the **safety** application.

The function block indicates the presence of an error message on the **DiagCode** output via the **Error** output parameter.

Diagnostic code

The diagnostic code is specified as a WORD data type. The values and meanings of these diagnostic codes are listed below.

In the event of status messages ($0xxx_{hex}$, $8xxx_{hex}$), the function block sets **Error** to FALSE.

In the event of error messages ($Cxxx_{hex}$), the function block sets **Error** to TRUE.

4.7.25 Diagnostic codes

Code (hex)	State	Description	Possible remedy
0000	IDLE	The function block is not enabled.	Enable the function block by setting **Activate** to TRUE.
8001	INIT	The function block has been enabled and the SafeMOTION module is in the INIT state. The SafeMOTION module restart inhibit is active.	Configure the "Startreset" parameter accordingly or execute a positive edge on the **Reset** input.
8002	OPERATIONAL	The SafeMOTION module is in the OPERATIONAL state. No safety function is selected. The SMS speed limit is monitored according to the configuration.	No action required
8003	WAIT FOR CONFIRMATION	The SafeMOTION module is in the internal OPERATIONAL state. At least one safety function has been requested and at least one safety function has not yet achieved its functional safe state. None of the limits currently being monitored have been violated.	No action required
8000	SAFE STATE	All requested safety functions have achieved their functional safe state. None of the limits currently being monitored have been violated.	No action required
C000	FUNCTIONAL FAIL SAFE	An error has occurred!	Check the Safety Logger in Automation Studio. It will provide detailed information about the current error. Depending on the type of error, check the standard and/or safety application. For functional errors, check the configuration of the ACOPOSmulti SafeMOTION module or replace the faulty ACOPOSmulti SafeMOTION inverter module.

Table 224: SF_SafeMC_BR(_V2, _V3): Diagnostic codes

4.7.26 AxisStatus

General function

- Diagnostic message from the function block, representation of the axis status bits in a DWORD

Data type

- DWORD

Connection

- Variable

Description of function

The **AxisStatus** output returns bit-coded information about the status of individual safety functions.
This information corresponds to a summary of the **S_xxx** outputs in a DWORD.
The individual bits have the following meaning:

Bit 0	Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7
Status STO	Status SBC	Status SOS	Status SS1	Status SS2	Status SLS1	Status SLS2	Status SLS3
Bit 8	**Bit 9**	**Bit 10**	**Bit 11**	**Bit 12**	**Bit 13**	**Bit 14**	**Bit 15**
Status SLS4	Status STO1	Status SDI pos	Status SLI	Status SDI neg	Status SLP	Status SMP	Status PositionValid
Bit 16	**Bit 17**	**Bit 18**	**Bit 19**	**Bit 20**	**Bit 21**	**Bit 22**	**Bit 23**
Status SLA	Status Setposition Alive Test	Status SFR	Status "All requested safety functions active"	Status SDC	Status operational	Status Not Encoder Error	Status Not Functional Error

Table 225: SF_SafeMC_BR_V3: SafeMOTION module status bits

4.8 State machine

The state machine illustrated here is implemented on the SafeMOTION module.

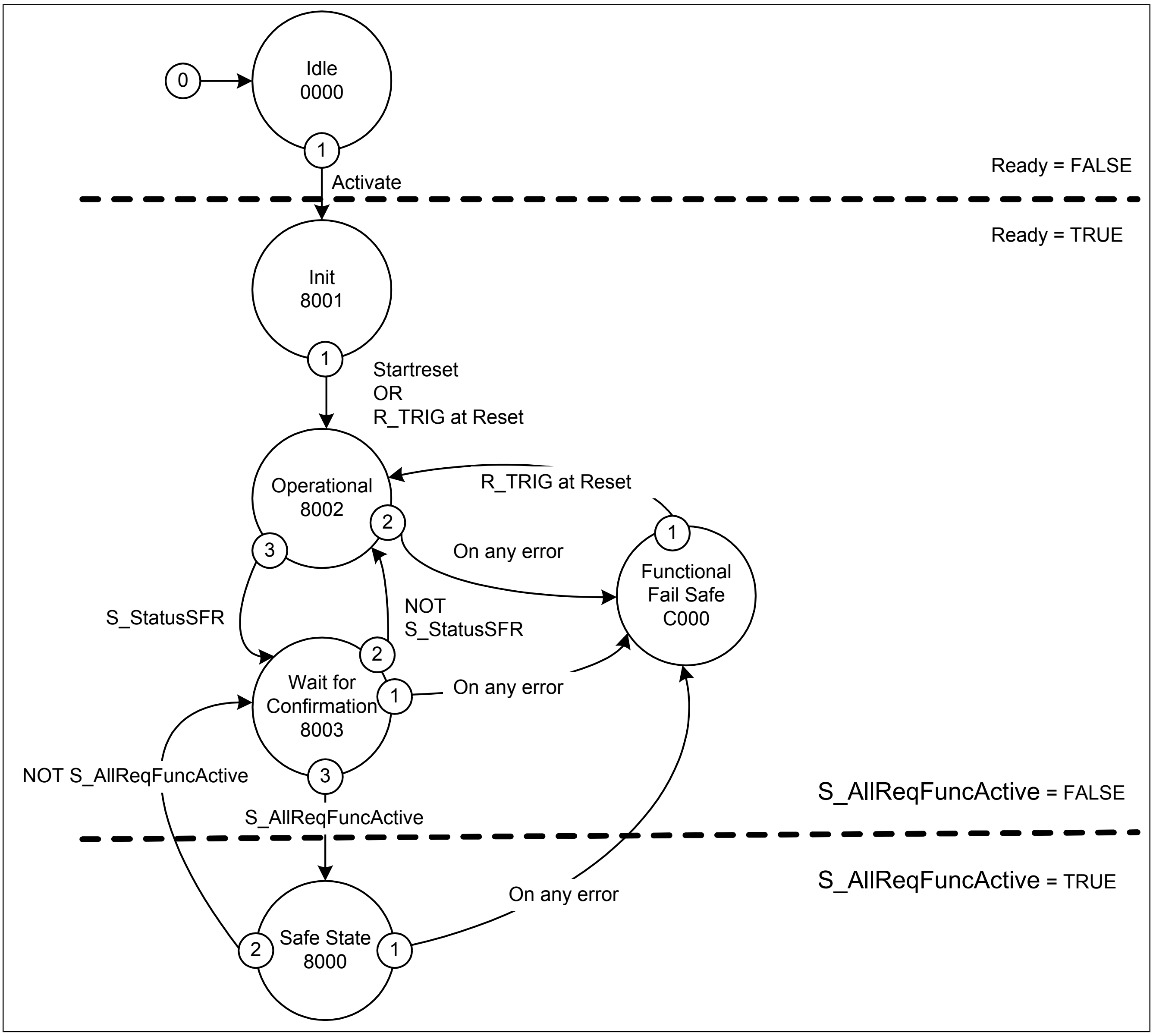


Figure 71: SF_SafeMC_BR(_V2, _V3): State machine

Individual states are reflected by the **DiagCode** output parameter. In this way, the function block provides a representation of the state machine on the SafeMOTION module.

4.9 Signal sequence diagram of the function block

A general signal sequence diagram of the function block cannot be specified since it depends on which safety functions are selected or deselected.

See "ACOPOSmulti SafeMOTION user's manual / Safety technology / Integrated safety functions".

5 SF_SafeMC_Speed_BR

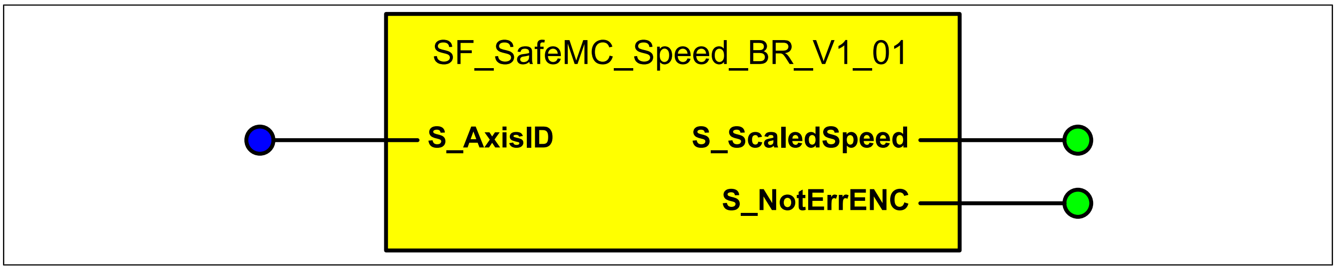


Figure 72: Function block SF_SafeMC_Speed_BR

5.1 Formal parameters of the function block

In the following, the term "variable" refers to both a variable as well as a graphic connection.

Name	Type	Connection	Signal type[1]	Initial value	Description / General function
S_AxisID	SAFEINT	Constant	Status	-1	Assigns an axis to the function block

Table 226: SF_SafeMC_Speed_BR: Overview of input parameters

1) Evaluation of the input parameter signals in the function block. The signals must be controlled accordingly by the user.

Name	Type	Connection	Signal type[1]	Initial value	Description / General function
S_ScaledSpeed	SAFEINT	Variable	Value	-	Scaled safe speed
S_NotErrENC	SAFEBOOL	Variable	Status	SAFEFALSE	No encoder error has been detected (=SAFETRUE), the signal S_ScaledSpeed is valid

Table 227: SF_SafeMC_Speed_BR: Overview of output parameters

1) Output of the output parameter signals. The signals must be evaluated and/or further processed accordingly by the user.

Type	Description	Size in bits	Format option
BOOL	Bit	1	Bit string
WORD	Word	16	Bit string
SAFEBOOL	Bit	1	Bit string (signal source: safe device)
SAFEDWORD	Double word	32	Bit string (signal source: safe device)
SAFEDINT	Double integer	32	Binary number, hexadecimal number, signed decimal number (signal source: safe device)
SAFEINT	Integer	16	Binary number, hexadecimal number, signed decimal number (signal source: safe device)

Table 228: Format description of the data types

5.2 Function

The primary purpose of the SF_SafeMC_Speed_BR function block is to establish a connection between the safe speed of an axis and the associated encoder error status. An assignment is then made to a defined safe axis.

The SF_SafeMC_Speed_BR function block can be used to process the current safe speed of an axis in the safe application.

Danger!

Make sure that the correct AxisID is always used on the input!
Each assignment must be validated separately.

To ensure valid evaluation of the speed signal, the corresponding encoder error status bit must also always be checked.
The speed signal itself is only considered valid if this output parameter is set to TRUE.

Danger!

If the speed signal is not validated, then an invalid speed value could be used in the safety application.
This can result in hazardous situations!

5.3 Fault avoidance

> **Danger!**
>
> **Validation**
>
> **Each safety function that is used must be validated separately.**
> **It is also necessary to test the entire safety application, including the interactions between individual functions.**

5.3.1 Plausibility errors

Plausibility errors (limit values, data types, variables/constants) that occur when using the function block are detected and reported by either the function block or compiler.
This is not always possible in the event of connection errors, however.

The function block cannot check whether:

- Actual parameter values or constants within the valid range are in fact incorrect for the safety functions being executed. A static TRUE signal on the Reset input is detected by the function block and indicated as an error, however.
- Actual parameters have been connected incorrectly.
- I/O formal parameters were not connected inadvertently.

Therefore, note the following:

> **Danger!**
>
> **The user is responsible for the connection of the safety function (sub-application).**
>
> **The connection for validating the sub-application must be checked**

5.3.2 Validate the speed signal

In order for the speed signal to undergo a valid evaluation, the associated encoder error status bit must always be checked as well.
The speed signal itself is only considered valid if this output parameter is set to TRUE.

> **Danger!**
>
> **If the speed signal is not validated, then an invalid speed value could be used in the safety application. This can result in hazardous situations!**

5.3.3 Machine/System startup without performing functional testing of safety equipment

Faulty safety equipment can only be detected following functional testing. Functional testing is not supported by this function block. If additional measures are not taken, faulty safety equipment can result in errors.

> **Danger!**
>
> **You are responsible for performing functional testing of safety equipment.**
>
> **You must therefore ensure that your safety equipment undergoes validation!**

Possible causes of faulty safety equipment:

- Faulty devices (hardware error)
- Cross fault, short circuit or open line (user error, wiring error)

5.4 Input parameters

5.4.1 S_AxisID

General function

- This input parameter assigns a real axis to the function block.

Data type

- SAFEINT

Connection

- Constant

Description of function

The corresponding axis can be connected to the input in SafeDESIGNER using drag-and-drop.

> **Information:**
>
> **The combination of AxisID and function block SF_SafeMC_Speed_BR can be used more than once in the safety application!**

5.5 Output parameters

5.5.1 S_ScaledSpeed

General function

- Indicates the current value of the scaled safe speed

Data type

- SAFEINT

Connection

- Variable

Description of function

This output parameter indicates the current value of the scaled safe speed for a real axis.

Danger!

The value of the S_ScaledSpeed output parameter is only valid if the S_NotErrENC output parameter is TRUE. Otherwise, it is invalid and is not permitted to be used further.

5.5.2 S_NotErrENC

General function

- Information about the error state of the safe encoder signal

Data type

- SAFEBOOL

Connection

- Variable

Description of function

This output parameter indicates the error state of the signal for a defined safe encoder.
If an encoder error is detected or the SafeMOTION module is in an error state, then the output is set to FALSE. This state is maintained until the error has been corrected.

TRUE

An error was not detected on the encoder signal. The value of the safe speed on the **S_ScaledSpeed** output parameter is valid.

FALSE

The encoder signal from a defined safe axis is faulty, or the axis itself is in an error state. Additional information about the error can be found in the Safety Logger in Automation Studio.

Danger!

This signal should only be used for status information. It only provides information in connection with the requested safety functions.
S_NotErrENC does not represent the functional safe state of the SafeMOTION module!

Danger!

The value of the S_ScaledSpeed output parameter is only valid if the S_NotErrENC output parameter is TRUE. Otherwise, it is invalid and is not permitted to be used further.

5.6 Signal sequence diagram of the function block

A signal sequence diagram cannot be specified for this function block.

5.7 Application example

The following application example illustrates one possible comparison of the scaled safe speed with a permanent defined value in the safe application.

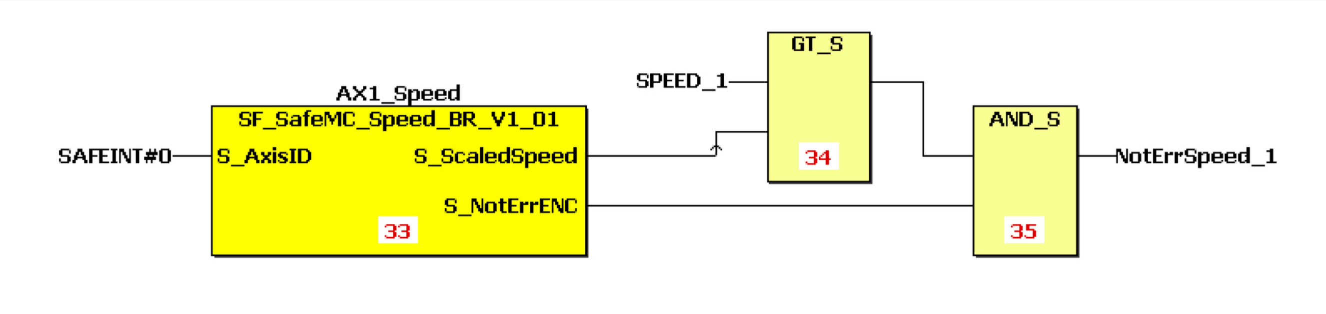


Figure 73: SF_SafeMC_Speed_BR: Evaluation of the scaled safe speed

6 SF_SafeMC_Position_BR

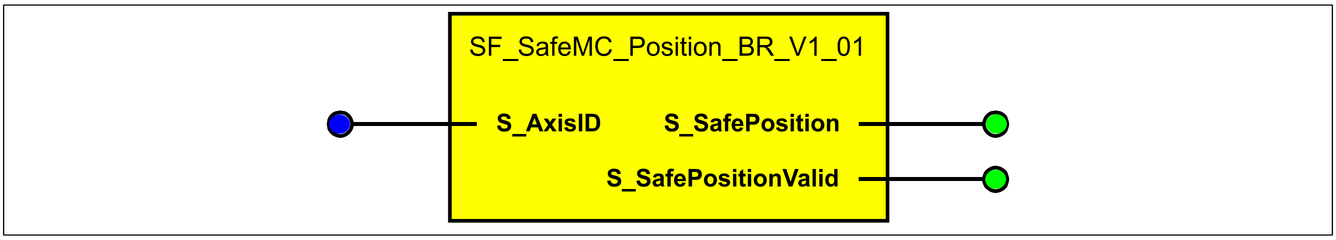


Figure 74: Function block SF_SafeMC_Position_BR

Information:

The SF_SafeMC_Position_BR_V1_01 function block can only be used with Safety Release 1.4.

If Safety Release 1.3 is being used, then SafeDESIGNER will return an error when compiling the safety application!

6.1 Formal parameters of the function block

In the following, the term "variable" refers to both a variable as well as a graphic connection.

Name	Type	Connection	Signal type 1)	Initial value	Description / General function
S_AxisID	SAFEINT	Constant	Status	-1	Assigns an axis to the function block

Table 229: SF_SafeMC_Position_BR: Overview of input parameters

1) Evaluation of the input parameter signals in the function block. The signals must be controlled accordingly by the user.

Name	Type	Connection	Signal type 1)	Initial value	Description / General function
S_SafePosition	SAFEDINT	Variable	Value	-	Safe position in units
S_SafePositionValid	SAFEBOOL	Variable	Status	SAFEFALSE	Specifies whether the safe position is valid (=SAFETRUE, homing procedure has completed successfully and there are no encoder errors)

Table 230: SF_SafeMC_Position_BR: Overview of output parameters

1) Output of the output parameter signals. The signals must be evaluated and/or further processed accordingly by the user.

Type	Description	Size in bits	Format option
BOOL	Bit	1	Bit string
WORD	Word	16	Bit string
SAFEBOOL	Bit	1	Bit string (signal source: safe device)
SAFEDWORD	Double word	32	Bit string (signal source: safe device)
SAFEDINT	Double integer	32	Binary number, hexadecimal number, signed decimal number (signal source: safe device)
SAFEINT	Integer	16	Binary number, hexadecimal number, signed decimal number (signal source: safe device)

Table 231: Format description of the data types

6.2 Function

The primary purpose of the SF_SafeMC_Position_BR function block is to establish a connection between the safe position of an axis and its associated status. An assignment is then made to a defined safe axis.

The SF_SafeMC_Position_BR function block can be used to process the current safe position of an axis in the safe application.

Danger!

Make sure that the correct AxisID is always used on the input!
Each assignment must be validated separately.

To ensure valid evaluation of the position signal, the corresponding status bit **S_PositionValid** must also always be checked.
The position itself is only considered homed and valid if this output parameter is set to SAFETRUE.

Danger!

If the position signal is not validated, then an invalid position could be used in the safety application. This can result in hazardous situations!

6.3 Fault avoidance

> **Danger!**
>
> **Validation**
>
> **Each safety function that is used must be validated separately.**
> **It is also necessary to test the entire safety application, including the interactions between individual functions.**

6.3.1 Plausibility errors

Plausibility errors (limit values, data types, variables/constants) that occur when using the function block are detected and reported by either the function block or compiler.

This is not possible in the event of connection errors, however.

The function block does not check for the following errors:

- Actual parameter values or constants are within their valid range but incorrect for the safety function being executed.
- Actual parameters have been connected incorrectly.
- Formal input/output parameters that should have been connected have not been connected.

> **Danger!**
>
> **Ensuring proper safety function connections (sub-application) is your responsibility as the user!**
>
> **Make sure to check these connections when validating the sub-application!**

6.3.2 Validate the position signal

To ensure valid evaluation of the position signal, the corresponding status bit **S_PositionValid** must also always be checked.
The position itself is only considered homed and valid if this output parameter is set to SAFETRUE.

> **Danger!**
>
> **If the position signal is not validated, then an invalid position could be used in the safety application. This can result in hazardous situations!**

6.3.3 Machine/System startup without performing functional testing of safety equipment

Faulty safety equipment can only be detected following functional testing. Functional testing is not supported by this function block. If additional measures are not taken, faulty safety equipment can result in errors.

> **Danger!**
>
> **You are responsible for performing functional testing of safety equipment.**
>
> **You must therefore ensure that your safety equipment undergoes validation!**

Possible causes of faulty safety equipment:

- Faulty devices (hardware error)
- Cross fault, short circuit or open line (user error, wiring error)

6.4 Input parameters

6.4.1 S_AxisID

General function

- This input parameter assigns a real axis to the function block.

Data type

- SAFEINT

Connection

- Constant

Description of function

The corresponding axis can be connected to the input in SafeDESIGNER using drag-and-drop.

> ## Information:
> **The combination of AxisID and function block SF_SafeMC_Position_BR can be used more than once in the safety application!**

6.5 Output parameters

6.5.1 S_SafePosition

General function

- Indicates the current safe position in units

Data type

- SAFEDINT

Connection

- Variable

Description of function

This output parameter indicates the current value of the safe position for a real axis in units.

> **Danger!**
>
> **The value of the S_SafePosition output parameter is only valid if the S_SafePositionValid output parameter is SAFETRUE. Otherwise, it is invalid and is not permitted to be used further.**

6.5.2 S_SafePositionValid

General function

- Status information for the "Safe Homing" safety function and the safe position

Data type

- SAFEBOOL

Connection

- Variable

Description of function

This output parameter specifies whether or not safe homing of the axis has been completed and whether or not the position signal is valid.

TRUE

The axis has been safely homed, and the safe position is valid.

FALSE

The axis has not yet been safely homed, the axis encoder signal contains errors, the SafeMOTION module is in an error state or the function block has not been enabled.
The safe position is invalid!

> **Danger!**
>
> **This signal should only be used for status information.**
>
> **S_SafePositionValid does not represent the functional safe state of the SafeMOTION module!**

> **Danger!**
>
> **The value of the S_SafePosition output parameter is only valid if the S_SafePositionValid output parameter is SAFETRUE. Otherwise, it is invalid and is not permitted to be used further.**

6.6 Signal sequence diagram of the function block

A signal sequence diagram cannot be specified for this function block.

6.7 Application example

The following application example illustrates one possible use of the Safe Position Monitor function on the SafeLOGIC controller.

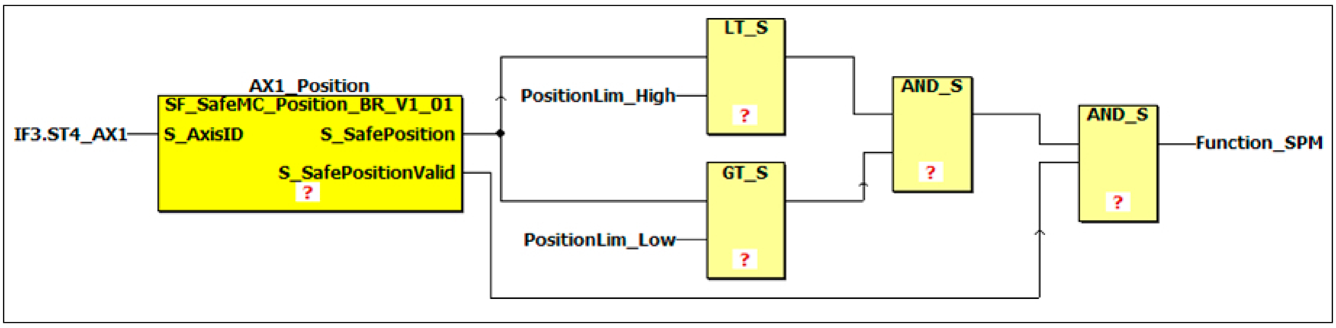


Figure 75: SF_SafeMC_Position_BR: The Safe Position Monitor function

7 SF_SafeMC_Position_BR_V2

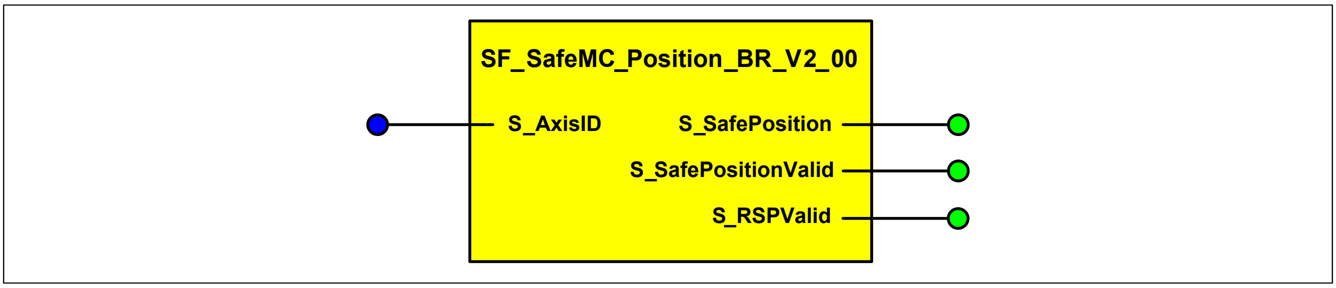


Figure 76: SF_SafeMC_Position_BR_V2 function block

Information:

The SF_SafeMC_Position_BR_V2 function block can only be used with Safety Release 1.9.

If a previous Safety Release is being used, then SafeDESIGNER will return an error when compiling the safety application!

7.1 Formal parameters of the function block

In the following, the term "variable" refers to both a variable as well as a graphic connection.

Name	Type	Connection	Signal type [1]	Initial value	Description / General function
S_AxisID	SAFEINT	Constant	Status	-1	Assigns an axis to the function block

Table 232: SF_SafeMC_Position_BR_V2: Overview of input parameters

1) Evaluation of the input parameter signals in the function block. The signals must be controlled accordingly by the user.

Name	Type	Connection	Signal type [1]	Initial value	Description / General function
S_SafePosition	SAFEDINT	Variable	Value	-	Safe position in units
S_SafePositionValid	SAFEBOOL	Variable	Status	SAFEFALSE	Specifies whether the safe position is valid (=SAFETRUE, homing procedure has completed successfully and there are no encoder errors)
S_RSPValid	SAFEBOOL	Variable	Status	SAFEFALSE	Validates and stores the remanent safe position (TRUE = safe position is stored, power off for homing with RSP is now possible)

Table 233: SF_SafeMC_Position_BR_V2: Overview of output parameters

1) Output of the output parameter signals. The signals must be evaluated and/or further processed accordingly by the user.

Type	Description	Size in bits	Format option
BOOL	Bit	1	Bit string
WORD	Word	16	Bit string
SAFEBOOL	Bit	1	Bit string (signal source: safe device)
SAFEDWORD	Double word	32	Bit string (signal source: safe device)
SAFEDINT	Double integer	32	Binary number, hexadecimal number, signed decimal number (signal source: safe device)
SAFEINT	Integer	16	Binary number, hexadecimal number, signed decimal number (signal source: safe device)

Table 234: Format description of the data types

7.2 Function

The primary purpose of the SF_SafeMC_Position_BR_V2 function block is to establish a connection between the safe position of an axis and its associated status. An assignment is then made to a defined safe axis.

The SF_SafeMC_Position_BR_V2 function block can be used to process the current safe position of an axis in the safety application.

Danger!

Make sure that the correct AxisID is always used on the input!
Each assignment must be validated separately.

To ensure valid evaluation of the position signal, the corresponding status bit **S_PositionValid** must also always be checked.
The position itself is only considered homed and valid if this output parameter is set to SAFETRUE.

Danger!

If the position signal is not validated, then an invalid position could be used in the safety application. This can result in hazardous situations!

7.3 Fault avoidance

> **Danger!**
>
> **Validation**
>
> **Each safety function that is used must be validated separately.**
> **It is also necessary to test the entire safety application, including the interactions between individual functions.**

7.3.1 Plausibility errors

Plausibility errors (limit values, data types, variables/constants) that occur when using the function block are detected and reported by either the function block or compiler.

This is not possible in the event of connection errors, however.

The function block does not check for the following errors:

- Actual parameter values or constants are within their valid range but incorrect for the safety function being executed.
- Actual parameters have been connected incorrectly.
- Formal input/output parameters that should have been connected have not been connected.

> **Danger!**
>
> **Ensuring proper safety function connections (sub-application) is your responsibility as the user!**
>
> **Make sure to check these connections when validating the sub-application!**

7.3.2 Validate the position signal

To ensure valid evaluation of the position signal, the corresponding status bit **S_PositionValid** must also always be checked.
The position itself is only considered homed and valid if this output parameter is set to SAFETRUE.

> **Danger!**
>
> **If the position signal is not validated, then an invalid position could be used in the safety application.**
> **This can result in hazardous situations!**

7.3.3 Machine/System startup without performing functional testing of safety equipment

Faulty safety equipment can only be detected following functional testing. Functional testing is not supported by this function block. If additional measures are not taken, faulty safety equipment can result in errors.

> **Danger!**
>
> **You are responsible for performing functional testing of safety equipment.**
> **You must therefore ensure that your safety equipment undergoes validation!**

Possible causes of faulty safety equipment:

- Faulty devices (hardware error)
- Cross fault, short circuit or open line (user error, wiring error)

7.4 Input parameters

7.4.1 S_AxisID

General function

- This input parameter assigns a real axis to the function block.

Data type

- SAFEINT

Connection

- Constant

Description of function

The corresponding axis can be connected to the input in SafeDESIGNER using drag-and-drop.

Information:

The combination of AxisID and function block SF_SafeMC_Position_BR can be used more than once in the safety application!

7.5 Output parameters

7.5.1 S_SafePosition

General function

- Indicates the current safe position in units

Data type

- SAFEDINT

Connection

- Variable

Description of function

This output parameter indicates the current value of the safe position for a real axis in units.

Danger!

The value of the S_SafePosition output parameter is only valid if the S_SafePositionValid output parameter is SAFETRUE. Otherwise, it is invalid and is not permitted to be used further.

7.5.2 S_SafePositionValid

General function

- Status information for the "Safe Homing" safety function and the safe position

Data type

- SAFEBOOL

Connection

- Variable

Description of function

This output parameter specifies whether or not safe homing of the axis has been completed and whether or not the position signal is valid.

TRUE

The axis has been safely homed, and the safe position is valid.

FALSE

The axis has not yet been safely homed, the axis encoder signal contains errors, the SafeMOTION module is in an error state or the function block has not been enabled.
The safe position is invalid!

Danger!

This signal should only be used for status information.

S_SafePositionValid does not represent the functional safe state of the SafeMOTION module!

Danger!

The value of the S_SafePosition output parameter is only valid if the S_SafePositionValid output parameter is SAFETRUE. Otherwise, it is invalid and is not permitted to be used further.

7.5.3 S_RSPValid

General function

- Status information for the "Remanent safe position" safety function

Data type

- SAFEBOOL

Connection

- Variable

Description of function

This output parameter indicates the following:

- The current safe position has been homed, validated and saved.
- Changes to the safe position are prevented by the active STO and SOS safety functions.
- Powering off the module does not result in loss of the safe remanent position.

TRUE

The safe position has been saved successfully. Power off for homing with RSP is possible in this state.

FALSE

One or more of the following is true:

- The axis was not successfully homed. (The state of **S_SafePositionValid** is not TRUE.)
- The STO safety function is not selected/active.
- The SOS safety function is not selected/active.

7.6 Signal sequence diagram of the function block

A signal sequence diagram cannot be specified for this function block.

7.7 Application example

The following application example illustrates one possible use of the Safe Position Monitor function on the SafeL-OGIC controller.

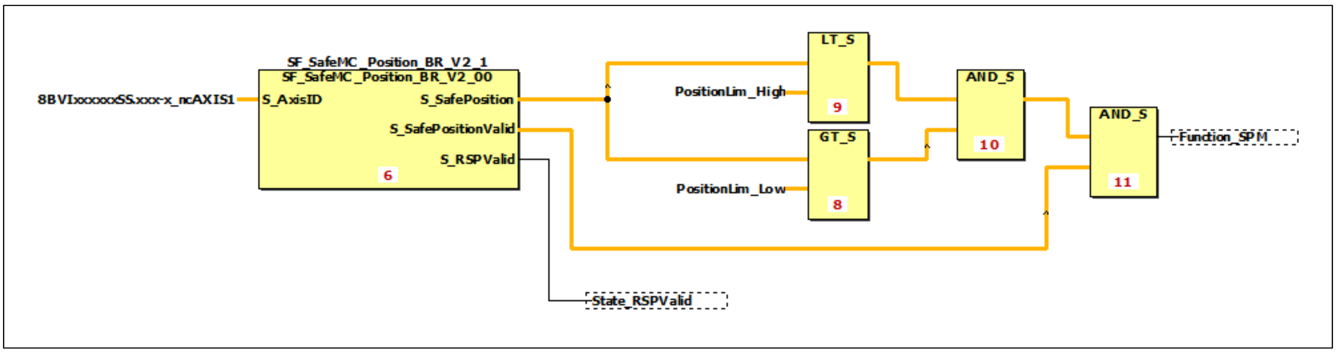


Figure 77: SF_SafeMC_Position_BR_V2: The Safe Position Monitor function

8 SF_SafeMC_SBT_BR

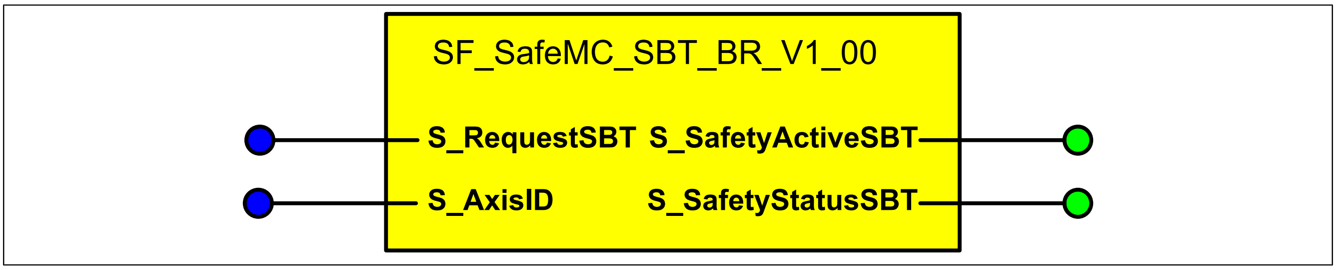


Figure 78: SF_SafeMC_SBT_BR function block

8.1 Formal parameters of the function block

In the following, the term "variable" refers to both a variable as well as a graphic connection.

Name	Type	Connection	Signal type	Initial value	Description / General function
S_RequestSBT	SAFEBOOL	Variable/Constant	Edge	SAFEFALSE	Requests the SBT safety function on a falling edge
S_AxisID	SAFEINT	Constant	Status	-1	Assigns an axis to the function block

Table 235: SF_SafeMC_SBT_BR: Overview of input parameters

Name	Type	Connection	Signal type	Initial value	Description / General function
S_SafetyActiveSBT	SAFEBOOL	Variable	Status	SAFEFALSE	SBT safety function active (= SAFETRUE)
S_SafetyStatusSBT	SAFEBOOL	Variable	Status	SAFEFALSE	Safety function completed successfully, valid test status (= SAFETRUE)

Table 236: SF_SafeMC_SBT_BR: Overview of output parameters

Type	Description	Size in bits	Format option
BOOL	Bit	1	Bit string
WORD	Word	16	Bit string
SAFEBOOL	Bit	1	Bit string (signal source: safe device)
SAFEDWORD	Double word	32	Bit string (signal source: safe device)
SAFEDINT	Double integer	32	Binary number, hexadecimal number, signed decimal number (signal source: safe device)
SAFEINT	Integer	16	Binary number, hexadecimal number, signed decimal number (signal source: safe device)

Table 237: Format description of the data types

8.2 Safe Brake Test (SBT)

See ACOPOSmulti SafeMOTION user's manual / Safety technology / Integrated safety functions / Safe Brake Test, SBT.

8.3 Fault avoidance

Danger!

Validation

Each safety function that is used must be validated separately.
It is also necessary to test the entire safety application, including the interactions between individual functions.

8.3.1 Plausibility errors

Plausibility errors (limit values, data types, variables/constants) that occur when using the function block are detected and reported by either the function block or compiler.

This is not possible in the event of connection errors, however.

The function block does not check for the following errors:

- Actual parameter values or constants are within their valid range but incorrect for the safety function being executed.
- Actual parameters have been connected incorrectly.
- Formal input/output parameters that should have been connected have not been connected.

Danger!

Ensuring proper safety function connections (sub-application) is your responsibility as the user!

Make sure to check these connections when validating the sub-application!

8.3.2 Sporadically changing/toggling signal levels or impermissible signals

Sporadically changing or toggling signal levels on

- Edge-controlled formal input parameters cause the function block to interpret the signal as an edge, which results in an unintended action being triggered in the function block if error prevention measures are not in place.

Possible causes of these signals:

- Programming error in the application program (user error)
- Cross fault, short circuit or open line (user error, wiring error)
- Error in the standard controller

To prevent this, the following measures can be taken depending on the safety function:

- Use of safe device signals
- Implementing additional measures for preventing a hazard if using a signal from a standard controller (e.g. executing an additional function start after a safety function has been triggered or an error has been corrected)
- Line control in the safe control system
- Suitable cabling when using non-safe signals from the standard controller
- Verifying the source code in the application program and final validation of the safety functionality

The measures listed above can also be taken in combination to safely prevent errors.

It is important to note that a signal change detected on a status-controlled formal parameter will be output as a diagnostic code.

8.4 Input parameters

8.4.1 S_RequestSBT

General function

- Selects/Deselects the "Safe Brake Test" (SBT) safety function

Data type

- SAFEBOOL

Connection

- Variable

Description of function

This input parameter is used to start the SBT safety function.

Falling edge

A falling edge or state transition from SAFETRUE to SAFEFALSE on the **S_RequestSBT** input parameter starts the "Safe Brake Test" (SBT) safety function.

Not connected

The safety function is deactivated.

Relevant configuration parameters

Parameter	Unit	Description	Default value
Safety Additional Parameters			
Delay time to start SBT (us)	[µs]	Delay time between the SBT request and activation of the safety function	0
Safe Brake Test			
Safe Brake Test interval (s)	[s]	Retry interval for the safe brake test	28800
Safe Brake Test threshold (uA)	[µA]	Threshold value for the stator current that must be exceeded during the brake test	0
Safe Brake Test external load (uA)	[µA]	External load	0
Safe Brake Test maximum torque duration (us)	[µs]	Duration of the test for which the maximum torque must be present	0
Safe Brake Test position tolerance (units)	[units]	Position tolerance	0

Table 238: SBT safety function - Parameters

8.4.2 S_AxisID

General function

- This input parameter assigns a real axis to the function block.

Data type

- SAFEINT

Connection

- Constant

Description of function

The corresponding axis can be connected to the input in SafeDESIGNER using drag-and-drop.

Information:

There can only be one combination of AxisID and SF_SafeMC_SBT_BR in the safety application. Otherwise, it will not be possible to compile the safety application.

8.5 Output parameters

8.5.1 S_SafetyActiveSBT

General function

- Status information for the "Safe Brake Test" (SBT) safety function

Data type

- SAFEBOOL

Connection

- Variable

Description of function

Indicates the functional safe state of the SBT safety function

TRUE

The SBT safety function is being executed.

FALSE

The SBT safety function has not been requested.

8.5.2 S_SafetyStatusSBT

General function

- Additional information for testing the holding brake with "Safe Brake Test" (SBT)

Data type

- SAFEBOOL

Connection

- Variable

Description of function

Returns the status of the holding brake test "Safe Brake Test" (SBT)

TRUE

The SBT safety function has been executed. The status of the testing is valid.

FALSE

The SBT safety function has not been executed. The status of the testing is invalid or expired.

8.6 Signal sequence diagram

Signal sequence diagram for the "Safe Brake Test" (SBT) safety function (see "ACOPOSmulti SafeMOTION user's manual / Safety technology / Integrated safety functions / Safe Brake Test (SBT)").

Chapter 6 • SafeDESIGNER

See Integrated Safety user's manual (MASAFETY1-ENG), Chapter "SafeDESIGNER".

Chapter 7 • Standards and certifications

1 Applicable European directives

- EMC directive 2004/108/EC
- Low-voltage directive 2006/95/EC
- Machinery directive 2006/42/EC[1)]

2 Applicable standards

Standard	Description
IEC/EN 61800-2	Adjustable speed electrical power drive systems • Part 2: General requirements; Rating specifications for low voltage adjustable frequency AC power drive systems
IEC/EN 61800-3	Adjustable speed electrical power drive systems • Part 3: EMC requirements and specific test methods
IEC 61800-5-1	Adjustable speed electrical power drive systems • Part 5-1: Safety requirements - Electrical, thermal and energy (IEC 61800-5-1:2003)
EN 61800-5-2	Adjustable speed electrical power drive systems • Part 5-2: Safety requirements - Functional
IEC/EN 61131-2	Programmable logic controllers • Part 2: Equipment requirements and tests
EN 60204-1	Safety of machinery - Electrical equipment of machines • Part 1: General requirements
IEC 61508	Functional safety of electrical / electronic / programmable electronic safety-related systems
EN 50178-1	Electronic equipment for use in power installations
EN 1037	Safety of machinery - Prevention of unexpected startup
EN ISO 13849-1	Safety of machinery - Safety-related parts of control systems • Part 1: General principles for design
EN 62061	Safety of machinery - Functional safety of safety-related electrical, electronic and programmable electronic control systems
UL 508C	Power conversion equipment

Table 239: Applicable standards for ACOPOS servo drives

2.1 Limit values

The limit values specified from section Mechanical conditions during operation to section Additional environmental limit values are taken from the product standard EN 61800 (or IEC 61800) for servo drives in industrial environments (Category C3[2)]). Stricter test procedures and limit values are used during the type tests for ACOPOSmulti servo drives. Additional information is available from B&R.

3 Environmental limits

3.1 Mechanical conditions in accordance with EN 61800-2

Operation

IEC 60721-3-3, class 3M1	
	EN 61800-2
Vibration during operation 2 ≤ f < 9 Hz 9 ≤ f < 200 Hz	 0.3 mm amplitude m/s² acceleration

Table 240: Mechanical conditions during operation

Chapter 7
Standards and certifications

1) This machinery directive only applies to logic units for safety functions that are initially made available by B&R for sale or use.

2) EN 61800-3 C3 (second environment).

Transport

IEC 60721-3-2, class 2M1	
	EN 61800-2
Vibration during transport [1)2)] 2 ≤ f < 9 Hz 9 ≤ f < 200 Hz 200 ≤ f < 500 Hz	 3.5 mm amplitude 10 m/s² acceleration 15 m/s² acceleration
Drop height in free fall [1)] Weight < 100 kg	 0.25 m

Table 241: Mechanical conditions during transport

1) Only valid for components in original packaging.
2) The values in section "Operation" inSection "Mechanical conditions in accordance with EN 61800-2" apply to components that are not in their original packaging.

3.2 Climate conditions in accordance with EN 61800-2

Operation

IEC 60721-3-3, class 3K3	
	EN 61800-2
Ambient temperature during operation	5 to 40°C
Relative humidity during operation	5 to 85%, non-condensing

Table 242: Climate conditions during operation

Storage

IEC 60721-3-1, class 1K4	
	EN 61800-2
Storage temperature	-25 to +55°C

Table 243: Climate conditions during storage - Temperature

IEC 60721-3-1, class 1K3	
	EN 61800-2
Relative humidity during storage	5 to 95%, non-condensing

Table 244: Climate conditions during storage - Relative humidity

Transport

IEC 60721-3-2, class 2K3	
	EN 61800-2
Transport temperature	-25 to +70°C
Relative humidity during transport	Max. 95% at +40°C

Table 245: Climate conditions during transport

4 Requirements for immunity to disturbances (EMC)

- EN 61800-3 requirements apply.
- For all modules that have certified safety functions, stricter requirements apply for section 4.3 "High-frequency disturbances in accordance with EN 61800-3" in accordance with IFA (previously BGIA): EMC and functional safety for drive systems 2/2012.

4.1 Evaluation criteria (performance criteria)

Performance criteria (PC)	Description
A	The test object is not interfered with during testing.
B	The test object is only interfered with temporarily during testing.
C	The system does not reboot itself automatically (reset required).
FS	Functional safety - Behavior of test object in accordance with EN 61800-5-2, Item 6.2.5.3

Table 246: Evaluation criteria (performance criteria) for immunity to disturbances

4.2 Low-frequency disturbances in accordance with EN 61800-3

The following limit values are applicable for industrial environments (category C3).

Power mains harmonics and commutation notches / voltage distortions

IEC 61000-2-4, class 3		
	EN 61800-3	Performance criteria
Harmonics	THD = 10%	A
Short harmonics (<15 s)	1.5x continuous level	B

Table 247: Limit values for power mains harmonics

IEC 60146-1-1, class 3		
	EN 61800-3	Performance criteria
Commutation notches	Depth = 40%, Total area = 250% x degree	A

Table 248: Limit values for commutation notches / voltage distortions

Voltage changes, fluctuations, dips and short-term interruptions

IEC 61000-2-4, class 3		
	EN 61800-3	Performance criteria
Voltage changes and fluctuations	±10%	A
Voltage changes and fluctuations (<1 min)	+10% to -15%	

Table 249: Limit values for voltage changes and fluctuations

IEC 61000-2-1		
	EN 61800-3	Performance criteria
Voltage dips and short-term interruptions	10% to 100%	C

Table 250: Limit values for voltage dips and short-term interruptions

Asymmetrical voltage and frequency changes

IEC 61000-2-4, class 3		
	EN 61800-3	Performance criteria
Asymmetrical voltages	3% negative component	A
Frequency change and change rate	±2%, 1%/s (±4%, 2%/s if the power supply is isolated from general power mains)	

Table 251: Limit values for asymmetrical voltages and frequency changes

4.3 High-frequency disturbances in accordance with EN 61800-3

These immunity tests are applicable for industrial environments (category C3).

Electrostatic discharge

Tests in accordance with EN 61000-4-2				
	EN 61800-3		**Increased immunity to disturbances**	
	Requirement	**PC**	**Requirement** [1]	**PC**
Contact discharge to powder-coated and bare metal housing parts	4 kV	B	6 kV	FS
Discharge through the air to plastic housing parts	8 kV		15 kV	

Table 252: Limits for electrostatic discharge

1) The total number of discharges depends on the required Safety Integrity Level (SIL) and can be found in IFA (previously BGIA): EMC and functional safety for drive systems 2/2012.

Electromagnetic fields

Tests in accordance with EN 61000-4-3				
	EN 61800-3		**Increased immunity to disturbances**	
	Requirement	**PC**	**Requirement**	**PC**
Housing, completely wired	80 MHz - 1 GHz, 10 V/m, 80% amplitude modulation at 1 kHz	A	80 MHz to 1 GHz ... 20 V/m, 1.4 to 2 GHz ... 10 V/m, 2 GHz to 2.7 GHz ... 3 V/m, 80% amplitude modulation at 1 kHz	FS

Table 253: Limits for electromagnetic fields

Burst

Tests in accordance with EN 61000-4-4				
	EN 61800-3		**Increased immunity to disturbances**	
	Requirement	**PC**	**Requirement** [1]	**PC**
Power connection	2 kV, 1 min, direct coupling	B	4 kV, direct coupling	FS
Connections for measurement and control functions in the process environment	2 kV, 1 min		4 kV	
Signal interfaces, other wires	1 kV, 1 min		2 kV	

Table 254: Limits for burst

1) How long the effects last depends on the required Safety Integrity Level (SIL) and can be found in IFA (previously BGIA): EMC and functional safety for drive systems 2/2012.

Surge

Tests in accordance with EN 61000-4-5				
	EN 61800-3		**Increased immunity to disturbances**	
	Requirement	**PC**	**Requirement** [1]	**PC**
Power connection	1 kV (2 Ω) [2], DM, symmetrical 2 kV (12 Ω) [2], CM, asymmetrical	B	2 kV (2 Ω) [2], DM, symmetrical 4 kV (12 Ω) [2], CM, asymmetrical	FS

Table 255: Limits for surge

1) The number of pulses depends on the required safety integrity level (SIL) and can be found in IFA (previously BGIA): EMC and functional safety for drive systems 2/2012.
2) The impedance from IEC 61000-4-5 has been added because it is not defined in IEC 61800-3.

High-frequency conducted disturbances

Tests in accordance with EN 61000-4-6				
	EN 61800-3		**Increased immunity to disturbances**	
	Requirement	**PC**	**Requirement**	**PC**
Power connection	0.15 - 80 MHz, 10 V, 80% amplitude modulation at 1 kHz	A	0.15 - 80 MHz, 20 V, 80% amplitude modulation at 1 kHz	FS
Connections for measurement and control functions in the process environment				
Signal interfaces, other wires				

Table 256: Limits for high-frequency conducted disturbances

5 Requirements for emissions (EMC)

5.1 High-frequency emissions in accordance with EN 61800-3

These emission tests are applicable for industrial environments (category C3).

Disturbance voltages on power connections

Tests in accordance with EN 55011			
Continuous current on motor	**Frequency range [MHz]**	**Quasi-peak value**	**Average**
I ≤ 100 A	0.15 ≤ f < 0.5	100 dB (µV)	90 dB (µV)
	0.5 ≤ f < 5	86 dB (µV)	76 dB (µV)
	5 ≤ f < 30	90 dB (µV) Decreases with the logarithm of the frequency to 70	80 dB (µV) Decreases with the logarithm of the frequency to 60
100 A < I	0.15 ≤ f < 0.5	130 dB (µV)	120 dB (µV)
	0.5 ≤ f < 5	125 dB (µV)	115 dB (µV)
	5 ≤ f < 30	115 dB (µV)	105 dB (µV)

Table 257: Limits for disturbance voltages on power connections

Electromagnetic emissions

Tests in accordance with EN 55011	
Frequency range [MHz]	**Quasi-peak value**
30 ≤ f ≤ 230	40 dB (µV/m), measured at distance of 30 m [1)]
230 < f ≤ 1000	50 dB (µV/m), measured at distance of 30 m [1)]

Table 258: Limit values for electromagnetic emissions

1) Limit values are increased by 10 dB (µV/m) when measured from a distance of 10 m.

6 Additional environmental limit values in accordance with EN 61800-2

	EN 61800-2
Degree of pollution in accordance with EN 61800-2, 4.1.2.1.	2 (non-conductive pollution)
Overvoltage category in accordance with IEC 60364-4-443:1999	III
EN 60529 protection	IP20
Reduction of the continuous current at installation elevations over 500 m above sea level	10% per 1000 m
Maximum installation elevation	4000 m

Table 259: Additional environmental limit values

7 International certifications

B&R products and services comply with applicable standards. This includes international standards from organizations such as ISO, IEC and CENELEC, as well as national standards from organizations such as UL, CSA, FCC, VDE, ÖVE, etc. We are committed to ensuring the reliability of our products in an industrial environment.

Certifications	
USA and Canada	All important B&R products are tested and listed by Underwriters Laboratories and checked quarterly by a UL inspector. This mark is valid for the USA and Canada and simplifies the certification of your machines and systems in these areas.
Europe	This mark certifies that all harmonized EN standards for the applicable directives have been met.
Russian Federation	GOST-R certification is available for the export of all ACOPOS servo drives to the Russian Federation.
	All significant B&R servo drives have the FS - Functional Safety - mark from TÜV Rheinland.

Table 260: International certifications

8 Standards and definitions for safety technology

Stop functions in accordance with EN 60204-1:2006 (Electrical equipment for machines, Part 1: General requirements)

There are three categories of stop functions:

Category	Description
0	Stop by immediately switching off power to the machine drive elements (i.e. uncontrolled stop)
1	A controlled stop where power to the machine drive elements remains on until the stop procedure is completed. Power is only switched off after the stop is complete.
2	A controlled stop where power to the machine drive elements is not switched off

Table 261: Overview of stop function categories

The necessary stop functions must be determined based on a risk assessment of the machine. Stop functions in Category 0 and Category 1 must be able to function regardless of the operating mode. A Category 0 stop must have priority. Stop functions must have priority over assigned start functions. Resetting the stop function must never result in a dangerous state.

Emergency stops in accordance with EN 60204-1:2006 (Electrical equipment for machines - Part 1: General requirements)

The following requirements are valid for an emergency stop in addition to the requirements for stop functions:

- It must have priority over all other functions and operations in all operating modes.
- Power to machine drive elements that can cause a dangerous state must be switched off as quickly as possible without creating other dangers.
- Resetting is not permitted to cause a restart.

Emergency stops must be category 0 or category 1 stop functions. The stop function required must be determined based on a risk assessment for the machine.

For category 0 emergency stop functions, only hard-wired electromechanical equipment can be used. In addition, this functionality is not permitted to depend on electronic switching logic (hardware or software) or the transfer of commands via a communication network or data connection. [3)]

When using a category 1 emergency stop function, it must be guaranteed that the power to the machine drive elements is completely switched off. These elements must be switched off using electromechanical equipment. [4)]

Performance levels (PL) in accordance with EN ISO 13849-1 (Safety of machinery – Safety-related parts of control systems, Part 1: General principles for design)

The safety-related parts of control systems must meet one or more of the requirements for five defined performance levels. These performance levels define the required behavior of safety-related controller parts with regard to their resistance to errors.

Performance level (in accordance with EN ISO 13849-1)	Safety integrity level - SIL (in accordance with IEC 61508-2)	Short description	System behavior
a	---	Safety-related components must be designed and built in such away that they can meet the expected operational requirements (no specific safety measures are implemented).	**Caution!** **An error can cause the loss of safety functionality.**
b	1	Safety-related components must be designed and built in such a way that only reliable components and safety principles are used (e.g. preventing short circuits by using sufficient distances, reducing the probability of errors by using oversized components, defining the failure route, closed-circuit principle, etc.).	**Caution!** **An error can cause the loss of safety functionality.**

Table 262: Overview of performance levels (PL)

Chapter 7 Standards and certifications

3) In accordance with the national foreword of the valid German-language version of EN 60204-1:2006, electronic equipment – and especially emergency stop systems – may be used regardless of the stop category, if e.g. it provides the same safety using the standards EN ISO 13849-1:2008 and/or IEC 61508 as required by EN 60204-1.

4) In accordance with the national foreword of the valid German-language version of EN 60204-1:2006, electronic equipment – and especially emergency stop systems – may be used regardless of the stop category, if e.g. it provides the same safety using the standards EN ISO 13849-1:2008 and/or IEC 61508 as required by EN 60204-1.

Performance level (in accordance with EN ISO 13849-1)	Safety integrity level - SIL (in accordance with IEC 61508-2)	Short description	System behavior
c	1	Safety related parts must be designed so that their safety functions are checked in suitable intervals by the machine controller. (e.g. automatic or manual check during start-up)	**Caution!** **An error between checks can cause the loss of safety functionality. The loss of safety functionality will be detected during the check.**
d	2	Safety-related components must be designed in such a way that individual errors do not cause the loss of safety functionality. Individual errors should – if possible – be detected the next time (or before) the safety function is required.	**Caution!** **Safety functionality remains active when an error occurs. Some but not all errors are detected. A buildup of undetected errors can cause safety functionality to fail.**
e	3	Safety-related components must be designed in such a way that individual errors do not cause the loss of safety functionality. Individual errors must be detected the next time (or before) the safety function is required. If this type of detection is not possible, a buildup of errors is not permitted to cause safety functionality to fail.	**Information:** **Safety functionality remains active when an error occurs. Errors are detected in time to prevent safety functionality from failing.**

Table 262: Overview of performance levels (PL)

A suitable performance level must be selected separately for each drive system (or for each axis) based on a risk assessment. This risk assessment is a part of the total risk assessment for the machine.

The following risk graph (in accordance with EN ISO 13849-1, Appendix A) provides a simplified procedure for risk assessment:

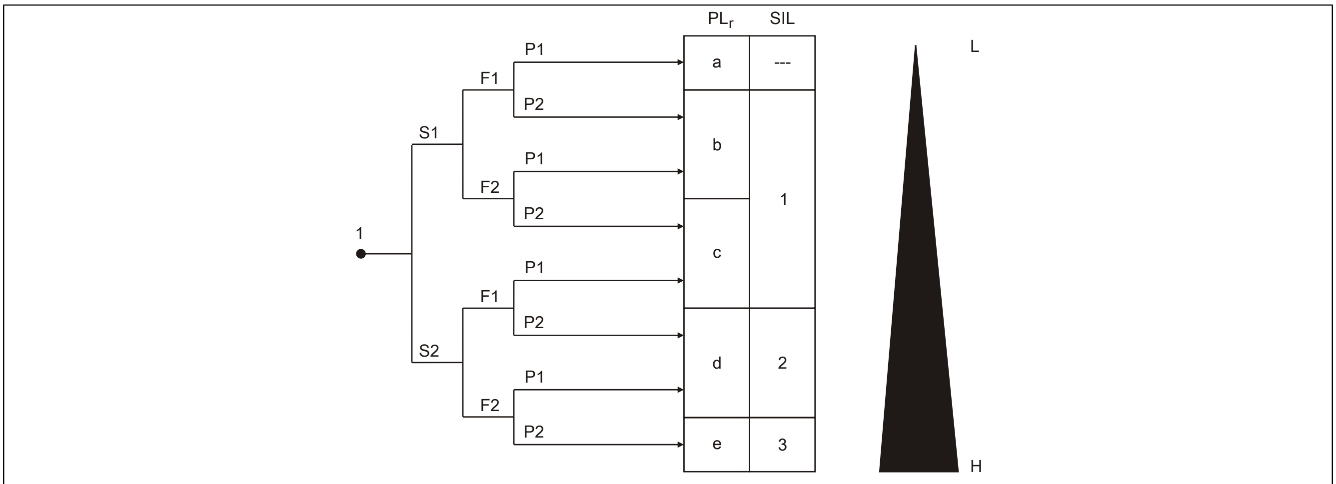


Figure 79: Risk diagram for determining the PL_r for each safety function in accordance with EN ISO 13849-1, Appendix A

Key

1 Starting point for assessing the impact on risk reduction
L Low impact on risk reduction
H High impact on risk reduction
PL_r Required performance level
SIL Safety Integrity Level in accordance with IEC 61508-2

Risk parameters

S Severity of injury
S1 Slight (usually reversible) injury
S2 Serious (usually irreversible) injury or death
F Frequency and/or duration of the exposure to the hazard
F1 Rare to often and/or short exposure to the hazard
F2 Frequent to continuous and/or long exposure
P Possibility to circumvent the danger or limit the damage
P1 Possible under some conditions
P2 Nearly impossible

The performance level to be used is determined by starting at the specified starting point and taking the risk parameters S, F and P into consideration.

Restart inhibit in accordance with EN 1037/04.96 (Safety of Machinery – Prevention of Unexpected Startup)

Keeping a machine in a state of rest when people are working in the danger zone is one of the most important requirements for safely operating machines.

Starting refers to the transition of a machine or its parts from a state of rest to a moving state. Any start is unexpected if it is caused by:

- A startup command sent because of a controller failure or because of external influences on the controller
- A startup command sent because of incorrect operation of a start element or another part of the machine
- Restoration of the power supply after an interruption
- External/Internal influences on parts of the machine

To prevent unexpected startup of machines or parts of machines, power should be removed and dissipated. If this is not practical (e.g. frequent brief interventions in danger zones), other measures must be taken:

- Measures to prevent random startup commands
- Measures to prevent random startup commands from causing unexpected startup
- Measures to automatically stop dangerous parts of the machine before a dangerous situation can be caused by unexpected startup

Appendix A • EC declaration of conformity

This document was originally written in the German language. The German edition therefore represents the original instruction manual in accordance with the 2006/42/EC machinery directive. Documents in other languages are to be interpreted as translations of the original instruction manual.

Product manufacturer:

Bernecker + Rainer

Industrie-Elektronik Ges.m.b.H.

B&R Strasse 1

5142 Eggelsberg

AUSTRIA

The EC declarations of conformity for B&R products can be downloaded from the B&R website at www.br-automation.com.

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