ACOPOSmulti with SafeMC

User Manual

Version: **2.3 (November 2012)**
Model no.: **MAACPMSAFEMC-ENG**

Chapter 1: General Information

Chapter 2: ACOPOSmulti SafeMC

Chapter 3: System characteristics

Chapter 4: Safety technology

Chapter 5: PLCopen Safety

Chapter 6: SafeDESIGNER

Chapter 7: Standards and certifications

Chapter 8: CE declaration of conformity

Chapter 1 • General Information

Information:

This user's manual is only valid together with the ACOPOSmulti User's Manual MAACPM-ENG and the Integrated Safety User'S Manual MASAFETY1-ENG!

1 Manual history

Information:

B&R works hard to keep the printed versions of its user's manuals as current as possible. However from a safety standpoint, the current version from the homepage must be used (www.br-automation.com).

Version	Date	Comment
1.00	2010-03-26	Start of revision history publication
2.2	2012-03-19	Update manual for Safety Release 1.4
2.3	2012-09-24	Chapter "General information": Disclaimer added Chapter "System characteristics": Detection of errors within the module added Chapter "Safety tecchnology / Integrated safety technology in the ACOPOSmulti with SafeMC / The safe power transmission": Encoder options and danger notice added Chapter "Safety tecchnology / Safety characteristics": Danger notice regarding measurement devices added

Table 1: Manual history

1.1 Publications

Model number	Medium	Contents
MAACPMSAFEMC-ENG	Electronic	Complete
MAACPM-ENG	Electronic	Complete
MASAFETY-ENG	Electronic	Complete
MASAFETY1-ENG	Print version	Without chapter 4: PLCopen
MASAFETY2-ENG	Print version	Only chapter 4: PLCopen

Table 2: Publications

1.2 Release information

Manual version	Valid for
V1.00	Safety Release 1.3
V2.00	Safety Release 1.3 and Safety Release 1.4

Table 3: Release information

2 Safety guidelines

2.1 Organization of safety notices

The safety notices in this manual are organized as follows:

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

Table 4: 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.

Danger!

Drive systems and servo motors can have bare parts with voltages applied (e.g. terminals) or hot surfaces. Additional hazardous sources include moving machine parts. Improperly removing 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 the device 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!

Handling drive systems and servo motors incorrectly 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 that are familiar with relevant safety concepts for automation technology and the applicable standards and regulations.
- Qualified personnel that plan, develop, install and commission safety equipment in machines and systems.

Qualified personnel in the context of this manual's safety guidelines are people 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 being used as intended unless the machine meets directive 2006/42/EC (machine directive) as well as directive 2004/108/CE (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 filtering 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. These connection and environmental specifications 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 placed in a secure state.

2.5 Disclaimer

It is the user's responsibility to clarify guidelines for the use of B&R safety-related control components with the respective authorities and 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 correctly (see Section 2.6.2 "Guidelines for proper ESD handling" on page 13).

Electrical components without a housing must be protected by ESD-proof packaging.

2.6.2 Guidelines for proper ESD handling

Electrical components with housing

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

Electrical components without housing

The following apply in addition to the points listed in "Electrical components with housing":

- Any persons handling electrical components or devices with electrical components installed in them must be grounded.
- Components may only 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.
- Measurement devices and equipment must be grounded.
- Measurement probes on potential-free measurement devices 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, humidity, aggressive 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.**
>
> **Therefore, during handling and installation of heavy B&R drive systems or servo motors, there's danger of personal injury or damage to property (shearing, impact, cutting or crushing). Suitable protective equipment (e.g. safety glasses, protective gloves, safety shoes, etc.) should be used when necessary!**

Devices must be installed according to the user's manual using suitable equipment and tools.

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

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

The electrical installation must be carried out according to the relevant guidelines (e.g. line cross section, fuse, protective ground connection, also see chapter 5 "Dimensioning" on page 104).

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 voltages 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). These ground connections must be made even when the drive system is being tested or operated for only 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 safety functions integrated in the drive system, then the safety functions must be fully validated before being turned on for the first time. This could lead to death, severe injury or damage to equipment.**

Control and high power contacts can still carry voltage even if the motor is not turning. Touching contacts 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 protected against being switched on again.

> **Danger!**
>
> **Dangerously High Voltage!**
>
> **Before servicing, disconnect supply and wait 5 minutes to be sure that the capacitors have discharged. See instructions!**

The ACOPOSmulti modules are labeled with the following warning:

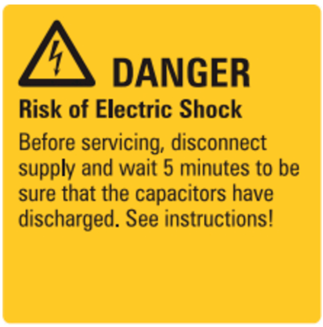


Figure 1: Warning label on the ACOPOSmulti module

The connections for the signal voltages (5 to 30 V) found on the drive system are isolated circuits. Therefore, the signal voltage connections and interfaces are 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 protective low voltage of class DVC A 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 a mistake when handling 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 light barriers.

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 the motors cannot prevent hoisting equipment from dropping their load.

2.10 The characteristics of functional safety

The specifications of the safety functions are described at section 3 "Safety characteristics" on page 134.

The specifications are determined based on a proof test interval of maximum 20 years. A proof test cannot be carried out for B&R drive systems, so the proof test interval is the mission time of the system.

According to the standards EN ISO 13849, EN 62061 and IEC 61508, the safety functions described in section Chapter 4 "Safety technology" on page 123 cannot be used beyond the specified mission time.

Danger!

Operating SafeMC modules beyond the specified mission time is not permitted!

The user must ensure that all SafeMC modules are removed from operation i.e. replaced by new SafeMC modules, 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 5: Environmentally-friendly separation of materials

Disposal must comply with applicable legal regulations.

Chapter 2 • ACOPOSmulti SafeMC

1 Configuration of an ACOPOSmulti drive system

The ACOPOSmulti drive system consists of a mounting plate, different modules (power supply, auxiliary supply and 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.

The configuration of an ACOPOSmulti drive system is done in 10 steps:

1. Determine the cooling method
2. Define and check supply voltage range and mains type
3. Select the ACOPOSmulti inverter modules according to application requirements
4. Select the ACOPOSmulti plug-in modules for motor encoder and external axis encoder according to the application requirements
5. If the ACOPOSmulti drive system should be expandable:
   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 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 may not be used in combination with ACOPOSmulti inverter modules!**

9. Determine the total number of slots by adding the width units 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 Indicators

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

2.1 8BVI inverter modules with SafeMC

2.1.1 Single-axis modules

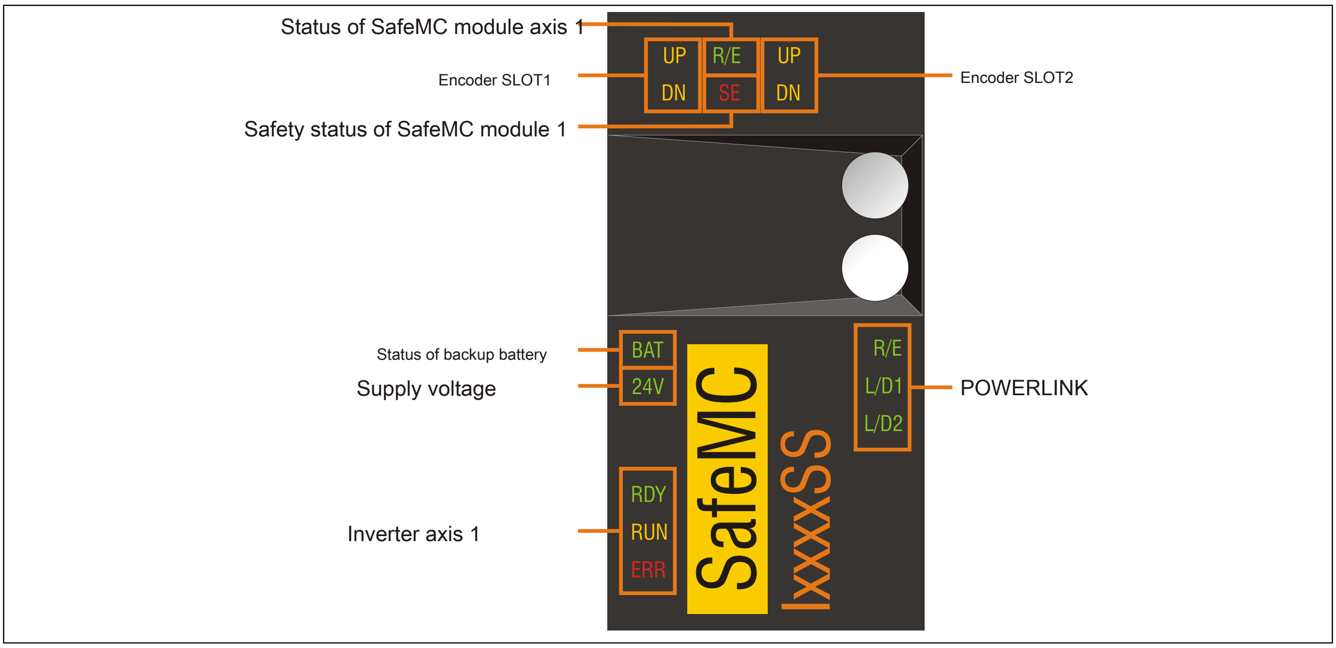


Figure 2: Indicator groups for 8BVI inverter modules with SafeMC (single-axis modules)

LED status

Indicator group	Labeling	Color	Function	Description
POWERLINK	R/E	Green/red	Ready/Error	see "LED status - POWERLINK" on page 20
	L/D1	Green	Link/Data activity on Port 1	
	L/D2		Link/Data activity on Port 2	
Inverter axis 1	RDY	Green	Ready	see "LED status RDY, RUN, ERR (8BVI, 8BVP, 8B0P)" on page 20
	RUN	Orange	Run	
	ERR	Red	Error	
Status of backup battery	BAT	Green/red	Ready/Error	see "LED status - Backup battery" on page 20
Supply voltage	24V	Green	24 V OK	The 24V module supply voltage is within the tolerance range.
Encoder SLOT1	UP	Orange	Encoder direction of rotation +	The encoder position of the connected encoder changed in the positive direction. The faster the encoder position changes, the brighter the LED is lit.
	DN		Encoder direction of rotation -	The encoder position of the connected encoder changed 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 SafeMC module axis 1	R/E	Green/red	Ready/Error	see "LED status - SafeMC module" on page 21
Safety status of SafeMC module 1	SE	Red	Safe/Error	

Table 6: LED status - 8BVI inverter modules with SafeMC (single-axis modules)

2.1.2 Dual-axis modules

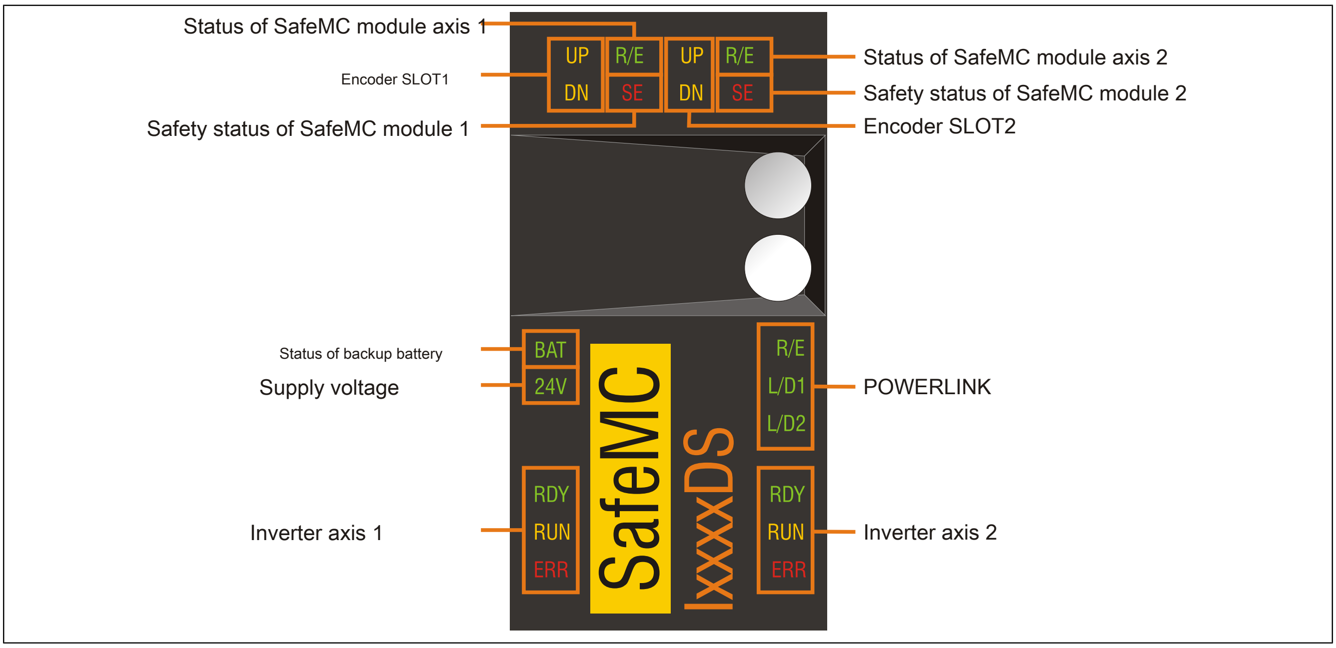


Figure 3: Indicator groups for 8BVI inverter modules with SafeMC (two-axis modules)

LED status

Indicator group	Labeling	Color	Function	Description
POWERLINK	R/E	Green/red	Ready/Error	see "LED status - POWERLINK" on page 20
	L/D1	Green	Link/Data activity on Port 1	
	L/D2		Link/Data activity on Port 2	
Inverter axis 1	RDY	Green	Ready	see "LED status RDY, RUN, ERR (8BVI, 8BVP, 8B0P)" on page 20
	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 "LED status - Backup battery" on page 20
Supply voltage	24V	Green	24 V OK	The 24V module supply voltage is within the tolerance range.
Encoder SLOT1	UP	Orange	Encoder direction of rotation +	The encoder position of the connected encoder changed in the positive direction. The faster the encoder position changes, the brighter the LED is lit.
	DN		Encoder direction of rotation -	The encoder position of the connected encoder changed 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 SafeMC module axis 1	R/E	Green/red	Ready/Error	see "LED status - SafeMC module" on page 21
Safety status of SafeMC module 1	SE	Red	Safe/Error	
Status of SafeMC module axis 2	R/E	Green/red	Ready/Error	
Safety status of SafeMC module 2	SE	Red	Safe/Error	

Table 7: LED status - 8BVI inverter modules with SafeMC (two-axis modules)

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

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)	Module is not ready for operation **Examples:** • No signal on one or both enable inputs • DC bus voltage exceeds the tolerance range • Over-temperature on the motor (temperature sensor) • Motor feedback not connected or defective • Motor temperature sensor not connected or defective • Over-temperature on the module (IGBT junction, heat sink, etc.) • Network fault
RUN	Orange	Run	Orange (lit)	The module' power stage is enabled.
ERR	Red	Error	Red (lit) 1)	There is a permanent error on the module. **Examples:** • Permanent overcurrent • Data in EPROM not valid

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

1) Firmware V2.130 and higher

2.1.4 LED status - POWERLINK

Labeling	Color	Function	Description	
R/E	Green/red	Ready/Error	LED not lit	Supply voltage is not applied to the module or initialization of the network interface has failed.
			Red (lit)	The POWERLINK node number of the module is 0.
			Red/green blinking	The client is in an error state (drops out of cyclic operation).
			Green (blinking) (1x)	The client recognizes a valid POWERLINK frame on the network.
			Green (blinking) (2x)	Cyclic operation on the network; however, the client itself is not yet participating in cyclic operation.
			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 that are participating in cyclic operation.
L/D1	Green	Link/Data activity on Port 1	Green (lit)	There is a physical connection to another station on the network.
			Green (blinking)	Activity Port 1
L/D2	Green	Link/Data activity on Port 2	Green (lit)	There is a physical connection to another station on the network.
			Green (blinking)	Activity Port 2

Table 9: LED status - POWERLINK

2.1.5 LED status - Backup battery

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 • An EnDat encoder with backup battery is connected and registering "Battery ok" , but the module's firmware version does not support EnDat encoders with battery backup.
			Green (lit)	An EnDat encoder with battery backup is connected and registering "Battery ok" (voltage of the installed backup battery is within the tolerance range).
			Red (lit)	An EnDat encoder with battery backup 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 10: LED status - Backup battery

2.1.6 LED status - SafeMC module

Opening the front cover of an ACOPOSmulti with SafeMC reveals 3 additional LEDs for each safe axis:

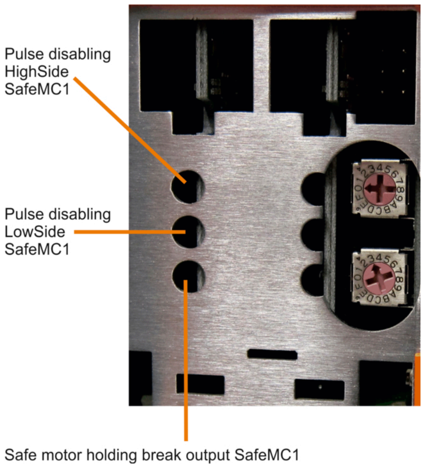


Figure 4: Single-axis modules

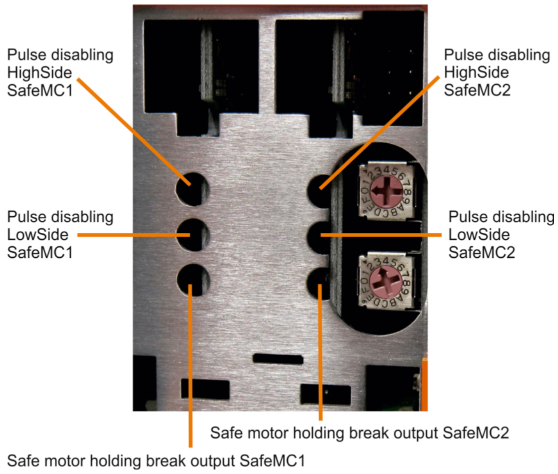


Figure 5: Dual-axis modules

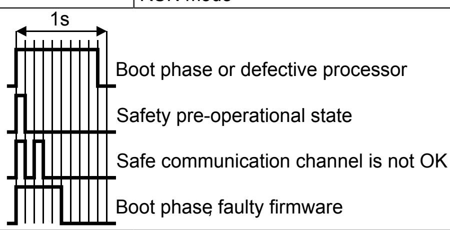
LED	Color		Description
R/E	Green	Red	
	Off	Off	Module not supplied with current, no communication
	Single Flash		Unlink mode
	Double Flash		Firmware update
	Blinking		PREOPERATIONAL mode
	On		RUN mode
	On	Single flash, inverse	Safety-related firmware invalid
		Triple flash, inverse	Update of safety-related firmware
		On	Communication error
	Off	On	Error
Status LED Pulse disabling output, highside	Red		Channel warning/error During the start-up 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, lowside	Red		Channel warning/error During the start-up 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		Channel warning/error During the start-up 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
			
		On	Non-acknowledgeable error state, Fail Safe status
	"SE" are actually two LEDs, that separately display the states in the safety processor 1 and safety processor 2. However, this is only distinguishable when the front cover is open.		

Table 11: LED-Status SafeMC module

Danger!

Constantly lit LEDs "SE" indicate a fail safe state that cannot be acknowledged. 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 measures for repair are initiated after an error occurs as successive errors can result in dangerous situations.

2.1.7 Status changes when booting the operating system loader

The following timing is used for the indication diagram:

Block size: 50 ms
Repeats after: 3000 ms

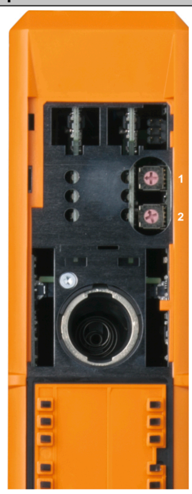
Status	LED	Display
1. Boot procedure for basic hardware active	RDY	
	RUN	
	ERR	
2. Configuration network active	RDY	
	RUN	
	ERR	
3. Waiting for network telegram	RDY	
	RUN	
	ERR	
4. Network communication active	RDY	
	RUN	
	ERR	
5. ACOPOS operating system being transferred/burned [1)]	RDY	
	RUN	
	ERR	

Table 12: Status changes when booting the operating system loader

1) Firmware V2.140 and higher.

2.1.8 POWERLINK station number settings

The POWERLINK station number can be set using two HEX code switches that are located behind the black cover of the module:

<table>
<tr><th colspan="2">Image</th><th rowspan="2">Code switch</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, because they are intended for future system expansions.

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

Table 13: Setting the POWERLINK station number

3 Module Data Sheets

3.1 Overview

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

Product ID	Short description	on page
8BVI0014HCSS.000-1	ACOPOSmulti inverter unit, 1.9 A, HV, cold plate or feed through mounting, SafeMC EnDat 2.2	24
8BVI0014HWSS.000-1	ACOPOSmulti inverter unit, 1.9 A, HV, wall mounting, SafeMC EnDat 2.2	24
8BVI0028HCSS.000-1	ACOPOSmulti inverter unit, 3.8 A, HV, cold plate or feed through mounting, SafeMC EnDat 2.2	28
8BVI0028HWSS.000-1	ACOPOSmulti inverter unit, 3.8 A, HV, wall mounting, SafeMC EnDat 2.2	28
8BVI0055HCSS.000-1	ACOPOSmulti inverter unit, 7.6 A, HV, cold plate or feed through mounting, SafeMC EnDat 2.2	31
8BVI0055HWSS.000-1	ACOPOSmulti inverter unit, 7.6 A, HV, wall mounting, SafeMC EnDat 2.2	31
8BVI0110HCSS.000-1	ACOPOSmulti inverter unit, 15.1 A, HV, cold plate or feed through mounting, SafeMC EnDat 2.2	35
8BVI0110HWSS.000-1	ACOPOSmulti inverter unit, 15.1 A, HV, wall mounting, SafeMC EnDat 2.2	35

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

Product ID	Short description	on page
8BVI0220HCSS.000-1	ACOPOSmulti inverter unit, 22 A, HV, cold plate or feed through mounting, SafeMC EnDat 2.2	42
8BVI0220HWSS.000-1	ACOPOSmulti inverter unit, 22 A, HV, wall mounting, SafeMC EnDat 2.2	42
8BVI0330HCSS.000-1	ACOPOSmulti inverter unit, 33 A, HV, cold plate or feed through mounting, SafeMC EnDat 2.2	46
8BVI0330HWSS.000-1	ACOPOSmulti inverter unit, 33 A, HV, wall mounting, SafeMC EnDat 2.2	46
8BVI0440HCSS.000-1	ACOPOSmulti inverter unit, 44 A, HV, cold plate or feed through mounting, SafeMC EnDat 2.2	49
8BVI0440HWSS.000-1	ACOPOSmulti inverter unit, 44 A, HV, wall mounting, SafeMC EnDat 2.2	49

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

Product ID	Short description	on page
8BVI0660HCSS.000-1	ACOPOSmulti inverter unit, 66 A, HV, cold plate or feed through mounting, SafeMC EnDat 2.2	83
8BVI0660HWSS.000-1	ACOPOSmulti inverter unit, 66 A, HV, wall mounting, SafeMC EnDat 2.2	83
8BVI0880HCSS.004-1	ACOPOSmulti inverter unit, 88 A, HV, cold plate or feed through mounting, SafeMC EnDat 2.2	87
8BVI0880HWSS.004-1	ACOPOSmulti inverter unit, 88 A, HV, wall mounting, SafeMC EnDat 2.2	87

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

Product ID	Short description	on page
8BVI1650HCSS.000-1	ACOPOSmulti inverter unit, 165 A, HV, cold plate or feed through mounting, SafeMC EnDat 2.2	95

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

Product ID	Short description	on page
8BVI0014HCDS.000-1	ACOPOSmulti inverter unit, 1.9 A, HV, cold plate or feed through mounting, 2 axes, SafeMC	57
8BVI0014HWDS.000-1	ACOPOSmulti inverter unit, 1.9 A, HV, wall mounting, 2 axes, SafeMC	57
8BVI0028HCDS.000-1	ACOPOSmulti inverter unit, 3.8 A, HV, cold plate or feed throuch mounting, 2 axes, SafeMC	60
8BVI0028HWDS.000-1	ACOPOSmulti inverter unit, 3.8 A, HV, wall mounting, 2 axes, SafeMC	60
8BVI0055HCDS.000-1	ACOPOSmulti inverter unit, 7.6 A, HV, cold plate or feed through mounting, 2 axes, SafeMC	64
8BVI0055HWDS.000-1	ACOPOSmulti inverter unit, 7.6 A, HV, wall mounting, 2 axes, SafeMC	64

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

Product ID	Short description	on page
8BVI0110HCDS.000-1	ACOPOSmulti inverter unit, 15.1 A, HV, cold plate or feed through mounting, 2 axes, SafeMC	72
8BVI0110HWDS.000-1	ACOPOSmulti inverter unit, 15.1 A, HV, wall mounting, 2 axes, SafeMC	72
8BVI0220HCDS.000-1	ACOPOSmulti inverter unit, 22 A, HV, cold plate or feed through mounting, 2 axes, SafeMC	75
8BVI0220HWDS.000-1	ACOPOSmulti inverter unit, 22 A, HV, wall mounting, 2 axes, SafeMC	75

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

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

General Information

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

Order data

Model number	Short description	Figure
	Cold plate or feed-through mounting	
8BVI0014HCSS.000-1	ACOPOSmulti inverter unit, 1.9 A, HV, cold plate or feed through mounting, SafeMC EnDat 2.2	
8BVI0014HWSS.000-1	ACOPOSmulti inverter unit, 1.9 A, HV, wall mounting, SafeMC EnDat 2.2	
	Required accessories	
	Terminal block sets	
8BZVI0055SS.000-1A	Screw clamp terminal block set for ACOPOSmulti modules 8BVI00xxHxSS: 1x 8TB3104.204G-00, 1x 8TB2104.203L-00, 1x 8TB2108.2010-00	
	Optional accessories	
	Fan modules	
8BXF001.0000-00	ACOPOSmulti fan unit, replacement fan for ACOPOSmulti modules (8BxP/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/BISS	
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 plug-in 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: 1 shielding plate 1fold type 0; 1 hose clamp, W 9 mm, D 12-22 mm	
8SCS002.0000-00	ACOPOSmulti shielding components set: 1 clamp plate; 2 clamps D 4-13.5 mm; 4 screws	
8SCS009.0000-00	ACOPOSmulti shielding components set: 1 ACOPOSmulti shielding plate SK8-14; 1 shielding clamp SK14	
	Terminal blocks	
8TB2104.203L-00	Screw clamp terminal block 4-pin, single-row, pitch: 5.08 mm, labeling 3: T- T+ B- B+, coding L: 1010	
8TB2108.2010-00	Screw clamp terminal block 8-pin, single-row, pitch: 5.08 mm, labeling 1: numbered consecutively	
8TB3104.204G-00	Screw clamp terminal block 4-pin, single-row, pitch: 7.62 mm, labeling 4: PE W V U, coding G: 0110	

Table 14: 8BVI0014HCSS.000-1, 8BVI0014HWSS.000-1 - Order data

Technical data

Product ID	8BVI0014HCSS.000-1	8BVI0014HWSS.000-1
General information		
B&R ID code	0xAA0C	0xAA0E
Cooling and mounting method	Cold plate or feed-through mounting	Wall mounting
Slots for plug-in modules	2 [1)]	
Certification c-UL-us	 Yes	
DC bus connection		
Voltage Rated	 750 VDC	
Continuous power consumption [2)]	1.46 kW	
Power loss depending on the switching frequency [3)] Switching frequency 5 kHz Switching frequency 10 kHz Switching frequency 20 kHz	 [0.6*I_M²+1.3*I_M+60] W [0.97*I_M²+0.5*I_M+110] W [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)]	
Design	ACOPOSmulti backplane	
24 VDC output		
Quantity	2	
Output voltage DC bus voltage (U_{DC}): 260 ... 315 VDC DC bus voltage (U_{DC}): 315 ... 800 VDC	 25 VDC * (U_{DC}/315) 24 VDC ±6%	
Fuse protection	250 mA (slow-blow) electronic, automatic reset	
Motor connection [5)]		
Quantity	1	
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 Switching frequency 10 kHz Switching frequency 20 kHz	 No reduction [7)] No reduction 0.13 A/K (from 46 °C)	 0.11 A/K (from 33 °C)
Reduction of continuous current depending on altitude Starting at 500 m above sea level	 0.19 A_{eff} per 1000 m	
Peak current	4.7 A_{eff}	
Rated switching frequency	5 kHz	
Possible switching frequencies [8)]	5/10/20 kHz	
Electrical stress of the connected motor in accordance with IEC TS 60034-25	Limit value curve A	
Protective measures / safeguards Overload protection Short circuit and ground fault	 Yes Yes	
Max. output frequency	600 Hz [9)]	
Design U, V, W, PE Shield connection	 Plug Yes	
Terminal connection cross section Flexible and fine wire lines With wire tip sleeves Approbation data UL/C-UL-US CSA	 0.25 to 4 mm² 30 to 10 28 to 10	
Terminal cable cross-section dimension of the shield connection	12 to 22 mm	
Max. motor line length depending on the switching frequency Switching frequency 5 kHz Switching frequency 10 kHz Switching frequency 20 kHz	 25 m 25 m 10 m	
Motor holding brake connection		
Quantity	1	
Output voltage [10)]	24 VDC +5.8% / -0% [11)]	
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	

Table 15: 8BVI0014HCSS.000-1, 8BVI0014HWSS.000-1 - Technical data

Product ID	8BVI0014HCSS.000-1	8BVI0014HWSS.000-1
Max. switching frequency	0.5 Hz	
Protective measures / safeguards		
Overload and short circuit protection	Yes	
Cable breakage monitoring	Yes	
Undervoltage monitoring	Yes	
Response threshold for cable breakage monitoring	Approx. 0.25 A	
Response threshold for undervoltage monitoring	24 VDC +0% / -4%	
Encoder interfaces [12]		
Quantity	1	
Type	EnDat 2.2 [13]	
Connections	9-pin DSUB socket	
Displays	UP/DN LEDs	
Electrical isolation		
Encoder - ACOPOSmulti	No	
Encoder monitoring	Yes	
Max. encoder cable length	100 m Depending on the cross section of the supply wires on the encoder cable [14]	
Encoder supply		
Output voltage	Typ. 12.5 V	
Load capability	350 mA	
Protective measures / safeguards		
Short circuit protection	Yes	
Overload protection	Yes	
Synchronous serial interface		
Signal transfer	RS485	
Data transfer rate	6.25 Mbit/s	
Max. power consumption per encoder interface	P_{SMC} [W] = 19 V * $I_{Encoder}$ [A] [15]	
Trigger inputs		
Quantity	2	
Wiring	Sink	
Electrical isolation		
Input - Inverter module	Yes	
Input - Input	Yes	
Input voltage		
Rated	24 VDC	
Maximum	30 VDC	
Switching threshold		
Low	<5 V	
High	>15 V	
Input current at rated voltage	Approx. 10 mA	
Switching delay		
Positive edge	52 µs ± 0.5 µs (digitally filtered)	
Negative edge	53 µs ± 0.5 µs (digitally filtered)	
Modulation compared to ground potential	Max. ±38 V	
Operating conditions		
Permitted mounting orientations		
Hanging vertically	Yes	
Lying horizontally	Yes	
Standing horizontally	No	
Installation at altitudes above sea level		
Rated	0 to 500 m	
Maximum [16]	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 [17]	
Environmental conditions		
Temperature		
Operation		
Rated	5 to 40°C	
Maximum [18]	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 [19]		
Width	53 mm	
Height	317 mm	
Depth		
Wall mounting	-	263 mm

Table 15: 8BVI0014HCSS.000-1, 8BVI0014HWSS.000-1 - Technical data

Product ID	8BVI0014HCSS.000-1	8BVI0014HWSS.000-1
Cold-plate	212 mm	-
Feed-through mounting	209 mm	-
Weight	Approx. 2.1 kg	Approx. 2.6 kg
Module width	1	

Table 15: 8BVI0014HCSS.000-1, 8BVI0014HWSS.000-1 - Technical data

1) SLOT 1 of the ACOPOSmulti module is occupied by the encoder interface.
2) Valid in the following conditions: Bus voltage 750 VDC, switching frequency 5 kHz, 40°C ambient temperature, installation altitudes <500 m above sea level, no derating dependent on cooling type.
3) I_M ... Current on the motor connection [A].
4) P_{SMC1} ... Max. power consumption P_{SMC} [W] of the SafeMC module in SLOT1 (see the section "Encoder interfaces")
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) B&R 8BCM motor cables must be used when cabling the motor connections.
6) Valid in the following conditions: DC bus voltage 750 VDC, minimum permissible coolant flow volume (3 l/min). The temperature specifications are based on the return temperature of the cold-plate mounting plate.
7) Value for the nominal switching frequency.
8) B&R recommends operating the module at nominal switching frequency. Operating the module at a higher switching frequency for application-specific reasons reduces the continuous current and increases the CPU load.
9) The module's electrical output frequency (SCTRL_SPEED_ACT * MOTOR_POLEPAIRS) is monitored to protect against dual-use in accordance with EC 428/2009 | 3A225. If the electrical output frequency of the module exceeds the limit value of 600 Hz uninterrupted for more than 0.5 s, then the current motion is aborted and error 6060 is output (Power element: Limit speed exceeded).
10) 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.
11) The specified values 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 deactivated.
12) B&R 8BCF EnDat 2.2 cables must be used when cabling the encoder interfaces.
13) An EnDat 2.2 functional safety encoder is required when using ACOPOSmulti with SafeMC! With standard EnDat 2.2 encoders, only the timing of the functions STO, SBC and SS1 is monitored!
14) The maximum encoder cable length l_{max} can be calculated as follows (the maximum permissible encoder 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 [Ωmm²/m] (e.g. for copper: ρ = 0.0178)
15) $I_{Encoder}$ ... Max. power consumption of the connected encoder [A].
16) Continuous operation at altitudes ranging from 500 m to 4,000 m above sea level is possible (taking the continuous current reductions listed into consideration).
17) This value only applies with the factory settings (SLOT2 of the module is sealed by a slot cover shield plate). If SLOT2 on the module is not sealed, then the protection level is reduced to IP10. For this reason, we recommend only removing the slot cover shield plate if an ACOPOSmulti plug-in module is being used in SLOT2.
18) Continuous operation at ambient temperatures ranging from 40°C to max. 55°C is possible (taking the continuous current reductions listed into consideration), but results in a shorter lifespan.
19) The dimensions define the true device dimensions including the respective mounting plate. Make sure to leave additional space above and below the devices for mounting, connections and air circulation.

Wiring

For details, see section 3.2.5 "Wiring: Safe single-width inverter modules (single-axis modules)" on page 39

For general information, please see section 6 "Wiring" on page 105

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

General Information

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

Order data

Model number	Short description	Figure
	Cold plate or feed-through mounting	
8BVI0028HCSS.000-1	ACOPOSmulti inverter unit, 3.8 A, HV, cold plate or feed through mounting, SafeMC EnDat 2.2	
8BVI0028HWSS.000-1	ACOPOSmulti inverter unit, 3.8 A, HV, wall mounting, SafeMC EnDat 2.2	
	Required accessories	
	Terminal block sets	
8BZVI0055SS.000-1A	Screw clamp terminal block set for ACOPOSmulti modules 8BVI00xxHxSS: 1x 8TB3104.204G-00, 1x 8TB2104.203L-00, 1x 8TB2108.2010-00	
	Optional accessories	
	Fan modules	
8BXF001.0000-00	ACOPOSmulti fan unit, replacement fan for ACOPOSmulti modules (8BxP/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/BISS	
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 plug-in 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: 1 shielding plate 1fold type 0; 1 hose clamp, W 9 mm, D 12-22 mm	
8SCS002.0000-00	ACOPOSmulti shielding components set: 1 clamp plate; 2 clamps D 4-13.5 mm; 4 screws	
8SCS009.0000-00	ACOPOSmulti shielding components set: 1 ACOPOSmulti shielding plate SK8-14; 1 shielding clamp SK14	
	Terminal blocks	
8TB2104.203L-00	Screw clamp terminal block 4-pin, single-row, pitch: 5.08 mm, labeling 3: T- T+ B- B+, coding L: 1010	
8TB2108.2010-00	Screw clamp terminal block 8-pin, single-row, pitch: 5.08 mm, labeling 1: numbered consecutively	
8TB3104.204G-00	Screw clamp terminal block 4-pin, single-row, pitch: 7.62 mm, labeling 4: PE W V U, coding G: 0110	

Table 16: 8BVI0028HCSS.000-1, 8BVI0028HWSS.000-1 - Order data

Technical data

Product ID	8BVI0028HCSS.000-1	8BVI0028HWSS.000-1
General information		
B&R ID code	0xAA10	0xAA12
Cooling and mounting method	Cold plate or feed-through mounting	Wall mounting
Slots for plug-in modules	2 [1)]	
Certification		
c-UL-us	Yes	
DC bus connection		
Voltage		
Rated	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		

Table 17: 8BVI0028HCSS.000-1, 8BVI0028HWSS.000-1 - Technical data

Product ID	8BVI0028HCSS.000-1	8BVI0028HWSS.000-1
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]	
Design	ACOPOSmulti backplane	
24 VDC output		
Quantity	2	
Output voltage		
DC bus voltage (U_{DC}): 260 ... 315 VDC	25 VDC * (U_{DC}/315)	
DC bus voltage (U_{DC}): 315 ... 800 VDC	24 VDC ±6%	
Fuse protection	250 mA (slow-blow) electronic, automatic reset	
Motor connection [5]		
Quantity	1	
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	0.6 A/K (from 58 °C)	No reduction
Switching frequency 20 kHz	0.1 A/K (from 34 °C)	0.12 A/K (from 33 °C)
Reduction of continuous current depending on altitude		
Starting at 500 m above sea level	0.38 A_{eff} per 1000 m	
Peak current	9.5 A_{eff}	
Rated switching frequency	5 kHz	
Possible switching frequencies [8]	5/10/20 kHz	
Electrical stress of the connected motor in accordance with IEC TS 60034-25	Limit value curve A	
Protective measures / safeguards		
Overload protection	Yes	
Short circuit and ground fault	Yes	
Max. output frequency	600 Hz [9]	
Design		
U, V, W, PE	Plug	
Shield connection	Yes	
Terminal connection cross section		
Flexible and fine wire lines		
With wire tip 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 the 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 [10]	24 VDC +5.8% / -0% [11]	
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 / safeguards		
Overload and short circuit protection	Yes	
Cable breakage monitoring	Yes	
Undervoltage monitoring	Yes	
Response threshold for cable breakage monitoring	Approx. 0.25 A	
Response threshold for undervoltage monitoring	24 VDC +0% / -4%	
Encoder interfaces [12]		
Quantity	1	
Type	EnDat 2.2 [13]	
Connections	9-pin DSUB socket	
Displays	UP/DN LEDs	
Electrical isolation		
Encoder - ACOPOSmulti	No	
Encoder monitoring	Yes	
Max. encoder cable length	100 m Depending on the cross section of the supply wires on the encoder cable [14]	
Encoder supply		
Output voltage	Typ. 12.5 V	
Load capability	350 mA	

Table 17: 8BVI0028HCSS.000-1, 8BVI0028HWSS.000-1 - Technical data

Product ID	8BVI0028HCSS.000-1	8BVI0028HWSS.000-1
Protective measures / safeguards		
Short circuit protection	Yes	
Overload protection	Yes	
Synchronous serial interface		
Signal transfer	RS485	
Data transfer rate	6.25 Mbit/s	
Max. power consumption per encoder interface	P_{SMC} [W] = 19 V * $I_{Encoder}$ [A] [15]	
Trigger inputs		
Quantity	2	
Wiring	Sink	
Electrical isolation		
Input - Inverter module	Yes	
Input - Input	Yes	
Input voltage		
Rated	24 VDC	
Maximum	30 VDC	
Switching threshold		
Low	<5 V	
High	>15 V	
Input current at rated voltage	Approx. 10 mA	
Switching delay		
Positive edge	52 µs ± 0.5 µs (digitally filtered)	
Negative edge	53 µs ± 0.5 µs (digitally filtered)	
Modulation compared to ground potential	Max. ±38 V	
Operating conditions		
Permitted mounting orientations		
Hanging vertically	Yes	
Lying horizontally	Yes	
Standing horizontally	No	
Installation at altitudes above sea level		
Rated	0 to 500 m	
Maximum [16]	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 [17]	
Environmental conditions		
Temperature		
Operation		
Rated	5 to 40°C	
Maximum [18]	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 [19]		
Width	53 mm	
Height	317 mm	
Depth		
Wall mounting	-	263 mm
Cold-plate	212 mm	-
Feed-through mounting	209 mm	-
Weight	Approx. 2.1 kg	Approx. 2.6 kg
Module width	1	

Table 17: 8BVI0028HCSS.000-1, 8BVI0028HWSS.000-1 - Technical data

1) SLOT 1 of the ACOPOSmulti module is occupied by the encoder interface.
2) Valid in the following conditions: Bus voltage 750 VDC, switching frequency 5 kHz, 40°C ambient temperature, installation altitudes <500 m above sea level, no derating dependent on cooling type.
3) I_M ... Current on the motor connection [A].
4) P_{SMC1} ... Max. power consumption P_{SMC} [W] of the SafeMC module in SLOT1 (see the section "Encoder interfaces")
   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) B&R 8BCM motor cables must be used when cabling the motor connections.
6) Valid in the following conditions: DC bus voltage 750 VDC, minimum permissible coolant flow volume (3 l/min). The temperature specifications are based on the return temperature of the cold-plate mounting plate.
7) Value for the nominal switching frequency.
8) B&R recommends operating the module at nominal switching frequency. Operating the module at a higher switching frequency for application-specific reasons reduces the continuous current and increases the CPU load.

9) The module's electrical output frequency (SCTRL_SPEED_ACT * MOTOR_POLEPAIRS) is monitored to protect against dual-use in accordance with EC 428/2009 | 3A225. If the electrical output frequency of the module exceeds the limit value of 600 Hz uninterrupted for more than 0.5 s, then the current motion is aborted and error 6060 is output (Power element: Limit speed exceeded).
10) 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.
11) The specified values 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 deactivated.
12) B&R 8BCF EnDat 2.2 cables must be used when cabling the encoder interfaces.
13) An EnDat 2.2 functional safety encoder is required when using ACOPOSmulti with SafeMC! With standard EnDat 2.2 encoders, only the timing of the functions STO, SBC and SS1 is monitored!
14) The maximum encoder cable length l_{max} can be calculated as follows (the maximum permissible encoder 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 [Ωmm²/m] (e.g. for copper: ρ = 0.0178)
15) $I_{Encoder}$ ... Max. power consumption of the connected encoder [A].
16) Continuous operation at altitudes ranging from 500 m to 4,000 m above sea level is possible (taking the continuous current reductions listed into consideration).
17) This value only applies with the factory settings (SLOT2 of the module is sealed by a slot cover shield plate). If SLOT2 on the module is not sealed, then the protection level is reduced to IP10. For this reason, we recommend only removing the slot cover shield plate if an ACOPOSmulti plug-in module is being used in SLOT2.
18) Continuous operation at ambient temperatures ranging from 40°C to max. 55°C is possible (taking the continuous current reductions listed into consideration), but results in a shorter lifespan.
19) The dimensions define the true device dimensions including the respective mounting plate. Make sure to leave additional space above and below the devices for mounting, connections and air circulation.

Wiring

For details, see section 3.2.5 "Wiring: Safe single-width inverter modules (single-axis modules)" on page 39

For general information, please see section 6 "Wiring" on page 105

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

General Information

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

Order data

Model number	Short description	Figure
	Cold plate or feed-through mounting	
8BVI0055HCSS.000-1	ACOPOSmulti inverter unit, 7.6 A, HV, cold plate or feed through mounting, SafeMC EnDat 2.2	
8BVI0055HWSS.000-1	ACOPOSmulti inverter unit, 7.6 A, HV, wall mounting, SafeMC EnDat 2.2	
	Required accessories	
	Terminal block sets	
8BZVI0055SS.000-1A	Screw clamp terminal block set for ACOPOSmulti modules 8BVI00xxHxSS: 1x 8TB3104.204G-00, 1x 8TB2104.203L-00, 1x 8TB2108.2010-00	
	Optional accessories	
	Fan modules	
8BXF001.0000-00	ACOPOSmulti fan unit, replacement fan for ACOPOSmulti modules (8BxP/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	

Table 18: 8BVI0055HCSS.000-1, 8BVI0055HWSS.000-1 - Order data

Model number	Short description	Figure
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/BISS	
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 plug-in 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: 1 shielding plate 1fold type 0; 1 hose clamp, W 9 mm, D 12-22 mm	
8SCS002.0000-00	ACOPOSmulti shielding components set: 1 clamp plate; 2 clamps D 4-13.5 mm; 4 screws	
8SCS009.0000-00	ACOPOSmulti shielding components set: 1 ACOPOSmulti shielding plate SK8-14; 1 shielding clamp SK14	
	Terminal blocks	
8TB2104.203L-00	Screw clamp terminal block 4-pin, single-row, pitch: 5.08 mm, labeling 3: T- T+ B- B+, coding L: 1010	
8TB2108.2010-00	Screw clamp terminal block 8-pin, single-row, pitch: 5.08 mm, labeling 1: numbered consecutively	
8TB3104.204G-00	Screw clamp terminal block 4-pin, single-row, pitch: 7.62 mm, labeling 4: PE W V U, coding G: 0110	

Table 18: 8BVI0055HCSS.000-1, 8BVI0055HWSS.000-1 - Order data

Technical data

Product ID	8BVI0055HCSS.000-1	8BVI0055HWSS.000-1
General information		
B&R ID code	0xAA14	0xAA16
Cooling and mounting method	Cold plate or feed-through mounting	Wall mounting
Slots for plug-in modules	2 [1]	
Certification		
c-UL-us	Yes	
DC bus connection		
Voltage		
Rated	750 VDC	
Continuous power consumption [2]	5.6 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]	
Design	ACOPOSmulti backplane	
24 VDC output		
Quantity	2	
Output voltage		
DC bus voltage (U_{DC}): 260 ... 315 VDC	25 VDC * (U_{DC}/315)	
DC bus voltage (U_{DC}): 315 ... 800 VDC	24 VDC ±6%	
Fuse protection	250 mA (slow-blow) electronic, automatic reset	
Motor connection [5]		
Quantity	1	
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	0.65 A/K (from 57 °C) [7]	No reduction [7]
Switching frequency 10 kHz	0.28 A/K (from 46 °C)	0.2 A/K (from 49 °C)
Switching frequency 20 kHz	0.14 A/K (from 5 °C) [8]	0.13 A/K (from 4 °C) [21]
Reduction of continuous current depending on altitude		
Starting at 500 m above sea level	0.76 A_{eff} per 1000 m	
Peak current	18.9 A_{eff}	
Rated switching frequency	5 kHz	

Table 19: 8BVI0055HCSS.000-1, 8BVI0055HWSS.000-1 - Technical data

Product ID	8BVI0055HCSS.000-1	8BVI0055HWSS.000-1
Possible switching frequencies [9]	5/10/20 kHz	
Electrical stress of the connected motor in accordance with IEC TS 60034-25	Limit value curve A	
Protective measures / safeguards		
Overload protection	Yes	
Short circuit and ground fault	Yes	
Max. output frequency	600 Hz [10]	
Design		
U, V, W, PE	Plug	
Shield connection	Yes	
Terminal connection cross section		
Flexible and fine wire lines		
With wire tip 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 the 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 [11]	24 VDC +5.8% / -0% [12]	
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 / safeguards		
Overload and short circuit protection	Yes	
Cable breakage monitoring	Yes	
Undervoltage monitoring	Yes	
Response threshold for cable breakage monitoring	Approx. 0.25 A	
Response threshold for undervoltage monitoring	24 VDC +0% / -4%	
Encoder interfaces [13]		
Quantity	1	
Type	EnDat 2.2 [14]	
Connections	9-pin DSUB socket	
Displays	UP/DN LEDs	
Electrical isolation		
Encoder - ACOPOSmulti	No	
Encoder monitoring	Yes	
Max. encoder cable length	100 m Depending on the cross section of the supply wires on the encoder cable [15]	
Encoder supply		
Output voltage	Typ. 12.5 V	
Load capability	350 mA	
Protective measures / safeguards		
Short circuit protection	Yes	
Overload protection	Yes	
Synchronous serial interface		
Signal transfer	RS485	
Data transfer rate	6.25 Mbit/s	
Max. power consumption per encoder interface	P_{SMC} [W] = 19 V * $I_{Encoder}$ [A] [16]	
Trigger inputs		
Quantity	2	
Wiring	Sink	
Electrical isolation		
Input - Inverter module	Yes	
Input - Input	Yes	
Input voltage		
Rated	24 VDC	
Maximum	30 VDC	
Switching threshold		
Low	<5 V	
High	>15 V	
Input current at rated voltage	Approx. 10 mA	
Switching delay		
Positive edge	52 µs ± 0.5 µs (digitally filtered)	
Negative edge	53 µs ± 0.5 µs (digitally filtered)	
Modulation compared to ground potential	Max. ±38 V	
Operating conditions		

Table 19: 8BVI0055HCSS.000-1, 8BVI0055HWSS.000-1 - Technical data

Product ID	8BVI0055HCSS.000-1	8BVI0055HWSS.000-1
Permitted mounting orientations		
Hanging vertically	Yes	
Lying horizontally	Yes	
Standing horizontally	No	
Installation at altitudes above sea level		
Rated	0 to 500 m	
Maximum [17]	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 [18]	
Environmental conditions		
Temperature		
Operation		
Rated	5 to 40°C	
Maximum [19]	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 [20]		
Width	53 mm	
Height	317 mm	
Depth		
Wall mounting	-	263 mm
Cold-plate	212 mm	-
Feed-through mounting	209 mm	-
Weight	Approx. 2.2 kg	Approx. 2.7 kg
Module width	1	

Table 19: 8BVI0055HCSS.000-1, 8BVI0055HWSS.000-1 - Technical data

1) SLOT 1 of the ACOPOSmulti module is occupied by the encoder interface.
2) Valid in the following conditions: Bus voltage 750 VDC, switching frequency 5 kHz, 40°C ambient temperature, installation altitudes <500 m above sea level, no derating dependent on cooling type.
3) I_M ... Current on the motor connection [A].
4) P_{SMC1} ... Max. power consumption P_{SMC} [W] of the SafeMC module in SLOT1 (see the section "Encoder interfaces")
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) B&R 8BCM motor cables must be used when cabling the motor connections.
6) Valid in the following conditions: DC bus voltage 750 VDC, minimum permissible coolant flow volume (3 l/min). The temperature specifications are based on 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 return temperature, at which a derating of the continuous current must be accounted for, 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 low return-temperatures.
9) B&R recommends operating the module at nominal switching frequency. Operating the module at a higher switching frequency for application-specific reasons reduces the continuous current and increases the CPU load.
10) The module's electrical output frequency (SCTRL_SPEED_ACT * MOTOR_POLEPAIRS) is monitored to protect against dual-use in accordance with EC 428/2009 | 3A225. If the electrical output frequency of the module exceeds the limit value of 600 Hz uninterrupted for more than 0.5 s, then the current motion is aborted and error 6060 is output (Power element: Limit speed exceeded).
11) 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.
12) The specified values 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 deactivated.
13) B&R 8BCF EnDat 2.2 cables must be used when cabling the encoder interfaces.
14) An EnDat 2.2 functional safety encoder is required when using ACOPOSmulti with SafeMC! With standard EnDat 2.2 encoders, only the timing of the functions STO, SBC and SS1 is monitored!
15) The maximum encoder cable length l_{max} can be calculated as follows (the maximum permissible encoder 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 [Ωmm²/m] (e.g. for copper: ρ = 0.0178)
16) $I_{Encoder}$ ... Max. power consumption of the connected encoder [A].
17) Continuous operation at altitudes ranging from 500 m to 4,000 m above sea level is possible (taking the continuous current reductions listed into consideration).
18) This value only applies with the factory settings (SLOT2 of the module is sealed by a slot cover shield plate). If SLOT2 on the module is not sealed, then the protection level is reduced to IP10. For this reason, we recommend only removing the slot cover shield plate if an ACOPOSmulti plug-in module is being used in SLOT2.

19) Continuous operation at ambient temperatures ranging from 40°C to max. 55°C is possible (taking the continuous current reductions listed into consideration), but results in a shorter lifespan.
20) The dimensions define the true device dimensions including the respective mounting plate. Make sure to leave additional space above and below the devices for mounting, connections and air circulation.
21) The module cannot supply the full continuous current at this switching frequency. This unusual value for the ambient temperature, at which a derating of the continuous current must be accounted for, ensures that the derating of the continuous current can be determined in the same manner as at other switching frequencies.

Wiring

For details, see section 3.2.5 "Wiring: Safe single-width inverter modules (single-axis modules)" on page 39

For general information, please see section 6 "Wiring" on page 105

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

General Information

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

Order data

Model number	Short description	Figure
	Cold plate or feed-through mounting	
8BVI0110HCSS.000-1	ACOPOSmulti inverter unit, 15.1 A, HV, cold plate or feed through mounting, SafeMC EnDat 2.2	
8BVI0110HWSS.000-1	ACOPOSmulti inverter unit, 15.1 A, HV, wall mounting, SafeMC EnDat 2.2	
	Required accessories	
	Terminal block sets	
8BZVI0110SS.000-1A	Screw clamp terminal block set for ACOPOSmulti modules 8BVI0110HxSS: 1x 8TB3104.204G-00, 1x 8TB2104.203L-00, 1x 8TB2108.2010-00	
	Optional accessories	
	Fan modules	
8BXF001.0000-00	ACOPOSmulti fan unit, replacement fan for ACOPOSmulti modules (8BxP/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/BISS	
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 plug-in 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: 1 shielding plate 1fold type 0; 1 hose clamp, W 9 mm, D 12-22 mm	
8SCS002.0000-00	ACOPOSmulti shielding components set: 1 clamp plate; 2 clamps D 4-13.5 mm; 4 screws	
8SCS009.0000-00	ACOPOSmulti shielding components set: 1 ACOPOSmulti shielding plate SK8-14; 1 shielding clamp SK14	
	Terminal blocks	

Table 20: 8BVI0110HCSS.000-1, 8BVI0110HWSS.000-1 - Order data

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

Table 20: 8BVI0110HCSS.000-1, 8BVI0110HWSS.000-1 - Order data

Technical data

Product ID	8BVI0110HCSS.000-1	8BVI0110HWSS.000-1
General information		
B&R ID code	0xAA18	0xAA1A
Cooling and mounting method	Cold plate or feed-through mounting	Wall mounting
Slots for plug-in modules	2 [1]	
Certification		
c-UL-us	Yes	
DC bus connection		
Voltage		
Rated	750 VDC	
Continuous power consumption [2]	11.2 kW	
Power loss depending on the switching frequency [3]		
Switching frequency 5 kHz	$[0.16 \cdot I_M^2 + 5.6 \cdot I_M + 55]$ W	
Switching frequency 10 kHz	$[0.49 \cdot I_M^2 + 4.7 \cdot I_M + 95]$ W	
Switching frequency 20 kHz	$[0.87 \cdot I_M^2 + 10 \cdot I_M + 200]$ 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]	
Design	ACOPOSmulti backplane	
24 VDC output		
Quantity	2	
Output voltage		
DC bus voltage (U_{DC}): 260 ... 315 VDC	25 VDC * (U_{DC}/315)	
DC bus voltage (U_{DC}): 315 ... 800 VDC	24 VDC ±6%	
Fuse protection	250 mA (slow-blow) electronic, automatic reset	
Motor connection [5]		
Quantity	1	
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	0.73 A/K (from 55 °C) [7]	No reduction [7]
Switching frequency 10 kHz	0.32 A/K (from 35 °C)	0.26 A/K (from 33 °C)
Switching frequency 20 kHz	0.18 A/K (from -13 °C) [8]	0.15 A/K (from -28 °C) [21]
Reduction of continuous current depending on altitude		
Starting at 500 m above sea level	1.51 A_{eff} per 1000 m	
Peak current	37.7 A_{eff}	
Rated switching frequency	5 kHz	
Possible switching frequencies [9]	5/10/20 kHz	
Electrical stress of the connected motor in accordance with IEC TS 60034-25	Limit value curve A	
Protective measures / safeguards		
Overload protection	Yes	
Short circuit and ground fault	Yes	
Max. output frequency	600 Hz [10]	
Design		
U, V, W, PE	Plug	
Shield connection	Yes	
Terminal connection cross section		
Flexible and fine wire lines		
With wire tip 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 the shield connection	12 to 22 mm	
Max. motor line length depending on the switching frequency		

Table 21: 8BVI0110HCSS.000-1, 8BVI0110HWSS.000-1 - Technical data

Product ID	8BVI0110HCSS.000-1	8BVI0110HWSS.000-1
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 [11]	24 VDC +5.8% / -0% [12]	
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 / safeguards		
Overload and short circuit protection	Yes	
Cable breakage monitoring	Yes	
Undervoltage monitoring	Yes	
Response threshold for cable breakage monitoring	Approx. 0.5 A	
Response threshold for undervoltage monitoring	24 VDC +0% / -4%	
Encoder interfaces [13]		
Quantity	1	
Type	EnDat 2.2 [14]	
Connections	9-pin DSUB socket	
Displays	UP/DN LEDs	
Electrical isolation		
Encoder - ACOPOSmulti	No	
Encoder monitoring	Yes	
Max. encoder cable length	100 m Depending on the cross section of the supply wires on the encoder cable [15]	
Encoder supply		
Output voltage	Typ. 12.5 V	
Load capability	350 mA	
Protective measures / safeguards		
Short circuit protection	Yes	
Overload protection	Yes	
Synchronous serial interface		
Signal transfer	RS485	
Data transfer rate	6.25 Mbit/s	
Max. power consumption per encoder interface	P_{SMC} [W] = 19 V * $I_{Encoder}$ [A] [16]	
Trigger inputs		
Quantity	2	
Wiring	Sink	
Electrical isolation		
Input - Inverter module	Yes	
Input - Input	Yes	
Input voltage		
Rated	24 VDC	
Maximum	30 VDC	
Switching threshold		
Low	<5 V	
High	>15 V	
Input current at rated voltage	Approx. 10 mA	
Switching delay		
Positive edge	52 µs ± 0.5 µs (digitally filtered)	
Negative edge	53 µs ± 0.5 µs (digitally filtered)	
Modulation compared to ground potential	Max. ±38 V	
Operating conditions		
Permitted mounting orientations		
Hanging vertically	Yes	
Lying horizontally	Yes	
Standing horizontally	No	
Installation at altitudes above sea level		
Rated	0 to 500 m	
Maximum [17]	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 [18]	
Environmental conditions		
Temperature		
Operation		
Rated	5 to 40°C	
Maximum [19]	55°C	
Storage	-25 to 55°C	
Transport	-25 to 70°C	
Relative humidity		

Table 21: 8BVI0110HCSS.000-1, 8BVI0110HWSS.000-1 - Technical data

Product ID	8BVI0110HCSS.000-1	8BVI0110HWSS.000-1
Operation	5 to 85%	
Storage	5 to 95%	
Transport	Max. 95% at 40°C	
Mechanical characteristics		
Dimensions [20]		
Width	53 mm	
Height	317 mm	
Depth		
Wall mounting	-	263 mm
Cold-plate	212 mm	-
Feed-through mounting	209 mm	-
Weight	Approx. 2.4 kg	Approx. 2.9 kg
Module width	1	

Table 21: 8BVI0110HCSS.000-1, 8BVI0110HWSS.000-1 - Technical data

1) SLOT 1 of the ACOPOSmulti module is occupied by the encoder interface.
2) Valid in the following conditions: Bus voltage 750 VDC, switching frequency 5 kHz, 40°C ambient temperature, installation altitudes <500 m above sea level, no derating dependent on cooling type.
3) I_M ... Current on the motor connection [A].
4) P_{SMC1} ... Max. power consumption P_{SMC} [W] of the SafeMC module in SLOT1 (see the section "Encoder interfaces")
   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) B&R 8BCM motor cables must be used when cabling the motor connections.
6) Valid in the following conditions: DC bus voltage 750 VDC, minimum permissible coolant flow volume (3 l/min). The temperature specifications are based on 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 return temperature, at which a derating of the continuous current must be accounted for, 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 low return-temperatures.
9) B&R recommends operating the module at nominal switching frequency. Operating the module at a higher switching frequency for application-specific reasons reduces the continuous current and increases the CPU load.
10) The module's electrical output frequency (SCTRL_SPEED_ACT * MOTOR_POLEPAIRS) is monitored to protect against dual-use in accordance with EC 428/2009 | 3A225. If the electrical output frequency of the module exceeds the limit value of 600 Hz uninterrupted for more than 0.5 s, then the current motion is aborted and error 6060 is output (Power element: Limit speed exceeded).
11) 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.
12) The specified values 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 deactivated.
13) B&R 8BCF EnDat 2.2 cables must be used when cabling the encoder interfaces.
14) An EnDat 2.2 functional safety encoder is required when using ACOPOSmulti with SafeMC! With standard EnDat 2.2 encoders, only the timing of the functions STO, SBC and SS1 is monitored!
15) The maximum encoder cable length l_{max} can be calculated as follows (the maximum permissible encoder 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 [Ωmm²/m] (e.g. for copper: ρ = 0.0178)
16) $I_{Encoder}$ ... Max. power consumption of the connected encoder [A].
17) Continuous operation at altitudes ranging from 500 m to 4,000 m above sea level is possible (taking the continuous current reductions listed into consideration).
18) This value only applies with the factory settings (SLOT2 of the module is sealed by a slot cover shield plate). If SLOT2 on the module is not sealed, then the protection level is reduced to IP10. For this reason, we recommend only removing the slot cover shield plate if an ACOPOSmulti plug-in module is being used in SLOT2.
19) Continuous operation at ambient temperatures ranging from 40°C to max. 55°C is possible (taking the continuous current reductions listed into consideration), but results in a shorter lifespan.
20) The dimensions define the true device dimensions including the respective mounting plate. Make sure to leave additional space above and below the devices for mounting, connections and air circulation.
21) The module cannot supply the full continuous current at this switching frequency. This unusual value for the ambient temperature, at which a derating of the continuous current must be accounted for, ensures that the derating of the continuous current can be determined in the same manner as at other switching frequencies.

Wiring

For details, see section 3.2.5 "Wiring: Safe single-width inverter modules (single-axis modules)" on page 39

For general information, please see section 6 "Wiring" on page 105

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

Overview of pin assignments

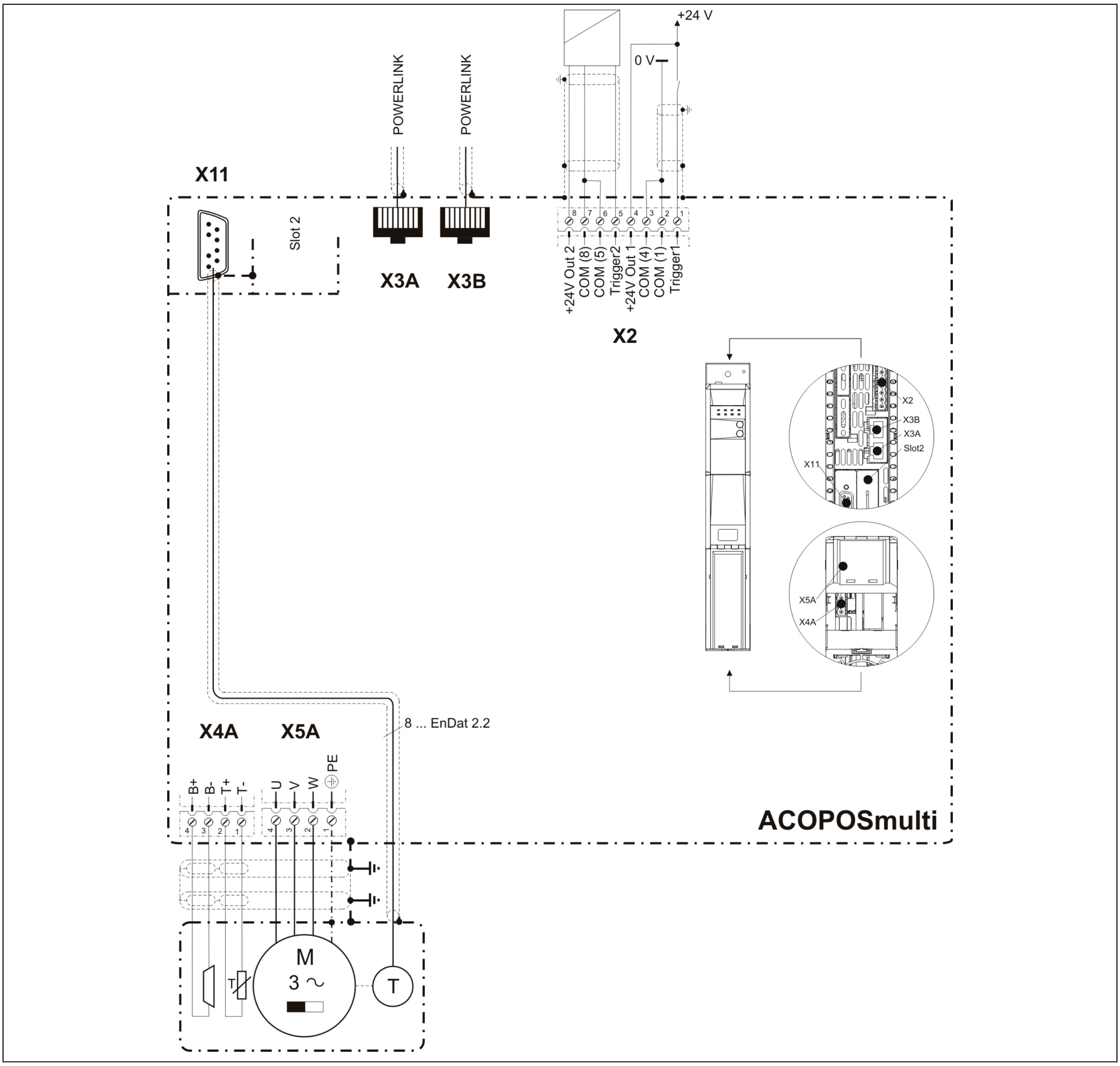


Figure 6: Overview of pin assignments

Pin assignments - X2 plug

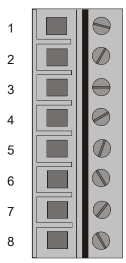
X2	Pin	Name	Function
	1	Trigger 1	Trigger 1
	2	COM (1)	Trigger 1 0 V
	3	COM (2)	+24 V output 1 0 V
	4	+24V Out 1	+24 V output 1
	5	Trigger 2	Trigger 2
	6	COM (5)	Trigger 2 0 V
	7	COM (8)	+24 V output 2 0 V
	8	+24V Out 2	+24 V output 2

Table 22: Pin assignments - X2 plug

Pin assignments - X3A, X3B plugs

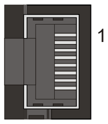
X3A, X3B	Pin	Bezeichnung	Funktion
	1	RXD	Receive Signal
	2	RXD\	Receive Signal inverted
	3	TXD	Transmit Signal
	4	Shield	Shield
	5	Shield	Shield
	6	TXD\	Transmit Signal inverted
	7	Shield	Shield
	8	Shield	Shield

Table 23: Pin assignments - X3A, X3B plugs

Pin assignments X4A plug

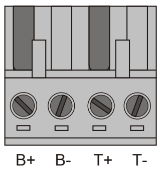
X4A	Name	Function
	T-	Axis 1: Temperature sensor -
	T+	Axis 1: Temperature sensor +
	B- [1)]	Axis 1: Brake -
	B+ [1)]	Axis 1: Brake +

Table 24: Pin assignments - X4A plug

1) The 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 24V. (i.e. safe pulse disabling is activated) However, the brake always remains on because of the short-circuit to 24 V!

This can lead to dangerous situations because the motor holding brake is not able to stop the spin-out movement!

Appropriate wiring measures must be implemented to ensure that the SBC output B+ is not shorted to 24V!

Danger!

The SBC output

- **must not be wired to multiple modules!**
- **must not be wired as open emitter!**
- **must not be wired as open collector!**

Information:

The transistors for the SBC output stage are tested cyclically. When output channels are activated , this test causes 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 isolated circuits. Therefore, these connections are only allowed to be connected to devices or components with at least safe 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!

Pin assignments - X5A plug

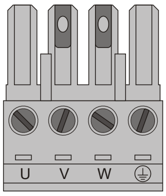
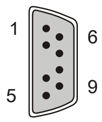
X5A	Name	Function
	⏚	Axis 1: Protective ground conductor
	W	Axis 1: Motor connection W
	V	Axis 1: Motor connection V
	U	Axis 1: Motor connection U

Table 25: Pin assignments - X5A plug

Warning!

B&R 8BCM motor cables must be used when cabling the motor connections.

Pin assignments - SafeMC module

Image	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\	Inverted data input
		9	T\	Inverted clock output

Information:

The SafeMC module must only be used together with 8BCF EnDat 2.2 cables!

Note:

The SafeMC modules cannot be exchanged! The SafeMC modules together with the 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

General Information

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

Order data

Model number	Short description	Figure
	Cold plate or feed-through mounting	
8BVI0220HCSS.000-1	ACOPOSmulti inverter unit, 22 A, HV, cold plate or feed through mounting, SafeMC EnDat 2.2	
8BVI0220HWSS.000-1	ACOPOSmulti inverter unit, 22 A, HV, wall mounting, SafeMC EnDat 2.2	
	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	
	Fan modules	
8BXF001.0000-00	ACOPOSmulti fan unit, replacement fan for ACOPOSmulti modules (8BxP/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/BISS	
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 plug-in 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: 1 shielding plate 1fold type 0; 1 hose clamp, W 9 mm, D 12-22 mm	
8SCS002.0000-00	ACOPOSmulti shielding components set: 1 clamp plate; 2 clamps D 4-13.5 mm; 4 screws	
8SCS009.0000-00	ACOPOSmulti shielding components set: 1 ACOPOSmulti shielding plate SK8-14; 1 shielding clamp SK14	
8SCS010.0000-00	ACOPOSmulti shielding components set: 1 ACOPOSmulti shielding plate SK14-20; 1 shielding clamp SK20	
	Terminal blocks	
8TB2104.203L-00	Screw clamp terminal block 4-pin, single-row, pitch: 5.08 mm, labeling 3: T- T+ B- B+, coding L: 1010	
8TB2108.2010-00	Screw clamp terminal block 8-pin, single-row, pitch: 5.08 mm, labeling 1: numbered consecutively	
8TB4104.204G-00	Screw clamp terminal block 4-pin, single-row, pitch: 10.16mm, labeling 4: PE W V U, coding G: 0110	

Table 26: 8BVI0220HCSS.000-1, 8BVI0220HWSS.000-1 - Order data

Technical data

Product ID	8BVI0220HCSS.000-1	8BVI0220HWSS.000-1
General information		
B&R ID code	0xAA1C	0xAA1E
Cooling and mounting method	Cold plate or feed-through mounting	Wall mounting
Slots for plug-in modules	2 1)	
Certification c-UL-us	Yes	
DC bus connection		
Voltage Rated	750 VDC	
Continuous power consumption 2)	16.2 kW	
Power loss depending on the switching frequency 3) Switching frequency 5 kHz Switching frequency 10 kHz Switching frequency 20 kHz	$[0.13*I_M^2+5.5*I_M+40]$ W $[0.43*I_M^2+3.7*I_M+110]$ W $[1.4*I_M^2+1.97*I_M+230]$ 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)	
Design	ACOPOSmulti backplane	
24 VDC output		
Quantity	2	
Output voltage DC bus voltage (U_{DC}): 260 ... 315 VDC DC bus voltage (U_{DC}): 315 ... 800 VDC	25 VDC * (U_{DC}/315) 24 VDC ±6%	
Fuse protection	250 mA (slow-blow) electronic, automatic reset	
Motor connection 5)		
Quantity	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 6) Switching frequency 5 kHz Switching frequency 10 kHz Switching frequency 20 kHz	0.36 A/K (from 5 °C) 7) 0.5 A/K (from 49 °C) No reduction 8)	No reduction 7) 0.4 A/K (from 31 °C) 0.31 A/K (from -16 °C) 21)
Reduction of continuous current depending on altitude Starting at 500 m above sea level	2.2 A_{eff} per 1000 m	
Peak current	55 A_{eff}	
Rated switching frequency	5 kHz	
Possible switching frequencies 9)	5/10/20 kHz	
Electrical stress of the connected motor in accordance with IEC TS 60034-25	Limit value curve A	
Protective measures / safeguards Overload protection Short circuit and ground fault	Yes Yes	
Max. output frequency	600 Hz 10)	
Design U, V, W, PE Shield connection	Plug Yes	
Terminal connection cross section Flexible and fine wire lines With wire tip sleeves Approbation data UL/C-UL-US CSA	0.5 to 6 mm² 20 to 8 20 to 8	
Terminal cable cross-section dimension of the shield connection	12 to 22 mm	
Max. motor line length depending on the switching frequency Switching frequency 5 kHz Switching frequency 10 kHz Switching frequency 20 kHz	25 m 25 m 25 m	
Motor holding brake connection		
Quantity	1	
Output voltage 11)	24 VDC +5.8% / -0% 12)	
Continuous current	4.2 A	
Max. internal resistance	0.15 Ω	
Extinction potential	Approx. 30 V	
Max. extinction energy per switching operation	3 Ws	

Table 27: 8BVI0220HCSS.000-1, 8BVI0220HWSS.000-1 - Technical data

Product ID	8BVI0220HCSS.000-1	8BVI0220HWSS.000-1
Max. switching frequency	0.5 Hz	
Protective measures / safeguards		
Overload and short circuit protection	Yes	
Cable breakage monitoring	Yes	
Undervoltage monitoring	Yes	
Response threshold for cable breakage monitoring	Approx. 0.5 A	
Response threshold for undervoltage monitoring	24 VDC +0% / -4%	
Encoder interfaces [13]		
Quantity	1	
Type	EnDat 2.2 [14]	
Connections	9-pin DSUB socket	
Displays	UP/DN LEDs	
Electrical isolation		
Encoder - ACOPOSmulti	No	
Encoder monitoring	Yes	
Max. encoder cable length	100 m Depending on the cross section of the supply wires on the encoder cable [15]	
Encoder supply		
Output voltage	Typ. 12.5 V	
Load capability	350 mA	
Protective measures / safeguards		
Short circuit protection	Yes	
Overload protection	Yes	
Synchronous serial interface		
Signal transfer	RS485	
Data transfer rate	6.25 Mbit/s	
Max. power consumption per encoder interface	P_{SMC} [W] = 19 V * $I_{Encoder}$ [A] [16]	
Trigger inputs		
Quantity	2	
Wiring	Sink	
Electrical isolation		
Input - Inverter module	Yes	
Input - Input	No	
Input voltage		
Rated	24 VDC	
Maximum	30 VDC	
Switching threshold		
Low	<5 V	
High	>15 V	
Input current at rated voltage	Approx. 10 mA	
Switching delay		
Positive edge	52 μs ± 0.5 μs (digitally filtered)	
Negative edge	53 μs ± 0.5 μs (digitally filtered)	
Modulation compared to ground potential	Max. ±38 V	
Operating conditions		
Permitted mounting orientations		
Hanging vertically	Yes	
Lying horizontally	Yes	
Standing horizontally	No	
Installation at altitudes above sea level		
Rated	0 to 500 m	
Maximum [17]	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 [18]	
Environmental conditions		
Temperature		
Operation		
Rated	5 to 40°C	
Maximum [19]	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 [20]		
Width	106.5 mm	
Height	317 mm	
Depth		
Wall mounting	-	263 mm

Table 27: 8BVI0220HCSS.000-1, 8BVI0220HWSS.000-1 - Technical data

Product ID	8BVI0220HCSS.000-1	8BVI0220HWSS.000-1
Cold-plate	212 mm	-
Feed-through mounting	209 mm	-
Weight	Approx. 3.9 kg	Approx. 5.2 kg
Module width	2	

Table 27: 8BVI0220HCSS.000-1, 8BVI0220HWSS.000-1 - Technical data

1) SLOT 1 of the ACOPOSmulti module is occupied by the encoder interface.
2) Valid in the following conditions: Bus voltage 750 VDC, switching frequency 5 kHz, 40°C ambient temperature, installation altitudes <500 m above sea level, no derating dependent on cooling type.
3) I_M ... Current on the motor connection [A].
4) P_{SMC1} ... Max. power consumption P_{SMC} [W] of the SafeMC module in SLOT1 (see the section "Encoder interfaces")
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) B&R 8BCM motor cables must be used when cabling the motor connections.
6) Valid in the following conditions: DC bus voltage 750 VDC, minimum permissible coolant flow volume (3 l/min). The temperature specifications are based on 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 return temperature, at which a derating of the continuous current must be accounted for, 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 low return-temperatures.
9) B&R recommends operating the module at nominal switching frequency. Operating the module at a higher switching frequency for application-specific reasons reduces the continuous current and increases the CPU load.
10) The module's electrical output frequency (SCTRL_SPEED_ACT * MOTOR_POLEPAIRS) is monitored to protect against dual-use in accordance with EC 428/2009 | 3A225. If the electrical output frequency of the module exceeds the limit value of 600 Hz uninterrupted for more than 0.5 s, then the current motion is aborted and error 6060 is output (Power element: Limit speed exceeded).
11) 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.
12) The specified values 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 deactivated.
13) B&R 8BCF EnDat 2.2 cables must be used when cabling the encoder interfaces.
14) An EnDat 2.2 functional safety encoder is required when using ACOPOSmulti with SafeMC! With standard EnDat 2.2 encoders, only the timing of the functions STO, SBC and SS1 is monitored!
15) The maximum encoder cable length l_{max} can be calculated as follows (the maximum permissible encoder 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 [Ωmm²/m] (e.g. for copper: ρ = 0.0178)
16) $I_{Encoder}$ ... Max. power consumption of the connected encoder [A].
17) Continuous operation at altitudes ranging from 500 m to 4,000 m above sea level is possible (taking the continuous current reductions listed into consideration).
18) This value only applies with the factory settings (SLOT2 of the module is sealed by a slot cover shield plate). If SLOT2 on the module is not sealed, then the protection level is reduced to IP10. For this reason, we recommend only removing the slot cover shield plate if an ACOPOSmulti plug-in module is being used in SLOT2.
19) Continuous operation at ambient temperatures ranging from 40°C to max. 55°C is possible (taking the continuous current reductions listed into consideration), but results in a shorter lifespan.
20) The dimensions define the true device dimensions including the respective mounting plate. Make sure to leave additional space above and below the devices for mounting, connections and air circulation.
21) The module cannot supply the full continuous current at this switching frequency. This unusual value for the ambient temperature, at which a derating of the continuous current must be accounted for, ensures that the derating of the continuous current can be determined in the same manner as at other switching frequencies.

Wiring

For details, see section 3.3.4 "Wiring: Safe double-width inverter modules (single-axis modules)" on page 54
For general information, please see section 6 "Wiring" on page 105

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

General Information

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

Order data

Model number	Short description	Figure
	Cold plate or feed-through mounting	
8BVI0330HCSS.000-1	ACOPOSmulti inverter unit, 33 A, HV, cold plate or feed through mounting, SafeMC EnDat 2.2	
8BVI0330HWSS.000-1	ACOPOSmulti inverter unit, 33 A, HV, wall mounting, SafeMC EnDat 2.2	
	Required accessories	
	Terminal block sets	
8BZVI0440SS.000-1A	Screw clamp terminal block set for ACOPOSmulti modules 8BVI0440HxSS: 1x 8TB2108.2010-00, 1x 8TB2104.203L-00, 1x 8TB4104.204G-10	
	Optional accessories	
	Fan modules	
8BXF001.0000-00	ACOPOSmulti fan unit, replacement fan for ACOPOSmulti modules (8BxP/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/BISS	
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 plug-in 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 shielding components set: 1 clamp plate; 2 clamps D 4-13.5 mm; 4 screws	
8SCS007.0000-00	ACOPOSmulti shielding components set: 1 shielding plate 2fold 45°; 4 screws	
8SCS008.0000-00	ACOPOSmulti shielding components set: 1 shielding plate 2fold type 0; 1 hose clamp, W 9 mm, D 23-35 mm	
8SCS010.0000-00	ACOPOSmulti shielding components set: 1 ACOPOSmulti shielding plate SK14-20; 1 shielding clamp SK20	
	Terminal blocks	
8TB2104.203L-00	Screw clamp terminal block 4-pin, single-row, pitch: 5.08 mm, labeling 3: T- T+ B- B+, coding L: 1010	
8TB2108.2010-00	Screw clamp terminal block 8-pin, single-row, pitch: 5.08 mm, labeling 1: numbered consecutively	
8TB4104.204G-10	Screw clamp terminal block 4-pin, single-row, pitch: 10.16 mm, labeling 4: PE W V U, coding G: 0110	

Table 28: 8BVI0330HCSS.000-1, 8BVI0330HWSS.000-1 - Order data

Technical data

Product ID	8BVI0330HCSS.000-1	8BVI0330HWSS.000-1
General information		
B&R ID code	0xADC3	0xADC4
Cooling and mounting method	Cold plate or feed-through mounting	Wall mounting
Slots for plug-in modules	2 [1]	
Certification		
c-UL-us	In preparation	
DC bus connection		
Voltage		
Rated	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	

Table 29: 8BVI0330HCSS.000-1, 8BVI0330HWSS.000-1 - Technical data

Product ID	8BVI0330HCSS.000-1	8BVI0330HWSS.000-1
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)]	
Design	ACOPOSmulti backplane	
24 VDC output		
Quantity	2	
Output voltage		
DC bus voltage (U_{DC}): 260 ... 315 VDC	25 VDC * (U_{DC}/315)	
DC bus voltage (U_{DC}): 315 ... 800 VDC	24 VDC ±6%	
Fuse protection	250 mA (slow-blow) electronic, automatic reset	
Motor connection [5)]		
Quantity	1	
Continuous power per motor connection [2)]	24 kW	
Continuous current per motor connection [2)]	33 A_{eff}	
Reduction of continuous current depending on the switching frequency [6)]		
Switching frequency 5 kHz	0.8 A/K (from 45 °C) [7)]	1.57 A/K (from 40 °C) [7)]
Switching frequency 10 kHz	0.62 A/K (from 6 °C)	0.5 A/K (from -10 °C) [21)]
Switching frequency 20 kHz	0.32 A/K (from -82 °C) [8)]	0.36 A/K (from -77 °C) [21)]
Reduction of continuous current depending on altitude		
Starting at 500 m above sea level	3.3 A_{eff} per 1000 m	
Peak current	83 A_{eff}	
Rated switching frequency	5 kHz	
Possible switching frequencies [9)]	5/10/20 kHz	
Electrical stress of the connected motor in accordance with IEC TS 60034-25	Limit value curve A	
Protective measures / safeguards		
Overload protection	Yes	
Short circuit and ground fault	Yes	
Max. output frequency	600 Hz [10)]	
Design		
U, V, W, PE	Plug	
Shield connection	Yes	
Terminal connection cross section		
Flexible and fine wire lines		
With wire tip 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 the 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 [11)]	24 VDC +5.8% / -0% [12)]	
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 / safeguards		
Overload and short circuit protection	Yes	
Cable breakage monitoring	Yes	
Undervoltage monitoring	Yes	
Response threshold for cable breakage monitoring	Approx. 0.5 A	
Response threshold for undervoltage monitoring	24 VDC +0% / -4%	
Encoder interfaces [13)]		
Quantity	1	
Type	EnDat 2.2 [14)]	
Connections	9-pin DSUB socket	
Displays	UP/DN LEDs	
Electrical isolation		
Encoder - ACOPOSmulti	No	
Encoder monitoring	Yes	
Max. encoder cable length	100 m Depending on the cross section of the supply wires on the encoder cable [15)]	
Encoder supply		

Table 29: 8BVI0330HCSS.000-1, 8BVI0330HWSS.000-1 - Technical data

Product ID	8BVI0330HCSS.000-1	8BVI0330HWSS.000-1
Output voltage	Typ. 12.5 V	
Load capability	350 mA	
Protective measures / safeguards		
Short circuit protection	Yes	
Overload protection	Yes	
Synchronous serial interface		
Signal transfer	RS485	
Data transfer rate	6.25 Mbit/s	
Max. power consumption per encoder interface	P_{SMC} [W] = 19 V * $I_{Encoder}$ [A] 16)	
Trigger inputs		
Quantity	2	
Wiring	Sink	
Electrical isolation		
Input - Inverter module	Yes	
Input - Input	No	
Input voltage		
Rated	24 VDC	
Maximum	30 VDC	
Switching threshold		
Low	<5 V	
High	>15 V	
Input current at rated voltage	Approx. 10 mA	
Switching delay		
Positive edge	52 µs ± 0.5 µs (digitally filtered)	
Negative edge	53 µs ± 0.5 µs (digitally filtered)	
Modulation compared to ground potential	Max. ±38 V	
Operating conditions		
Permitted mounting orientations		
Hanging vertically	Yes	
Lying horizontally	Yes	
Standing horizontally	No	
Installation at altitudes above sea level		
Rated	0 to 500 m	
Maximum 17)	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 18)	
Environmental conditions		
Temperature		
Operation		
Rated	5 to 40°C	
Maximum 19)	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 20)		
Width	106.5 mm	
Height	317 mm	
Depth		
Wall mounting	-	263 mm
Cold-plate	212 mm	-
Feed-through mounting	209 mm	-
Weight	Approx. 4.3 kg	Approx. 5.4 kg
Module width	2	

Table 29: 8BVI0330HCSS.000-1, 8BVI0330HWSS.000-1 - Technical data

1) SLOT 1 of the ACOPOSmulti module is occupied by the encoder interface.
2) Valid in the following conditions: Bus voltage 750 VDC, switching frequency 5 kHz, 40°C ambient temperature, installation altitudes <500 m above sea level, no derating dependent on cooling type.
3) I_M ... Current on the motor connection [A].
4) P_{SMC1} ... Max. power consumption P_{SMC} [W] of the SafeMC module in SLOT1 (see the section "Encoder interfaces")
   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) B&R 8BCM motor cables must be used when cabling the motor connections.
6) Valid in the following conditions: DC bus voltage 750 VDC, minimum permissible coolant flow volume (3 l/min). The temperature specifications are based on 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 return temperature, at which a derating of the continuous current must be accounted for, 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 low return-temperatures.
9) B&R recommends operating the module at nominal switching frequency. Operating the module at a higher switching frequency for application-specific reasons reduces the continuous current and increases the CPU load.
10) The module's electrical output frequency (SCTRL_SPEED_ACT * MOTOR_POLEPAIRS) is monitored to protect against dual-use in accordance with EC 428/2009 | 3A225. If the electrical output frequency of the module exceeds the limit value of 600 Hz uninterrupted for more than 0.5 s, then the current motion is aborted and error 6060 is output (Power element: Limit speed exceeded).
11) 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.
12) The specified values 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 deactivated.
13) B&R 8BCF EnDat 2.2 cables must be used when cabling the encoder interfaces.
14) An EnDat 2.2 functional safety encoder is required when using ACOPOSmulti with SafeMC! With standard EnDat 2.2 encoders, only the timing of the functions STO, SBC and SS1 is monitored!
15) The maximum encoder cable length l_{max} can be calculated as follows (the maximum permissible encoder 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 [Ωmm²/m] (e.g. for copper: ρ = 0.0178)
16) $I_{Encoder}$ ... Max. power consumption of the connected encoder [A].
17) Continuous operation at altitudes ranging from 500 m to 4,000 m above sea level is possible (taking the continuous current reductions listed into consideration).
18) This value only applies with the factory settings (SLOT2 of the module is sealed by a slot cover shield plate). If SLOT2 on the module is not sealed, then the protection level is reduced to IP10. For this reason, we recommend only removing the slot cover shield plate if an ACOPOSmulti plug-in module is being used in SLOT2.
19) Continuous operation at ambient temperatures ranging from 40°C to max. 55°C is possible (taking the continuous current reductions listed into consideration), but results in a shorter lifespan.
20) The dimensions define the true device dimensions including the respective mounting plate. Make sure to leave additional space above and below the devices for mounting, connections and air circulation.
21) The module cannot supply the full continuous current at this switching frequency. This unusual value for the ambient temperature, at which a derating of the continuous current must be accounted for, ensures that the derating of the continuous current can be determined in the same manner as at other switching frequencies.

Wiring

For details, see section 3.3.4 "Wiring: Safe double-width inverter modules (single-axis modules)" on page 54

For general information, please see section 6 "Wiring" on page 105

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

General Information

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

Order data

Model number	Short description	Figure
	Cold plate or feed-through mounting	
8BVI0440HCSS.000-1	ACOPOSmulti inverter unit, 44 A, HV, cold plate or feed through mounting, SafeMC EnDat 2.2	
8BVI0440HWSS.000-1	ACOPOSmulti inverter unit, 44 A, HV, wall mounting, SafeMC EnDat 2.2	
	Required accessories	
	Terminal block sets	
8BZVI0440SS.000-1A	Screw clamp terminal block set for ACOPOSmulti modules 8BVI0440HxSS: 1x 8TB2108.2010-00, 1x 8TB2104.203L-00, 1x 8TB4104.204G-10	
	Optional accessories	
	Fan modules	
8BXF001.0000-00	ACOPOSmulti fan unit, replacement fan for ACOPOSmulti modules (8BxP/8B0C/8BVI/8BVE/8B0K)	
	Plug-in modules	
8BAC0120.000-1	ACOPOSmulti plug-in module, EnDat 2.1 interface	

Table 30: 8BVI0440HCSS.000-1, 8BVI0440HWSS.000-1 - Order data

Model number	Short description	Figure
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/BISS	
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 plug-in 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 shielding components set: 1 clamp plate; 2 clamps D 4-13.5 mm; 4 screws	
8SCS007.0000-00	ACOPOSmulti shielding components set: 1 shielding plate 2fold 45°; 4 screws	
8SCS008.0000-00	ACOPOSmulti shielding components set: 1 shielding plate 2fold type 0; 1 hose clamp, W 9 mm, D 23-35 mm	
8SCS010.0000-00	ACOPOSmulti shielding components set: 1 ACOPOSmulti shielding plate SK14-20; 1 shielding clamp SK20	
	Terminal blocks	
8TB2104.203L-00	Screw clamp terminal block 4-pin, single-row, pitch: 5.08 mm, labeling 3: T- T+ B- B+, coding L: 1010	
8TB2108.2010-00	Screw clamp terminal block 8-pin, single-row, pitch: 5.08 mm, labeling 1: numbered consecutively	
8TB4104.204G-10	Screw clamp terminal block 4-pin, single-row, pitch: 10.16 mm, labeling 4: PE W V U, coding G: 0110	

Table 30: 8BVI0440HCSS.000-1, 8BVI0440HWSS.000-1 - Order data

Technical data

Product ID	8BVI0440HCSS.000-1	8BVI0440HWSS.000-1
General information		
B&R ID code	0xAA1F	0xAA20
Cooling and mounting method	Cold plate or feed-through mounting	Wall mounting
Slots for plug-in modules	2 [1)]	
Certification		
c-UL-us	Yes	
DC bus connection		
Voltage		
Rated	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)]	
Design	ACOPOSmulti backplane	
24 VDC output		
Quantity	2	
Output voltage		
DC bus voltage (U_{DC}): 260 ... 315 VDC	25 VDC * (U_{DC}/315)	
DC bus voltage (U_{DC}): 315 ... 800 VDC	24 VDC ±6%	
Fuse protection	250 mA (slow-blow) electronic, automatic reset	
Motor connection [5)]		
Quantity	1	
Continuous power per motor connection [2)]	32 kW	
Continuous current per motor connection [2)]	44 A_{eff}	

Table 31: 8BVI0440HCSS.000-1, 8BVI0440HWSS.000-1 - Technical data

Product ID	8BVI0440HCSS.000-1	8BVI0440HWSS.000-1
Reduction of continuous current depending on the switching frequency		
Switching frequency 5 kHz	0.8 A/K (from 45 °C) [6)]	1.57 A/K (from 40 °C) [6)]
Switching frequency 10 kHz	0.62 A/K (from 6 °C) [7)]	0.5 A/K (from -10 °C) [20)]
Switching frequency 20 kHz	0.32 A/K (from -82 °C) [7)]	0.36 A/K (from -77 °C) [20)]
Reduction of continuous current depending on altitude		
Starting at 500 m above sea level	4.4 A_{eff} per 1000 m	
Peak current	88 A_{eff}	
Rated switching frequency	5 kHz	
Possible switching frequencies [8)]	5/10/20 kHz	
Electrical stress of the connected motor in accordance with IEC TS 60034-25	Limit value curve A	
Protective measures / safeguards		
Overload protection	Yes	
Short circuit and ground fault	Yes	
Max. output frequency	600 Hz [9)]	
Design		
U, V, W, PE	Plug	
Shield connection	Yes	
Terminal connection cross section		
Flexible and fine wire lines		
With wire tip 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 the 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 [10)]	24 VDC +5.8% / -0% [11)]	
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 / safeguards		
Overload and short circuit protection	Yes	
Cable breakage monitoring	Yes	
Undervoltage monitoring	Yes	
Response threshold for cable breakage monitoring	Approx. 0.5 A	
Response threshold for undervoltage monitoring	24 VDC +0% / -4%	
Encoder interfaces [12)]		
Quantity	1	
Type	EnDat 2.2 [13)]	
Connections	9-pin DSUB socket	
Displays	UP/DN LEDs	
Electrical isolation		
Encoder - ACOPOSmulti	No	
Encoder monitoring	Yes	
Max. encoder cable length	100 m Depending on the cross section of the supply wires on the encoder cable [14)]	
Encoder supply		
Output voltage	Typ. 12.5 V	
Load capability	350 mA	
Protective measures / safeguards		
Short circuit protection	Yes	
Overload protection	Yes	
Synchronous serial interface		
Signal transfer	RS485	
Data transfer rate	6.25 Mbit/s	
Max. power consumption per encoder interface	P_{SMC} [W] = 19 V * $I_{Encoder}$ [A] [15)]	
Trigger inputs		
Quantity	2	
Wiring	Sink	
Electrical isolation		
Input - Inverter module	Yes	
Input - Input	No	
Input voltage		
Rated	24 VDC	

Table 31: 8BVI0440HCSS.000-1, 8BVI0440HWSS.000-1 - Technical data

Product ID	8BVI0440HCSS.000-1	8BVI0440HWSS.000-1
Maximum	30 VDC	
Switching threshold Low High	 <5 V >15 V	
Input current at rated voltage	Approx. 10 mA	
Switching delay Positive edge Negative edge	 52 µs ± 0.5 µs (digitally filtered) 53 µs ± 0.5 µs (digitally filtered)	
Modulation compared to ground potential	Max. ±38 V	
Operating conditions		
Permitted mounting orientations Hanging vertically Lying horizontally Standing horizontally	 Yes Yes No	
Installation at altitudes above sea level Rated Maximum [16]	 0 to 500 m 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 [17]	
Environmental conditions		
Temperature Operation Rated Maximum [18] Storage Transport	 5 to 40°C 55°C -25 to 55°C -25 to 70°C	
Relative humidity Operation Storage	 5 to 85% 5 to 95%	
Transport	Max. 95% at 40°C	Max. 95% at +40°C
Mechanical characteristics		
Dimensions [19] Width Height Depth	 106.5 mm 317 mm	
Wall mounting	-	263 mm
Cold-plate	212 mm	-
Feed-through mounting	209 mm	-
Weight	Approx. 4.3 kg	Approx. 5.4 kg
Module width	2	

Table 31: 8BVI0440HCSS.000-1, 8BVI0440HWSS.000-1 - Technical data

1) SLOT 1 of the ACOPOSmulti module is occupied by the encoder interface.
2) Valid in the following conditions: Bus voltage 750 VDC, switching frequency 5 kHz, 40°C ambient temperature, installation altitudes <500 m above sea level, no derating dependent on cooling type.
3) I_M ... Current on the motor connection [A].
4) P_{SMC1} ... Max. power consumption P_{SMC} [W] of the SafeMC module in SLOT1 (see the section "Encoder interfaces")
   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) B&R 8BCM motor cables must be used when cabling the motor connections.
6) Value for the nominal switching frequency.
7) The module cannot supply the full continuous current at this switching frequency. This unusual value for the return temperature, at which a derating of the continuous current must be accounted for, 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 low return-temperatures.
8) B&R recommends operating the module at nominal switching frequency. Operating the module at a higher switching frequency for application-specific reasons reduces the continuous current and increases the CPU load.
9) The module's electrical output frequency (SCTRL_SPEED_ACT * MOTOR_POLEPAIRS) is monitored to protect against dual-use in accordance with EC 428/2009 | 3A225. If the electrical output frequency of the module exceeds the limit value of 600 Hz uninterrupted for more than 0.5 s, then the current motion is aborted and error 6060 is output (Power element: Limit speed exceeded).
10) 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.
11) The specified values 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 deactivated.
12) B&R 8BCF EnDat 2.2 cables must be used when cabling the encoder interfaces.
13) An EnDat 2.2 functional safety encoder is required when using ACOPOSmulti with SafeMC! With standard EnDat 2.2 encoders, only the timing of the functions STO, SBC and SS1 is monitored!
14) The maximum encoder cable length l_{max} can be calculated as follows (the maximum permissible encoder 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 [Ωmm²/m] (e.g. for copper: ρ = 0.0178)

15) $I_{Encoder}$ ... Max. power consumption of the connected encoder [A].
16) Continuous operation at altitudes ranging from 500 m to 4,000 m above sea level is possible (taking the continuous current reductions listed into consideration).
17) This value only applies with the factory settings (SLOT2 of the module is sealed by a slot cover shield plate). If SLOT2 on the module is not sealed, then the protection level is reduced to IP10. For this reason, we recommend only removing the slot cover shield plate if an ACOPOSmulti plug-in module is being used in SLOT2.
18) Continuous operation at ambient temperatures ranging from 40°C to max. 55°C is possible (taking the continuous current reductions listed into consideration), but results in a shorter lifespan.
19) The dimensions define the true device dimensions including the respective mounting plate. Make sure to leave additional space above and below the devices for mounting, connections and air circulation.
20) The module cannot supply the full continuous current at this switching frequency. This unusual value for the ambient temperature, at which a derating of the continuous current must be accounted for, ensures that the derating of the continuous current can be determined in the same manner as at other switching frequencies.

Wiring

For details, see section 3.3.4 "Wiring: Safe double-width inverter modules (single-axis modules)" on page 54

For general information, please see section 6 "Wiring" on page 105

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

Overview of pin assignments

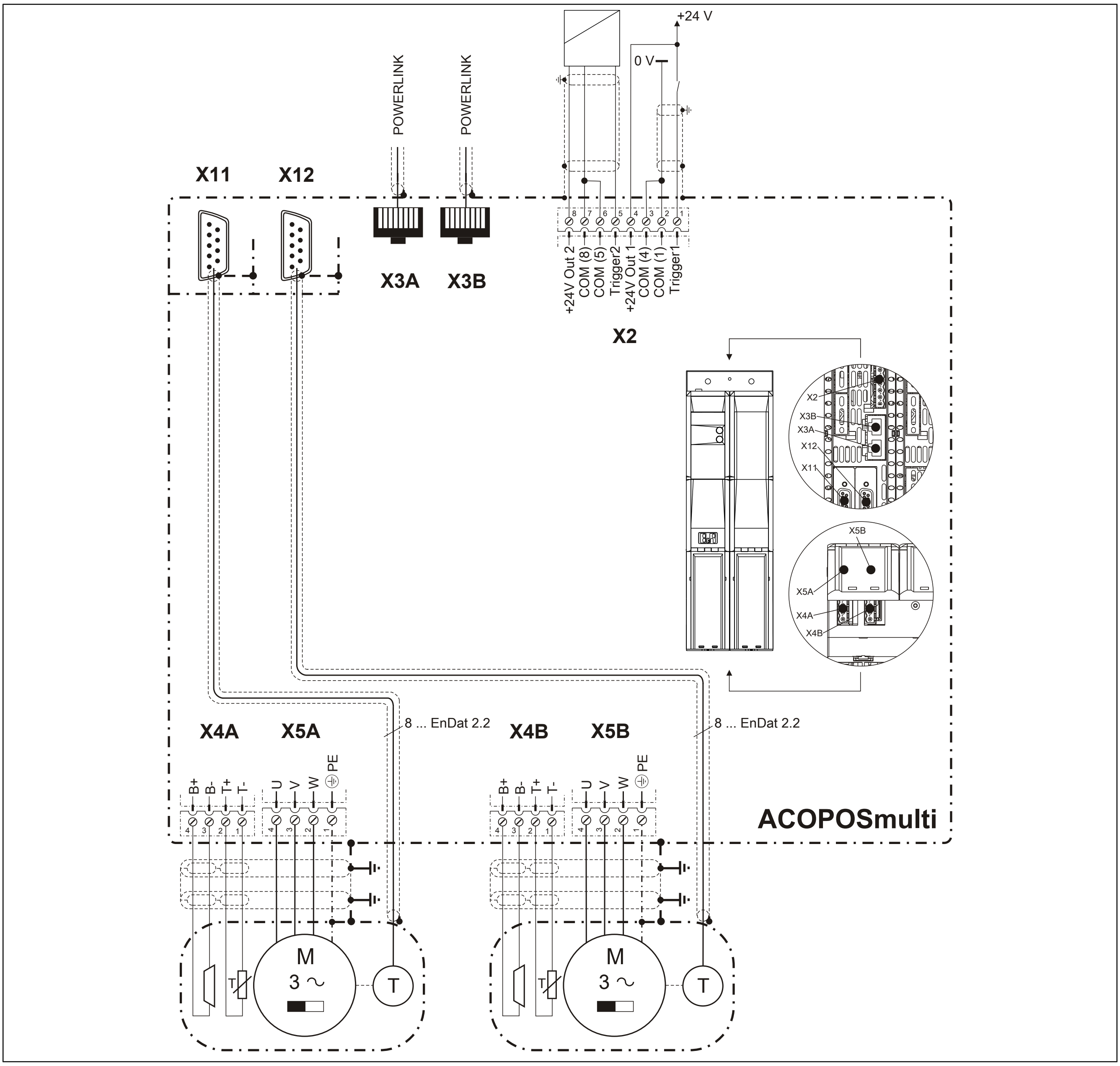


Figure 7: Overview of pin assignments

Pin assignments - X2 plug

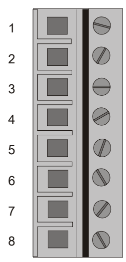
X2	Pin	Name	Function
	1	Trigger 1	Trigger 1
	2	COM (1)	Trigger 1 0 V
	3	COM (2)	+24 V output 1 0 V
	4	+24V Out 1	+24 V output 1
	5	Trigger 2	Trigger 2
	6	COM (5)	Trigger 2 0 V
	7	COM (8)	+24 V output 2 0 V
	8	+24V Out 2	+24 V output 2

Table 32: Pin assignments - X2 plug

Pin assignments - X3A, X3B plugs

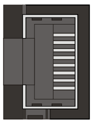
X3A, X3B	Pin	Bezeichnung	Funktion
	1	RXD	Receive Signal
	2	RXD\	Receive Signal inverted
	3	TXD	Transmit Signal
	4	Shield	Shield
	5	Shield	Shield
	6	TXD\	Transmit Signal inverted
	7	Shield	Shield
	8	Shield	Shield

Table 33: Pin assignments - X3A, X3B plugs

Pin assignments X4A plug

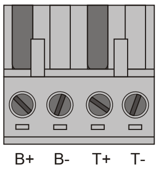
X4A	Name	Function
	T-	Axis 1: Temperature sensor -
	T+	Axis 1: Temperature sensor +
	B- [1)]	Axis 1: Brake -
	B+ [1)]	Axis 1: Brake +

Table 34: Pin assignments - X4A plug

1) The 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 24V. (i.e. safe pulse disabling is activated) However, the brake always remains on because of the short-circuit to 24 V!

This can lead to dangerous situations because the motor holding brake is not able to stop the spin-out movement!

Appropriate wiring measures must be implemented to ensure that the SBC output B+ is not shorted to 24V!

Danger!

The SBC output

- **must not be wired to multiple modules!**
- **must not be wired as open emitter!**
- **must not be wired as open collector!**

Information:

The transistors for the SBC output stage are tested cyclically. When output channels are activated , this test causes 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 isolated circuits. Therefore, these connections are only allowed to be connected to devices or components with at least safe 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!

Pin assignments - X5A plug

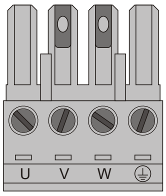
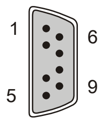
X5A	Name	Function
	⏚	Axis 1: Protective ground conductor
	W	Axis 1: Motor connection W
	V	Axis 1: Motor connection V
	U	Axis 1: Motor connection U

Table 35: Pin assignments - X5A plug

Warning!

B&R 8BCM motor cables must be used when cabling the motor connections.

Pin assignments - SafeMC module

Image	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\	Inverted data input
		9	T\	Inverted clock output

Information:

The SafeMC module must only be used together with 8BCF EnDat 2.2 cables!

Note:

The SafeMC modules cannot be exchanged! The SafeMC modules together with the 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

General Information

- Clearly structured, straightforward implementation via network-based safety technology
- Modular expandability through virtual wiring
- Immediate triggering of safety function thanks to short cycle times
- Easy implementation thanks to transparent control and status information, also in the functional application
- Compact construction
- Complete functionality of safety functions even in two-axis modules

Order data

Model number	Short description	Figure
	Cold plate or feed-through mounting	
8BVI0014HCDS.000-1	ACOPOSmulti inverter unit, 1.9 A, HV, cold plate or feed through mounting, 2 axes, SafeMC	
8BVI0014HWDS.000-1	ACOPOSmulti inverter unit, 1.9 A, HV, wall mounting, 2 axes, SafeMC	
	Required accessories	
	Terminal block sets	
8BZVI0055DS.000-1A	Screw clamp terminal block set for ACOPOSmulti modules 8BVI00xxHxDS: 1x 8TB2108.2010-00, 1x 8TB2104.203L-00, 1x 8TB2104.203F-00, 1x 8TB3104.204G-00, 1x 8TB3104.204K-00	
	Optional accessories	
	Fan modules	
8BXF001.0000-00	ACOPOSmulti fan unit, replacement fan for ACOPOSmulti modules (8BxP/8B0C/8BVI/8BVE/8B0K)	
	Shield component sets	
8SCS000.0000-00	ACOPOSmulti shielding components set: 1 shielding plate 1fold type 0; 1 hose clamp, W 9 mm, D 12-22 mm	
8SCS002.0000-00	ACOPOSmulti shielding components set: 1 clamp plate; 2 clamps D 4-13.5 mm; 4 screws	
8SCS009.0000-00	ACOPOSmulti shielding components set: 1 ACOPOSmulti shielding plate SK8-14; 1 shielding clamp SK14	
	Terminal blocks	
8TB2104.203F-00	Screw clamp terminal block 4-pin, single-row, pitch: 5.08 mm, labeling 3: T- T+ B- B+, coding F: 0101	
8TB2104.203L-00	Screw clamp terminal block 4-pin, single-row, pitch: 5.08 mm, labeling 3: T- T+ B- B+, coding L: 1010	
8TB2108.2010-00	Screw clamp terminal block 8-pin, single-row, pitch: 5.08 mm, labeling 1: numbered consecutively	
8TB3104.204G-00	Screw clamp terminal block 4-pin, single-row, pitch: 7.62 mm, labeling 4: PE W V U, coding G: 0110	
8TB3104.204K-00	Screw clamp terminal block 4-pin, single-row, pitch: 7.62 mm, labeling 4: PE W V U, coding K: 1001	

Table 36: 8BVI0014HCDS.000-1, 8BVI0014HWDS.000-1 - Order data

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 c-UL-us	Yes	
DC bus connection		
Voltage Rated	750 VDC	
Continuous power consumption 2)	2.91 kW	
Power loss depending on the switching frequency 3) Switching frequency 5 kHz Switching frequency 10 kHz Switching frequency 20 kHz	 $[1.2*I_M^2+2.62*I_M+100]$ W $[2.56*I_M^2+2.8*I_M+200]$ W $[6*I_M^2-9.4*I_M+430]$ W	
DC bus capacitance	165 µF	
Design	ACOPOSmulti backplane	
24 VDC supply		

Table 37: 8BVI0014HCDS.000-1, 8BVI0014HWDS.000-1 - Technical data

Product ID	8BVI0014HCDS.000-1	8BVI0014HWDS.000-1
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 ... 315 VDC DC bus voltage (U_{DC}): 315 ... 800 VDC	 25 VDC * (U_{DC}/315) 24 VDC ±6%	
Fuse 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 Switching frequency 10 kHz Switching frequency 20 kHz	 No reduction [7] No reduction 0.13 A/K (from 45 °C)	 0.11 A/K (from 15 °C)
Reduction of continuous current depending on altitude Starting at 500 m above sea level	 0.19 A_{eff} per 1000 m	
Peak current	4.7 A_{eff}	
Rated switching frequency	5 kHz	
Possible switching frequencies [8]	5/10/20 kHz	
Electrical stress of the connected motor in accordance with IEC TS 60034-25	Limit value curve A	
Protective measures / safeguards Overload protection Short circuit and ground fault	 Yes Yes	
Max. output frequency	600 Hz [9]	
Design U, V, W, PE Shield connection	 Plug Yes	
Terminal connection cross section Flexible and fine wire lines With wire tip sleeves Approbation data UL/C-UL-US CSA	 0.25 to 4 mm² 30 to 10 28 to 10	
Terminal cable cross-section dimension of the shield connection	12 to 22 mm	
Max. motor line length depending on the switching frequency Switching frequency 5 kHz Switching frequency 10 kHz Switching frequency 20 kHz	 25 m 25 m 10 m	
Motor holding brake connection		
Quantity	2	
Output voltage [10]	24 VDC +5.8% / -0% [11]	
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 / safeguards Overload and short circuit protection Cable breakage monitoring Undervoltage monitoring	 Yes Yes Yes	
Response threshold for cable breakage monitoring	Approx. 0.25 A	
Response threshold for undervoltage monitoring	24 VDC +0% / -4%	
Encoder interfaces [12]		
Quantity	2	
Type	EnDat 2.2 [13]	
Connections	9-pin DSUB socket	
Displays	UP/DN LEDs	
Electrical isolation Encoder - ACOPOSmulti	 No	
Encoder monitoring	Yes	
Max. encoder cable length	100 m Depending on the cross section of the supply wires on the encoder cable [14]	
Encoder supply Output voltage Load capability	 Typ. 12.5 V 350 mA	

Table 37: 8BVI0014HCDS.000-1, 8BVI0014HWDS.000-1 - Technical data

Product ID	8BVI0014HCDS.000-1	8BVI0014HWDS.000-1
Protective measures / safeguards		
Short circuit protection	Yes	
Overload protection	Yes	
Synchronous serial interface		
Signal transfer	RS485	
Data transfer rate	6.25 Mbit/s	
Max. power consumption per encoder interface	P_{SMC} [W] = 19 V * $I_{Encoder}$ [A] 15)	
Trigger inputs		
Quantity	2	
Wiring	Sink	
Electrical isolation		
Input - Inverter module	Yes	
Input - Input	Yes	
Input voltage		
Rated	24 VDC	
Maximum	30 VDC	
Switching threshold		
Low	<5 V	
High	>15 V	
Input current at rated voltage	Approx. 10 mA	
Switching delay		
Positive edge	52 µs ± 0.5 µs (digitally filtered)	
Negative edge	53 µs ± 0.5 µs (digitally filtered)	
Modulation compared to ground potential	Max. ±38 V	
Operating conditions		
Permitted mounting orientations		
Hanging vertically	Yes	
Lying horizontally	Yes	
Standing horizontally	No	
Installation at altitudes above sea level		
Rated	0 to 500 m	
Maximum 16)	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		
Rated	5 to 40°C	
Maximum 17)	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 18)		
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 37: 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: Bus voltage 750 VDC, switching frequency 5 kHz, 40°C ambient temperature, installation altitudes <500 m above sea level, no derating dependent on 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 SafeMC module in SLOT1 (see the section "Encoder interfaces")
P_{SMC2} ... Max. power consumption P_{SMC} [W] of the SafeMC module in SLOT2 (see the section "Encoder interfaces")
$P_{24\ V\ Out}$ ... 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) B&R 8BCM motor cables must be used when cabling the motor connections.
6) Valid in the following conditions: DC bus voltage 750 VDC, minimum permissible coolant flow volume (3 l/min). The temperature specifications are based on the return temperature of the cold-plate mounting plate.
7) Value for the nominal switching frequency.
8) B&R recommends operating the module at 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 double-axis modules, the increased CPU load causes a reduction of the functional range in the drive; if this is not taken into consideration, then it can cause the computing time to be exceeded in extreme cases.

9) The module's electrical output frequency (SCTRL_SPEED_ACT * MOTOR_POLEPAIRS) is monitored to protect against dual-use in accordance with EC 428/2009 | 3A225. If the electrical output frequency of the module exceeds the limit value of 600 Hz uninterrupted for more than 0.5 s, then the current motion is aborted and error 6060 is output (Power element: Limit speed exceeded).
10) 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.
11) The specified values 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 deactivated.
12) B&R 8BCF EnDat 2.2 cables must be used when cabling the encoder interfaces.
13) An EnDat 2.2 functional safety encoder is required when using ACOPOSmulti with SafeMC! With standard EnDat 2.2 encoders, only the timing of the functions STO, SBC and SS1 is monitored!
14) The maximum encoder cable length l_{max} can be calculated as follows (the maximum permissible encoder 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 [Ωmm²/m] (e.g. for copper: ρ = 0.0178)
15) $I_{Encoder}$ ... Max. power consumption of the connected encoder [A].
16) Continuous operation at altitudes ranging from 500 m to 4,000 m above sea level is possible (taking the continuous current reductions listed into consideration).
17) Continuous operation at ambient temperatures ranging from 40°C to max. 55°C is possible (taking the continuous current reductions listed into consideration), but results in a shorter lifespan.
18) The dimensions define the true device dimensions including the respective mounting plate. Make sure to leave additional space above and below the devices for mounting, connections and air circulation.

Wiring

For details, see section 3.4.4 "Wiring: Safe single-width inverter modules (dual-axis modules)" on page 67

For general information, please see section 6 "Wiring" on page 105

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

General Information

- Clearly structured, straightforward implementation via network-based safety technology
- Modular expandability through virtual wiring
- Immediate triggering of safety function thanks to short cycle times
- Easy implementation thanks to transparent control and status information, also in the functional application
- Compact construction
- Complete functionality of safety functions even in two-axis modules

Order data

Model number	Short description	Figure
	Cold plate or feed-through mounting	
8BVI0028HCDS.000-1	ACOPOSmulti inverter unit, 3.8 A, HV, cold plate or feed throuch mounting, 2 axes, SafeMC	
8BVI0028HWDS.000-1	ACOPOSmulti inverter unit, 3.8 A, HV, wall mounting, 2 axes, SafeMC	
	Required accessories	
	Terminal block sets	
8BZVI0055DS.000-1A	Screw clamp terminal block set for ACOPOSmulti modules 8BVI00xxHxDS: 1x 8TB2108.2010-00, 1x 8TB2104.203L-00, 1x 8TB2104.203F-00, 1x 8TB3104.204G-00, 1x 8TB3104.204K-00	
	Optional accessories	
	Fan modules	
8BXF001.0000-00	ACOPOSmulti fan unit, replacement fan for ACOPOSmulti modules (8BxP/8B0C/8BVI/8BVE/8B0K)	
	Shield component sets	
8SCS000.0000-00	ACOPOSmulti shielding components set: 1 shielding plate 1fold type 0; 1 hose clamp, W 9 mm, D 12-22 mm	
8SCS002.0000-00	ACOPOSmulti shielding components set: 1 clamp plate; 2 clamps D 4-13.5 mm; 4 screws	
8SCS009.0000-00	ACOPOSmulti shielding components set: 1 ACOPOSmulti shielding plate SK8-14; 1 shielding clamp SK14	
	Terminal blocks	
8TB2104.203F-00	Screw clamp terminal block 4-pin, single-row, pitch: 5.08 mm, labeling 3: T- T+ B- B+, coding F: 0101	
8TB2104.203L-00	Screw clamp terminal block 4-pin, single-row, pitch: 5.08 mm, labeling 3: T- T+ B- B+, coding L: 1010	

Table 38: 8BVI0028HCDS.000-1, 8BVI0028HWDS.000-1 - Order data

Model number	Short description	Figure
8TB2108.2010-00	Screw clamp terminal block 8-pin, single-row, pitch: 5.08 mm, labeling 1: numbered consecutively	
8TB3104.204G-00	Screw clamp terminal block 4-pin, single-row, pitch: 7.62 mm, labeling 4: PE W V U, coding G: 0110	
8TB3104.204K-00	Screw clamp terminal block 4-pin, single-row, pitch: 7.62 mm, labeling 4: PE W V U, coding K: 1001	

Table 38: 8BVI0028HCDS.000-1, 8BVI0028HWDS.000-1 - Order data

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		
c-UL-us	Yes	
DC bus connection		
Voltage		
Rated	750 VDC	
Continuous power consumption [2]	5.73 kW	
Power loss depending on the switching frequency [3]		
Switching frequency 5 kHz	$[1.2 \cdot I_M^2 + 2.62 \cdot I_M + 100]$ W	
Switching frequency 10 kHz	$[2.56 \cdot I_M^2 + 2.8 \cdot I_M + 200]$ W	
Switching frequency 20 kHz	$[6 \cdot I_M^2 - 9.4 \cdot I_M + 430]$ 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 ... 315 VDC	25 VDC * (U_{DC}/315)	
DC bus voltage (U_{DC}): 315 ... 800 VDC	24 VDC ±6%	
Fuse 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	0.6 A/K (from 57 °C)	No reduction
Switching frequency 20 kHz	0.12 A/K (from 34 °C)	0.12 A/K (from 13 °C)
Reduction of continuous current depending on altitude		
Starting at 500 m above sea level	0.38 A_{eff} per 1000 m	
Peak current	9.5 A_{eff}	
Rated switching frequency	5 kHz	
Possible switching frequencies [8]	5/10/20 kHz	
Electrical stress of the connected motor in accordance with IEC TS 60034-25	Limit value curve A	
Protective measures / safeguards		
Overload protection	Yes	
Short circuit and ground fault	Yes	
Max. output frequency	600 Hz [9]	
Design		
U, V, W, PE	Plug	
Shield connection	Yes	
Terminal connection cross section		
Flexible and fine wire lines		
With wire tip 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 the shield connection	12 to 22 mm	
Max. motor line length depending on the switching frequency		

Table 39: 8BVI0028HCDS.000-1, 8BVI0028HWDS.000-1 - Technical data

Product ID	8BVI0028HCDS.000-1	8BVI0028HWDS.000-1
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 [10]	24 VDC +5.8% / -0% [11]	
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 / safeguards		
Overload and short circuit protection	Yes	
Cable breakage monitoring	Yes	
Undervoltage monitoring	Yes	
Response threshold for cable breakage monitoring	Approx. 0.25 A	
Response threshold for undervoltage monitoring	24 VDC +0% / -4%	
Encoder interfaces [12]		
Quantity	2	
Type	EnDat 2.2 [13]	
Connections	9-pin DSUB socket	
Displays	UP/DN LEDs	
Electrical isolation		
Encoder - ACOPOSmulti	No	
Encoder monitoring	Yes	
Max. encoder cable length	100 m Depending on the cross section of the supply wires on the encoder cable [14]	
Encoder supply		
Output voltage	Typ. 12.5 V	
Load capability	350 mA	
Protective measures / safeguards		
Short circuit protection	Yes	
Overload protection	Yes	
Synchronous serial interface		
Signal transfer	RS485	
Data transfer rate	6.25 Mbit/s	
Max. power consumption per encoder interface	P_{SMC} [W] = 19 V * $I_{Encoder}$ [A] [15]	
Trigger inputs		
Quantity	2	
Wiring	Sink	
Electrical isolation		
Input - Inverter module	Yes	
Input - Input	Yes	
Input voltage		
Rated	24 VDC	
Maximum	30 VDC	
Switching threshold		
Low	<5 V	
High	>15 V	
Input current at rated voltage	Approx. 10 mA	
Switching delay		
Positive edge	52 µs ± 0.5 µs (digitally filtered)	
Negative edge	53 µs ± 0.5 µs (digitally filtered)	
Modulation compared to ground potential	Max. ±38 V	
Operating conditions		
Permitted mounting orientations		
Hanging vertically	Yes	
Lying horizontally	Yes	
Standing horizontally	No	
Installation at altitudes above sea level		
Rated	0 to 500 m	
Maximum [16]	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		
Rated	5 to 40°C	
Maximum [17]	55°C	
Storage	-25 to 55°C	
Transport	-25 to 70°C	
Relative humidity		

Table 39: 8BVI0028HCDS.000-1, 8BVI0028HWDS.000-1 - Technical data

Product ID	8BVI0028HCDS.000-1	8BVI0028HWDS.000-1
Operation	5 to 85%	
Storage	5 to 95%	
Transport	Max. 95% at 40°C	
Mechanical characteristics		
Dimensions 18)		
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 39: 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: Bus voltage 750 VDC, switching frequency 5 kHz, 40°C ambient temperature, installation altitudes <500 m above sea level, no derating dependent on 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 SafeMC module in SLOT1 (see the section "Encoder interfaces")
P_{SMC2} ... Max. power consumption P_{SMC} [W] of the SafeMC module in SLOT2 (see the section "Encoder interfaces")
$P_{24\ V\ Out}$ ... 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) B&R 8BCM motor cables must be used when cabling the motor connections.
6) Valid in the following conditions: DC bus voltage 750 VDC, minimum permissible coolant flow volume (3 l/min). The temperature specifications are based on the return temperature of the cold-plate mounting plate.
7) Value for the nominal switching frequency.
8) B&R recommends operating the module at 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 double-axis modules, the increased CPU load causes a reduction of the functional range in the drive; if this is not taken into consideration, then it can cause the computing time to be exceeded in extreme cases.
9) The module's electrical output frequency (SCTRL_SPEED_ACT * MOTOR_POLEPAIRS) is monitored to protect against dual-use in accordance with EC 428/2009 | 3A225. If the electrical output frequency of the module exceeds the limit value of 600 Hz uninterrupted for more than 0.5 s, then the current motion is aborted and error 6060 is output (Power element: Limit speed exceeded).
10) 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.
11) The specified values 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 deactivated.
12) B&R 8BCF EnDat 2.2 cables must be used when cabling the encoder interfaces.
13) An EnDat 2.2 functional safety encoder is required when using ACOPOSmulti with SafeMC! With standard EnDat 2.2 encoders, only the timing of the functions STO, SBC and SS1 is monitored!
14) The maximum encoder cable length l_{max} can be calculated as follows (the maximum permissible encoder 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 [Ωmm²/m] (e.g. for copper: ρ = 0.0178)
15) $I_{Encoder}$ ... Max. power consumption of the connected encoder [A].
16) Continuous operation at altitudes ranging from 500 m to 4,000 m above sea level is possible (taking the continuous current reductions listed into consideration).
17) Continuous operation at ambient temperatures ranging from 40°C to max. 55°C is possible (taking the continuous current reductions listed into consideration), but results in a shorter lifespan.
18) The dimensions define the true device dimensions including the respective mounting plate. Make sure to leave additional space above and below the devices for mounting, connections and air circulation.

Wiring

For details, see section 3.4.4 "Wiring: Safe single-width inverter modules (dual-axis modules)" on page 67

For general information, please see section 6 "Wiring" on page 105

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

General Information

- Clearly structured, straightforward implementation via network-based safety technology
- Modular expandability through virtual wiring
- Immediate triggering of safety function thanks to short cycle times
- Easy implementation thanks to transparent control and status information, also in the functional application
- Compact construction
- Complete functionality of safety functions even in two-axis modules

Order data

Model number	Short description	Figure
	Cold plate or feed-through mounting	
8BVI0055HCDS.000-1	ACOPOSmulti inverter unit, 7.6 A, HV, cold plate or feed through mounting, 2 axes, SafeMC	
8BVI0055HWDS.000-1	ACOPOSmulti inverter unit, 7.6 A, HV, wall mounting, 2 axes, SafeMC	
	Required accessories	
	Terminal block sets	
8BZVI0055DS.000-1A	Screw clamp terminal block set for ACOPOSmulti modules 8BVI00xxHxDS: 1x 8TB2108.2010-00, 1x 8TB2104.203L-00, 1x 8TB2104.203F-00, 1x 8TB3104.204G-00, 1x 8TB3104.204K-00	
	Optional accessories	
	Fan modules	
8BXF001.0000-00	ACOPOSmulti fan unit, replacement fan for ACOPOSmulti modules (8BxP/8B0C/8BVI/8BVE/8B0K)	
	Shield component sets	
8SCS000.0000-00	ACOPOSmulti shielding components set: 1 shielding plate 1fold type 0; 1 hose clamp, W 9 mm, D 12-22 mm	
8SCS002.0000-00	ACOPOSmulti shielding components set: 1 clamp plate; 2 clamps D 4-13.5 mm; 4 screws	
8SCS009.0000-00	ACOPOSmulti shielding components set: 1 ACOPOSmulti shielding plate SK8-14; 1 shielding clamp SK14	
	Terminal blocks	
8TB2104.203F-00	Screw clamp terminal block 4-pin, single-row, pitch: 5.08 mm, labeling 3: T- T+ B- B+, coding F: 0101	
8TB2104.203L-00	Screw clamp terminal block 4-pin, single-row, pitch: 5.08 mm, labeling 3: T- T+ B- B+, coding L: 1010	
8TB2108.2010-00	Screw clamp terminal block 8-pin, single-row, pitch: 5.08 mm, labeling 1: numbered consecutively	
8TB3104.204G-00	Screw clamp terminal block 4-pin, single-row, pitch: 7.62 mm, labeling 4: PE W V U, coding G: 0110	
8TB3104.204K-00	Screw clamp terminal block 4-pin, single-row, pitch: 7.62 mm, labeling 4: PE W V U, coding K: 1001	

Table 40: 8BVI0055HCDS.000-1, 8BVI0055HWDS.000-1 - Order data

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		
c-UL-us	Yes	
DC bus connection		
Voltage		
Rated	750 VDC	
Continuous power consumption [2]	11.19 kW	
Power loss depending on the switching frequency [3]		
Switching frequency 5 kHz	$[1.2 \cdot I_M^2 + 2.62 \cdot I_M + 100]$ W	
Switching frequency 10 kHz	$[2.56 \cdot I_M^2 + 2.8 \cdot I_M + 200]$ W	
Switching frequency 20 kHz	$[6 \cdot I_M^2 - 9.4 \cdot I_M + 430]$ 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 ... 315 VDC	25 VDC * (U_{DC}/315)	
DC bus voltage (U_{DC}): 315 ... 800 VDC	24 VDC ±6%	
Fuse 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	0.72 A/K (from 56 °C) [7]	No reduction [7]

Table 41: 8BVI0055HCDS.000-1, 8BVI0055HWDS.000-1 - Technical data

Product ID	8BVI0055HCDS.000-1	8BVI0055HWDS.000-1
Switching frequency 10 kHz	0.28 A/K (from 43 °C)	0.22 A/K (from 43 °C)
Switching frequency 20 kHz	0.13 A/K (from 3 °C) [8)]	0.15 A/K (from -14 °C) [20)]
Reduction of continuous current depending on altitude		
Starting at 500 m above sea level	0.76 A_{eff} per 1000 m	0.76 A_{eff} per 1000 m
Peak current	18.9 A_{eff}	18.9 A_{eff}
Rated switching frequency	5 kHz	5 kHz
Possible switching frequencies [9)]	5/10/20 kHz	5/10/20 kHz
Electrical stress of the connected motor in accordance with IEC TS 60034-25	Limit value curve A	Limit value curve A
Protective measures / safeguards		
Overload protection	Yes	Yes
Short circuit and ground fault	Yes	Yes
Max. output frequency	600 Hz [10)]	600 Hz [10)]
Design		
U, V, W, PE	Plug	Plug
Shield connection	Yes	Yes
Terminal connection cross section		
Flexible and fine wire lines		
With wire tip sleeves	0.25 to 4 mm²	0.25 to 4 mm²
Approbation data		
UL/C-UL-US	30 to 10	30 to 10
CSA	28 to 10	28 to 10
Terminal cable cross-section dimension of the shield connection	12 to 22 mm	12 to 22 mm
Max. motor line length depending on the switching frequency		
Switching frequency 5 kHz	25 m	25 m
Switching frequency 10 kHz	25 m	25 m
Switching frequency 20 kHz	10 m	10 m
Motor holding brake connection		
Quantity	2	2
Output voltage [11)]	24 VDC +5.8% / -0% [12)]	24 VDC +5.8% / -0% [12)]
Continuous current	1.1 A	1.1 A
Max. internal resistance	0.5 Ω	0.5 Ω
Extinction potential	Approx. 30 V	Approx. 30 V
Max. extinction energy per switching operation	1.5 Ws	1.5 Ws
Max. switching frequency	0.5 Hz	0.5 Hz
Protective measures / safeguards		
Overload and short circuit protection	Yes	Yes
Cable breakage monitoring	Yes	Yes
Undervoltage monitoring	Yes	Yes
Response threshold for cable breakage monitoring	Approx. 0.25 A	Approx. 0.25 A
Response threshold for undervoltage monitoring	24 VDC +0% / -4%	24 VDC +0% / -4%
Encoder interfaces [13)]		
Quantity	2	2
Type	EnDat 2.2 [14)]	EnDat 2.2 [14)]
Connections	9-pin DSUB socket	9-pin DSUB socket
Displays	UP/DN LEDs	UP/DN LEDs
Electrical isolation		
Encoder - ACOPOSmulti	No	No
Encoder monitoring	Yes	Yes
Max. encoder cable length	100 m Depending on the cross section of the supply wires on the encoder cable [15)]	100 m Depending on the cross section of the supply wires on the encoder cable [15)]
Encoder supply		
Output voltage	Typ. 12.5 V	Typ. 12.5 V
Load capability	350 mA	350 mA
Protective measures / safeguards		
Short circuit protection	Yes	Yes
Overload protection	Yes	Yes
Synchronous serial interface		
Signal transfer	RS485	RS485
Data transfer rate	6.25 Mbit/s	6.25 Mbit/s
Max. power consumption per encoder interface	P_{SMC} [W] = 19 V * $I_{Encoder}$ [A] [16)]	P_{SMC} [W] = 19 V * $I_{Encoder}$ [A] [16)]
Trigger inputs		
Quantity	2	2
Wiring	Sink	Sink
Electrical isolation		
Input - Inverter module	Yes	Yes
Input - Input	Yes	Yes
Input voltage		
Rated	24 VDC	24 VDC
Maximum	30 VDC	30 VDC
Switching threshold		
Low	<5 V	<5 V

Table 41: 8BVI0055HCDS.000-1, 8BVI0055HWDS.000-1 - Technical data

Product ID	8BVI0055HCDS.000-1	8BVI0055HWDS.000-1
High	>15 V	
Input current at rated voltage	Approx. 10 mA	
Switching delay		
Positive edge	52 µs ± 0.5 µs (digitally filtered)	
Negative edge	53 µs ± 0.5 µs (digitally filtered)	
Modulation compared to ground potential	Max. ±38 V	
Operating conditions		
Permitted mounting orientations		
Hanging vertically	Yes	
Lying horizontally	Yes	
Standing horizontally	No	
Installation at altitudes above sea level		
Rated	0 to 500 m	
Maximum 17)	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		
Rated	5 to 40°C	
Maximum 18)	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 19)		
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 41: 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: Bus voltage 750 VDC, switching frequency 5 kHz, 40°C ambient temperature, installation altitudes <500 m above sea level, no derating dependent on 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 SafeMC module in SLOT1 (see the section "Encoder interfaces")
P_{SMC2} ... Max. power consumption P_{SMC} [W] of the SafeMC module in SLOT2 (see the section "Encoder interfaces")
$P_{24\ V\ Out}$ ... 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) B&R 8BCM motor cables must be used when cabling the motor connections.
6) Valid in the following conditions: DC bus voltage 750 VDC, minimum permissible coolant flow volume (3 l/min). The temperature specifications are based on 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 return temperature, at which a derating of the continuous current must be accounted for, 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 low return-temperatures.
9) B&R recommends operating the module at 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 double-axis modules, the increased CPU load causes a reduction of the functional range in the drive; if this is not taken into consideration, then it can cause the computing time to be exceeded in extreme cases.
10) The module's electrical output frequency (SCTRL_SPEED_ACT * MOTOR_POLEPAIRS) is monitored to protect against dual-use in accordance with EC 428/2009 | 3A225. If the electrical output frequency of the module exceeds the limit value of 600 Hz uninterrupted for more than 0.5 s, then the current motion is aborted and error 6060 is output (Power element: Limit speed exceeded).
11) 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.
12) The specified values 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 deactivated.
13) B&R 8BCF EnDat 2.2 cables must be used when cabling the encoder interfaces.
14) An EnDat 2.2 functional safety encoder is required when using ACOPOSmulti with SafeMC! With standard EnDat 2.2 encoders, only the timing of the functions STO, SBC and SS1 is monitored!
15) The maximum encoder cable length l_{max} can be calculated as follows (the maximum permissible encoder 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 [Ωmm²/m] (e.g. for copper: ρ = 0.0178)

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

17) Continuous operation at altitudes ranging from 500 m to 4,000 m above sea level is possible (taking the continuous current reductions listed into consideration).

18) Continuous operation at ambient temperatures ranging from 40°C to max. 55°C is possible (taking the continuous current reductions listed into consideration), but results in a shorter lifespan.

19) The dimensions define the true device dimensions including the respective mounting plate. Make sure to leave additional space above and below the devices for mounting, connections and air circulation.

20) The module cannot supply the full continuous current at this switching frequency. This unusual value for the ambient temperature, at which a derating of the continuous current must be accounted for, ensures that the derating of the continuous current can be determined in the same manner as at other switching frequencies.

Wiring

For details, see section 3.4.4 "Wiring: Safe single-width inverter modules (dual-axis modules)" on page 67

For general information, please see section 6 "Wiring" on page 105

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

Overview of pin assignments

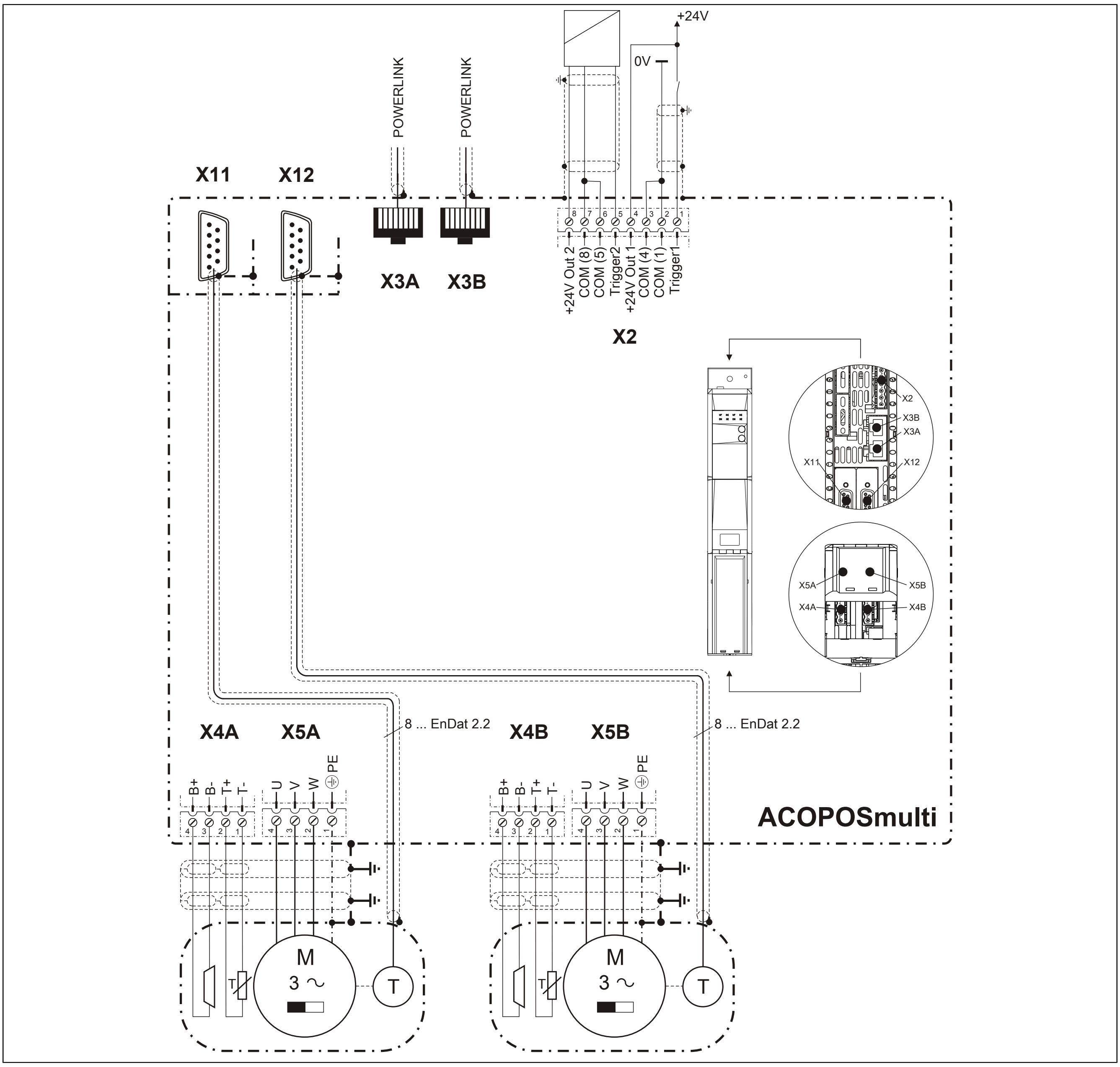


Figure 8: Overview of pin assignments

Pin assignments - X2 plug

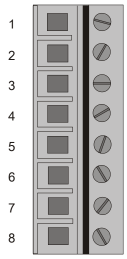
X2	Pin	Name	Function
	1	Trigger 1	Trigger 1
	2	COM (1)	Trigger 1 0 V
	3	COM (2)	+24 V output 1 0 V
	4	+24V Out 1	+24 V output 1
	5	Trigger 2	Trigger 2
	6	COM (5)	Trigger 2 0 V
	7	COM (8)	+24 V output 2 0 V
	8	+24V Out 2	+24 V output 2

Table 42: Pin assignments - X2 plug

Pin assignments - X3A, X3B plugs

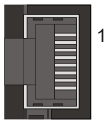
X3A, X3B	Pin	Bezeichnung	Funktion
	1	RXD	Receive Signal
	2	RXD\	Receive Signal inverted
	3	TXD	Transmit Signal
	4	Shield	Shield
	5	Shield	Shield
	6	TXD\	Transmit Signal inverted
	7	Shield	Shield
	8	Shield	Shield

Table 43: Pin assignments - X3A, X3B plugs

Pin assignments - X4A plug

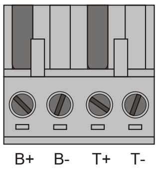
X4A	Name	Function
	T-	Axis 1: Temperature sensor -
	T+	Axis 1: Temperature sensor +
	B- 1)	Axis 1: Brake -
	B+ 1)	Axis 1: Brake +

Table 44: Pin assignments - X4A plug

1) The 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 24V. (i.e. safe pulse disabling is activated) However, the brake always remains on because of the short-circuit to 24 V!

This can lead to dangerous situations because the motor holding brake is not able to stop the spin-out movement!

Appropriate wiring measures measures must be implemented to ensure that the SBC output B+ is not shorted to 24V!

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

Danger!

The SBC output

- **must not be wired to multiple modules!**
- **must not be wired as open emitter!**
- **must not be wired as open collector!**

Information:

The transistors for the SBC output stage are tested cyclically. When output channels are activated , this test causes 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 isolated circuits. Therefore, these connections are only allowed to be connected to devices or components with at least safe 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!

Pin assignments - X4B plug

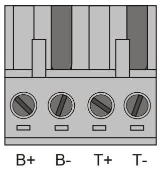
X4B	Name	Function
	T-	Axis 2: Temperature sensor -
	T+	Axis 2: Temperature sensor +
	B- [1)]	Axis 2: Brake -
	B+ [1)]	Axis 2: Brake +

Table 45: Pin assignments X4B plug

1) The 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 24V. (i.e. safe pulse disabling is activated) However, the brake always remains on because of the short-circuit to 24 V!

This can lead to dangerous situations because the motor holding brake is not able to stop the spin-out movement!

Appropriate wiring measures measures must be implemented to ensure that the SBC output B+ is not shorted to 24V!

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

Danger!

The SBC output

- **must not be wired to multiple modules!**
- **must not be wired as open emitter!**
- **must not be wired as open collector!**

Information:

The transistors for the SBC output stage are tested cyclically. When output channels are activated , this test causes 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 isolated circuits. Therefore, these connections are only allowed to be connected to devices or components with at least safe 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!

Pin assignments - X5A plug

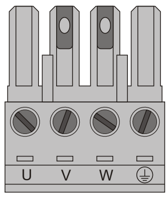
X5A	Name	Function
	⏚	Axis 1: Protective ground conductor
	W	Axis 1: Motor connection W
	V	Axis 1: Motor connection V
	U	Axis 1: Motor connection U

Table 46: Pin assignments - X5A plug

Warning!

B&R 8BCM motor cables must be used when cabling the motor connections.

Pin assignments - X5B plug

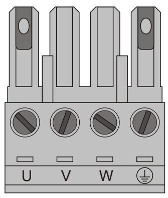
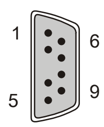
X5B	Name	Function
	⏚	Axis 2: Protective ground conductor
	W	Axis 2: Motor connection W
	V	Axis 2: Motor connection V
	U	Axis 2: Motor connection U

Table 47: Pin assignments - X5B plug

Warning!

B&R 8BCM motor cables must be used when cabling the motor connections.

Pin assignments - SafeMC module

Image	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\	Inverted data input
		9	T\	Inverted clock output

Information:

The SafeMC module must only be used together with 8BCF EnDat 2.2 cables!

Note:

The SafeMC modules cannot be exchanged! The SafeMC modules together with the 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

General Information

- Clearly structured, straightforward implementation via network-based safety technology
- Modular expandability through virtual wiring
- Immediate triggering of safety function thanks to short cycle times
- Easy implementation thanks to transparent control and status information, also in the functional application
- Compact construction
- Complete functionality of safety functions even in two-axis modules

Order data

Model number	Short description	Figure
	Cold plate or feed-through mounting	
8BVI0110HCDS.000-1	ACOPOSmulti inverter unit, 15.1 A, HV, cold plate or feed through mounting, 2 axes, SafeMC	
8BVI0110HWDS.000-1	ACOPOSmulti inverter unit, 15.1 A, HV, wall mounting, 2 axes, SafeMC	
	Required accessories	
	Terminal block sets	
8BZVI0110DS.000-1A	Screw clamp terminal block set for ACOPOSmulti modules 8BVI0110HxDS: 1x 8TB2108.2010-00, 1x 8TB2104.203L-00, 1x 8TB2104.203F-00, 1x 8TB3104.204G-00, 1x 8TB3104.204K-00	
	Optional accessories	
	Fan modules	
8BXF001.0000-00	ACOPOSmulti fan unit, replacement fan for ACOPOSmulti modules (8BxP/8B0C/8BVI/8BVE/8B0K)	
	Shield component sets	
8SCS000.0000-00	ACOPOSmulti shielding components set: 1 shielding plate 1fold type 0; 1 hose clamp, W 9 mm, D 12-22 mm	
8SCS002.0000-00	ACOPOSmulti shielding components set: 1 clamp plate; 2 clamps D 4-13.5 mm; 4 screws	
8SCS009.0000-00	ACOPOSmulti shielding components set: 1 ACOPOSmulti shielding plate SK8-14; 1 shielding clamp SK14	
	Terminal blocks	
8TB2104.203F-00	Screw clamp terminal block 4-pin, single-row, pitch: 5.08 mm, labeling 3: T- T+ B- B+, coding F: 0101	
8TB2104.203L-00	Screw clamp terminal block 4-pin, single-row, pitch: 5.08 mm, labeling 3: T- T+ B- B+, coding L: 1010	
8TB2108.2010-00	Screw clamp terminal block 8-pin, single-row, pitch: 5.08 mm, labeling 1: numbered consecutively	
8TB3104.204G-00	Screw clamp terminal block 4-pin, single-row, pitch: 7.62 mm, labeling 4: PE W V U, coding G: 0110	
8TB3104.204K-00	Screw clamp terminal block 4-pin, single-row, pitch: 7.62 mm, labeling 4: PE W V U, coding K: 1001	

Table 48: 8BVI0110HCDS.000-1, 8BVI0110HWDS.000-1 - Order data

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 c-UL-us	Yes	
DC bus connection		
Voltage Rated	750 VDC	
Continuous power consumption [2]	22.3 kW	
Power loss depending on the switching frequency [3] Switching frequency 5 kHz Switching frequency 10 kHz Switching frequency 20 kHz	 $[0.33*I_M^2+11*I_M+90]$ W $[0.97*I_M^2+9.5*I_M+170]$ W $[1.66*I_M^2+21*I_M+380]$ W	
DC bus capacitance	660 µF	
Design	ACOPOSmulti backplane	
24 VDC supply		

Table 49: 8BVI0110HCDS.000-1, 8BVI0110HWDS.000-1 - Technical data

Product ID	8BVI0110HCDS.000-1	8BVI0110HWDS.000-1
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 ... 315 VDC	25 VDC * (U_{DC}/315)	
DC bus voltage (U_{DC}): 315 ... 800 VDC	24 VDC ±6%	
Fuse 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	In preparation	
Switching frequency 10 kHz	In preparation	
Switching frequency 20 kHz	In preparation	
Reduction of continuous current depending on altitude		
Starting at 500 m above sea level	1.51 A_{eff} per 1000 m	
Peak current	37.7 A_{eff}	
Rated switching frequency	5 kHz	
Possible switching frequencies [7)]	5/10/20 kHz	
Electrical stress of the connected motor in accordance with IEC TS 60034-25	Limit value curve A	
Protective measures / safeguards		
Overload protection	Yes	
Short circuit and ground fault	Yes	
Max. output frequency	600 Hz [8)]	
Design		
U, V, W, PE	Plug	
Shield connection	Yes	
Terminal connection cross section		
Flexible and fine wire lines		
With wire tip 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 the 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 [9)]	24 VDC +5.8% / -0% [10)]	
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 / safeguards		
Overload and short circuit protection	Yes	
Cable breakage monitoring	Yes	
Undervoltage monitoring	Yes	
Response threshold for cable breakage monitoring	Approx. 0.5 A	
Response threshold for undervoltage monitoring	24 VDC +0% / -4%	
Encoder interfaces [11)]		
Quantity	2	
Type	EnDat 2.2 [12)]	
Connections	9-pin DSUB socket	
Displays	UP/DN LEDs	
Electrical isolation		
Encoder - ACOPOSmulti	No	
Encoder monitoring	Yes	
Max. encoder cable length	100 m Depending on the cross section of the supply wires on the encoder cable [13)]	
Encoder supply		
Output voltage	Typ. 12.5 V	
Load capability	350 mA	

Table 49: 8BVI0110HCDS.000-1, 8BVI0110HWDS.000-1 - Technical data

Product ID	8BVI0110HCDS.000-1	8BVI0110HWDS.000-1
Protective measures / safeguards		
Short circuit protection	Yes	
Overload protection	Yes	
Synchronous serial interface		
Signal transfer	RS485	
Data transfer rate	6.25 Mbit/s	
Max. power consumption per encoder interface	P_{SMC} [W] = 19 V * $I_{Encoder}$ [A] 14)	
Trigger inputs		
Quantity	2	
Wiring	Sink	
Electrical isolation		
Input - Inverter module	Yes	
Input - Input	No	
Input voltage		
Rated	24 VDC	
Maximum	30 VDC	
Switching threshold		
Low	<5 V	
High	>15 V	
Input current at rated voltage	Approx. 10 mA	
Switching delay		
Positive edge	52 µs ± 0.5 µs (digitally filtered)	
Negative edge	53 µs ± 0.5 µs (digitally filtered)	
Modulation compared to ground potential	Max. ±38 V	
Operating conditions		
Permitted mounting orientations		
Hanging vertically	Yes	
Lying horizontally	Yes	
Standing horizontally	No	
Installation at altitudes above sea level		
Rated	0 to 500 m	
Maximum 15)	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		
Rated	5 to 40°C	
Maximum 16)	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 17)		
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 49: 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: Bus voltage 750 VDC, switching frequency 5 kHz, 40°C ambient temperature, installation altitudes <500 m above sea level, no derating dependent on 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 SafeMC module in SLOT1 (see the section "Encoder interfaces")
P_{SMC2} ... Max. power consumption P_{SMC} [W] of the SafeMC module in SLOT2 (see the section "Encoder interfaces")
$P_{24\ V\ Out}$ ... 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) B&R 8BCM motor cables must be used when cabling the motor connections.
6) Valid in the following conditions: DC bus voltage 750 VDC, minimum permissible coolant flow volume (3 l/min). The temperature specifications are based on the return temperature of the cold-plate mounting plate.
7) B&R recommends operating the module at 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 double-axis modules, the increased CPU load causes a reduction of the functional range in the drive; if this is not taken into consideration, then it can cause the computing time to be exceeded in extreme cases.

8) The module's electrical output frequency (SCTRL_SPEED_ACT * MOTOR_POLEPAIRS) is monitored to protect against dual-use in accordance with EC 428/2009 | 3A225. If the electrical output frequency of the module exceeds the limit value of 600 Hz uninterrupted for more than 0.5 s, then the current motion is aborted and error 6060 is output (Power element: Limit speed exceeded).
9) 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.
10) The specified values 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 deactivated.
11) B&R 8BCF EnDat 2.2 cables must be used when cabling the encoder interfaces.
12) An EnDat 2.2 functional safety encoder is required when using ACOPOSmulti with SafeMC! With standard EnDat 2.2 encoders, only the timing of the functions STO, SBC and SS1 is monitored!
13) The maximum encoder cable length l_{max} can be calculated as follows (the maximum permissible encoder 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 [Ωmm²/m] (e.g. for copper: ρ = 0.0178)
14) $I_{Encoder}$ ... Max. power consumption of the connected encoder [A].
15) Continuous operation at altitudes ranging from 500 m to 4,000 m above sea level is possible (taking the continuous current reductions listed into consideration).
16) Continuous operation at ambient temperatures ranging from 40°C to max. 55°C is possible (taking the continuous current reductions listed into consideration), but results in a shorter lifespan.
17) The dimensions define the true device dimensions including the respective mounting plate. Make sure to leave additional space above and below the devices for mounting, connections and air circulation.

Wiring

For details, see section 3.5.3 "Wiring: Safe double-width inverter modules (dual-axis modules)" on page 79

For general information, please see section 6 "Wiring" on page 105

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

General Information

- Clearly structured, straightforward implementation via network-based safety technology
- Modular expandability through virtual wiring
- Immediate triggering of safety function thanks to short cycle times
- Easy implementation thanks to transparent control and status information, also in the functional application
- Compact construction
- Complete functionality of safety functions even in two-axis modules

Order data

Model number	Short description	Figure
	Cold plate or feed-through mounting	
8BVI0220HCDS.000-1	ACOPOSmulti inverter unit, 22 A, HV, cold plate or feed through mounting, 2 axes, SafeMC	
8BVI0220HWDS.000-1	ACOPOSmulti inverter unit, 22 A, HV, wall mounting, 2 axes, SafeMC	
	Required accessories	
	Terminal block sets	
8BZVI0220DS.000-1A	Screw clamp terminal block set for ACOPOSmulti modules 8BVI0220HxDS: 1x 8TB2108.2010-00, 1x 8TB2104.203L-00, 1x 8TB2104.203F-00, 1x 8TB3104.204G-10, 1x 8TB3104.204K-10	
	Optional accessories	
	Fan modules	
8BXF001.0000-00	ACOPOSmulti fan unit, replacement fan for ACOPOSmulti modules (8BxP/8B0C/8BVI/8BVE/8B0K)	
	Shield component sets	
8SCS000.0000-00	ACOPOSmulti shielding components set: 1 shielding plate 1fold type 0; 1 hose clamp, W 9 mm, D 12-22 mm	
8SCS002.0000-00	ACOPOSmulti shielding components set: 1 clamp plate; 2 clamps D 4-13.5 mm; 4 screws	
8SCS009.0000-00	ACOPOSmulti shielding components set: 1 ACOPOSmulti shielding plate SK8-14; 1 shielding clamp SK14	
	Terminal blocks	
8TB2104.203F-00	Screw clamp terminal block 4-pin, single-row, pitch: 5.08 mm, labeling 3: T- T+ B- B+, coding F: 0101	

Table 50: 8BVI0220HCDS.000-1, 8BVI0220HWDS.000-1 - Order data

Model number	Short description	Figure
8TB2104.203L-00	Screw clamp terminal block 4-pin, single-row, pitch: 5.08 mm, labeling 3: T- T+ B- B+, coding L: 1010	
8TB2108.2010-00	Screw clamp terminal block 8-pin, single-row, pitch: 5.08 mm, labeling 1: numbered consecutively	
8TB3104.204G-10	Screw clamp terminal block 4-pin, single-row, pitch: 7.62 mm, labeling 4: PE W V U, coding G: 0110	
8TB3104.204K-10	Screw clamp terminal block 4-pin, single-row, pitch: 7.62 mm, labeling 4: PE W V U, coding K: 1001	

Table 50: 8BVI0220HCDS.000-1, 8BVI0220HWDS.000-1 - Order data

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		
c-UL-us	Yes	
DC bus connection		
Voltage		
Rated	750 VDC	
Continuous power consumption [2)]	In preparation	
Power loss depending on the switching frequency [3)]		
Switching frequency 5 kHz	In preparation	
Switching frequency 10 kHz	In preparation	
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 ... 315 VDC	25 VDC * (U_{DC}/315)	
DC bus voltage (U_{DC}): 315 ... 800 VDC	24 VDC ±6%	
Fuse 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	In preparation	
Switching frequency 10 kHz	In preparation	
Reduction of continuous current depending on altitude		
Starting at 500 m above sea level	2.2 A_{eff} per 1000 m	
Peak current	55 A_{eff} [7)]	
Rated switching frequency	5 kHz	
Possible switching frequencies [8)]	5/10 kHz	
Electrical stress of the connected motor in accordance with IEC TS 60034-25	Limit value curve A	
Protective measures / safeguards		
Overload protection	Yes	
Short circuit and ground fault	Yes	
Max. output frequency	600 Hz [9)]	
Design		
U, V, W, PE	Plug	
Shield connection	Yes	
Terminal connection cross section		
Flexible and fine wire lines		
With wire tip 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 the shield connection	12 to 22 mm	
Max. motor line length depending on the switching frequency		
Switching frequency 5 kHz	25 m	

Table 51: 8BVI0220HCDS.000-1, 8BVI0220HWDS.000-1 - Technical data

Product ID	8BVI0220HCDS.000-1	8BVI0220HWDS.000-1
Switching frequency 10 kHz	25 m	
Motor holding brake connection		
Quantity	2	
Output voltage [10]	24 VDC +5.8% / -0% [11]	
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 / safeguards		
Overload and short circuit protection	Yes	
Cable breakage monitoring	Yes	
Undervoltage monitoring	Yes	
Response threshold for cable breakage monitoring	Approx. 0.5 A	
Response threshold for undervoltage monitoring	24 VDC +0% / -4%	
Encoder interfaces [12]		
Quantity	2	
Type	EnDat 2.2 [13]	
Connections	9-pin DSUB socket	
Displays	UP/DN LEDs	
Electrical isolation		
Encoder - ACOPOSmulti	No	
Encoder monitoring	Yes	
Max. encoder cable length	100 m Depending on the cross section of the supply wires on the encoder cable [14]	
Encoder supply		
Output voltage	Typ. 12.5 V	
Load capability	350 mA	
Protective measures / safeguards		
Short circuit protection	Yes	
Overload protection	Yes	
Synchronous serial interface		
Signal transfer	RS485	
Data transfer rate	6.25 Mbit/s	
Max. power consumption per encoder interface	P_{SMC} [W] = 19 V * $I_{Encoder}$ [A] [15]	
Trigger inputs		
Quantity	2	
Wiring	Sink	
Electrical isolation		
Input - Inverter module	Yes	
Input - Input	No	
Input voltage		
Rated	24 VDC	
Maximum	30 VDC	
Switching threshold		
Low	<5 V	
High	>15 V	
Input current at rated voltage	Approx. 10 mA	
Switching delay		
Positive edge	52 µs ± 0.5 µs (digitally filtered)	
Negative edge	53 µs ± 0.5 µs (digitally filtered)	
Modulation compared to ground potential	Max. ±38 V	
Operating conditions		
Permitted mounting orientations		
Hanging vertically	Yes	
Lying horizontally	Yes	
Standing horizontally	No	
Installation at altitudes above sea level		
Rated	0 to 500 m	
Maximum [16]	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		
Rated	5 to 40°C	
Maximum [17]	55°C	
Storage	-25 to 55°C	
Transport	-25 to 70°C	
Relative humidity		
Operation	5 to 85%	
Storage	5 to 95%	

Table 51: 8BVI0220HCDS.000-1, 8BVI0220HWDS.000-1 - Technical data

Product ID	8BVI0220HCDS.000-1	8BVI0220HWDS.000-1
Transport	Max. 95% at 40°C	
Mechanical characteristics		
Dimensions [18]		
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 51: 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: Bus voltage 750 VDC, switching frequency 5 kHz, 40°C ambient temperature, installation altitudes <500 m above sea level, no derating dependent on 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 SafeMC module in SLOT1 (see the section "Encoder interfaces")
P_{SMC2} ... Max. power consumption P_{SMC} [W] of the SafeMC module in SLOT2 (see the section "Encoder interfaces")
$P_{24\ V\ Out}$ ... 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) B&R 8BCM motor cables must be used when cabling the motor connections.
6) Valid in the following conditions: DC bus voltage 750 VDC, minimum permissible coolant flow volume (3 l/min). The temperature specifications are based on the return temperature of the cold-plate mounting plate.
7) The thermal pulse load capacity is lower than for the single-axis module 8BVI0220HxS0.000-1. 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.
8) B&R recommends operating the module at 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 double-axis modules, the increased CPU load causes a reduction of the functional range in the drive; if this is not taken into consideration, then it can cause the computing time to be exceeded in extreme cases.
9) The module's electrical output frequency (SCTRL_SPEED_ACT * MOTOR_POLEPAIRS) is monitored to protect against dual-use in accordance with EC 428/2009 | 3A225. If the electrical output frequency of the module exceeds the limit value of 600 Hz uninterrupted for more than 0.5 s, then the current motion is aborted and error 6060 is output (Power element: Limit speed exceeded).
10) 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.
11) The specified values 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 deactivated.
12) B&R 8BCF EnDat 2.2 cables must be used when cabling the encoder interfaces.
13) An EnDat 2.2 functional safety encoder is required when using ACOPOSmulti with SafeMC! With standard EnDat 2.2 encoders, only the timing of the functions STO, SBC and SS1 is monitored!
14) The maximum encoder cable length l_{max} can be calculated as follows (the maximum permissible encoder 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 [Ωmm²/m] (e.g. for copper: ρ = 0.0178)
15) $I_{Encoder}$ ... Max. power consumption of the connected encoder [A].
16) Continuous operation at altitudes ranging from 500 m to 4,000 m above sea level is possible (taking the continuous current reductions listed into consideration).
17) Continuous operation at ambient temperatures ranging from 40°C to max. 55°C is possible (taking the continuous current reductions listed into consideration), but results in a shorter lifespan.
18) The dimensions define the true device dimensions including the respective mounting plate. Make sure to leave additional space above and below the devices for mounting, connections and air circulation.

Wiring

For details, see section 3.5.3 "Wiring: Safe double-width inverter modules (dual-axis modules)" on page 79

For general information, please see section 6 "Wiring" on page 105

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

Overview of pin assignments

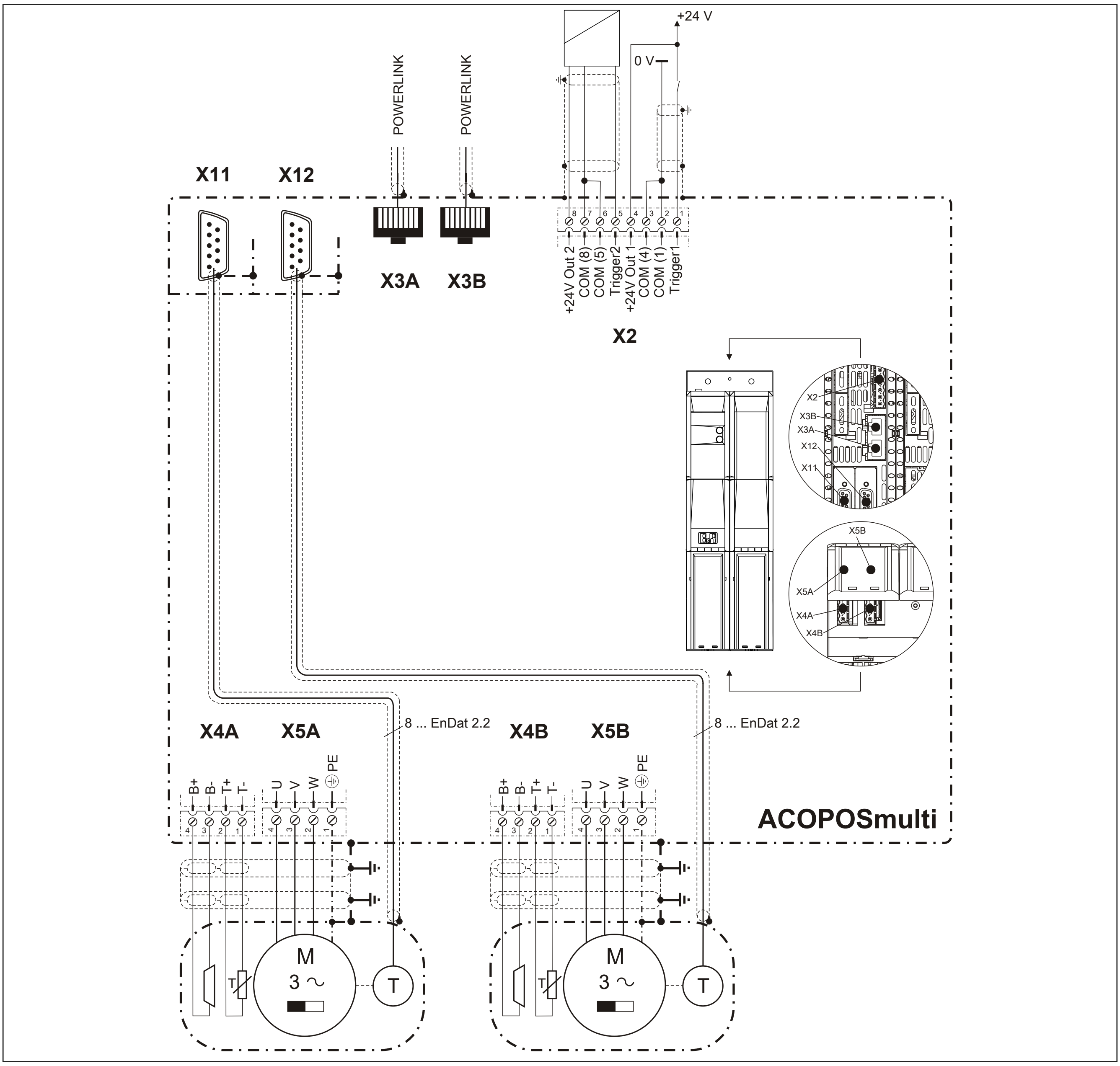


Figure 9: Overview of pin assignments

Pin assignments - X2 plug

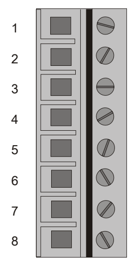
X2	Pin	Name	Function
	1	Trigger 1	Trigger 1
	2	COM (1)	Trigger 1 0 V
	3	COM (2)	+24 V output 1 0 V
	4	+24V Out 1	+24 V output 1
	5	Trigger 2	Trigger 2
	6	COM (5)	Trigger 2 0 V
	7	COM (8)	+24 V output 2 0 V
	8	+24V Out 2	+24 V output 2

Table 52: Pin assignments - X2 plug

Pin assignments - X3A, X3B plugs

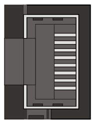
X3A, X3B	Pin	Bezeichnung	Funktion
	1	RXD	Receive Signal
	2	RXD\	Receive Signal inverted
	3	TXD	Transmit Signal
	4	Shield	Shield
	5	Shield	Shield
	6	TXD\	Transmit Signal inverted
	7	Shield	Shield
	8	Shield	Shield

Table 53: Pin assignments - X3A, X3B plugs

Pin assignments - X4A plug

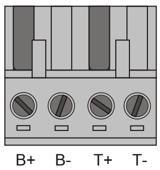
X4A	Name	Function
	T-	Axis 1: Temperature sensor -
	T+	Axis 1: Temperature sensor +
	B- [1)]	Axis 1: Brake -
	B+ [1)]	Axis 1: Brake +

Table 54: Pin assignments - X4A plug

1) The 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 24V. (i.e. safe pulse disabling is activated) However, the brake always remains on because of the short-circuit to 24 V!

This can lead to dangerous situations because the motor holding brake is not able to stop the spin-out movement!

Appropriate wiring measures measures must be implemented to ensure that the SBC output B+ is not shorted to 24V!

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

Danger!

The SBC output

- **must not be wired to multiple modules!**
- **must not be wired as open emitter!**
- **must not be wired as open collector!**

Information:

The transistors for the SBC output stage are tested cyclically. When output channels are activated , this test causes 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 isolated circuits. Therefore, these connections are only allowed to be connected to devices or components with at least safe 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!

Pin assignments - X4B plug

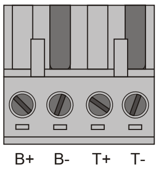
X4B	Name	Function
	T-	Axis 2: Temperature sensor -
	T+	Axis 2: Temperature sensor +
	B- [1]	Axis 2: Brake -
	B+ [1]	Axis 2: Brake +

Table 55: Pin assignments X4B plug

1) The 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 24V. (i.e. safe pulse disabling is activated) However, the brake always remains on because of the short-circuit to 24 V!

This can lead to dangerous situations because the motor holding brake is not able to stop the spin-out movement!

Appropriate wiring measures measures must be implemented to ensure that the SBC output B+ is not shorted to 24V!

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

Danger!

The SBC output

- **must not be wired to multiple modules!**
- **must not be wired as open emitter!**
- **must not be wired as open collector!**

Information:

The transistors for the SBC output stage are tested cyclically. When output channels are activated , this test causes 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 isolated circuits. Therefore, these connections are only allowed to be connected to devices or components with at least safe 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!

Pin assignments - X5A plug

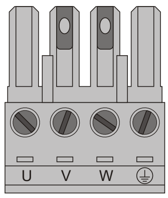
X5A	Name	Function
	⏚	Axis 1: Protective ground conductor
	W	Axis 1: Motor connection W
	V	Axis 1: Motor connection V
	U	Axis 1: Motor connection U

Table 56: Pin assignments - X5A plug

Warning!

B&R 8BCM motor cables must be used when cabling the motor connections.

Pin assignments - X5B plug

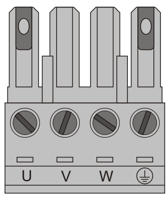
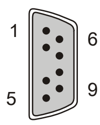
X5B	Name	Function
	⏚	Axis 2: Protective ground conductor
	W	Axis 2: Motor connection W
	V	Axis 2: Motor connection V
	U	Axis 2: Motor connection U

Table 57: Pin assignments - X5B plug

Warning!

B&R 8BCM motor cables must be used when cabling the motor connections.

Pin assignments - SafeMC module

Image	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\	Inverted data input
		9	T\	Inverted clock output

Information:

The SafeMC module must only be used together with 8BCF EnDat 2.2 cables!

Note:

The SafeMC modules cannot be exchanged! The SafeMC modules together with the 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

General Information

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

Order data

Model number	Short description	Figure
	Cold plate or feed-through mounting	
8BVI0660HCSS.000-1	ACOPOSmulti inverter unit, 66 A, HV, cold plate or feed through mounting, SafeMC EnDat 2.2	
8BVI0660HWSS.000-1	ACOPOSmulti inverter unit, 66 A, HV, wall mounting, SafeMC EnDat 2.2	
	Required accessories	
	Terminal block sets	
8BZVI1650SS.000-1A	Screw clamp terminal block set for ACOPOSmulti modules 8BVI0660HxSS, 8BVI0880HxSS and 8BVI1650HxSS: 1x 8TB2104.203L-00, 1x 8TB2108.2010-00	
	Optional accessories	
	Fan modules	
8BXF001.0000-00	ACOPOSmulti fan unit, replacement fan for ACOPOSmulti modules (8BxP/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/BISS	
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 plug-in 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 shielding components set: 1 shielding plate 4fold type 1; 1 hose clamp, W 9 mm, D 12-22 mm	
8SCS002.0000-00	ACOPOSmulti shielding components set: 1 clamp plate; 2 clamps D 4-13.5 mm; 4 screws	
8SCS003.0000-00	ACOPOSmulti shielding components set: 1 shielding plate 4fold 45°; 8 screws	
8SCS004.0000-00	ACOPOSmulti shielding components set: 1 shielding plate 1fold type 0; 2 hose clamps, W 9 mm, D 32-50 mm	
8SCS010.0000-00	ACOPOSmulti shielding components set: 1 ACOPOSmulti shielding plate SK14-20; 1 shielding clamp SK20	
	Terminal blocks	
8TB2104.203L-00	Screw clamp terminal block 4-pin, single-row, pitch: 5.08 mm, labeling 3: T- T+ B- B+, coding L: 1010	
8TB2106.2010-00	Screw clamp terminal block 6-pin, single-row, pitch: 5.08 mm, labeling 1: numbered consecutively	
8TB2108.2010-00	Screw clamp terminal block 8-pin, single-row, pitch: 5.08 mm, labeling 1: numbered consecutively	

Table 58: 8BVI0660HCSS.000-1, 8BVI0660HWSS.000-1 - Order data

Technical data

Product ID	8BVI0660HCSS.000-1	8BVI0660HWSS.000-1
General information		
B&R ID code	0xBE89	0xBE8B
Cooling and mounting method	Cold plate or feed-through mounting	Wall mounting
Slots for plug-in modules	2	
Certification c-UL-us	 In preparation	
DC bus connection		
Voltage Rated	 750 VDC	
Continuous power consumption [1]	48.8 kW	
Power loss depending on the switching frequency [2] Switching frequency 5 kHz Switching frequency 10 kHz Switching frequency 20 kHz	 $[0.03*I_M^2+7.9*I_M+90]$ W $[0.11*I_M^2+11*I_M+185]$ W $[0.17*I_M^2+27*I_M+310]$ 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	$33 W + P_{SMC1} + P_{SLOT2} + P_{24\ V\ Out} + P_{HoldingBrake} + 4 * P_{Fan8B0M...}$ [3]	
Design	ACOPOSmulti backplane	
24 VDC output		
Quantity	2	
Output voltage DC bus voltage (U_{DC}): 260 ... 315 VDC DC bus voltage (U_{DC}): 315 ... 800 VDC	 25 VDC * (U_{DC}/315) 24 VDC ±6%	
Fuse protection	250 mA (slow-blow) electronic, automatic reset	
Motor connection [4]		
Quantity	1	
Continuous power per motor connection [1]	48 kW	
Continuous current per motor connection [1]	66 A_{eff}	
Reduction of continuous current depending on the switching frequency [5] Switching frequency 5 kHz Switching frequency 10 kHz Switching frequency 20 kHz	 No reduction [6] 1.36 A/K (from 43 °C) 0.75 A/K (from -8 °C) [7]	 No reduction [6] 0.92 A/K (from 18 °C) [22] 0.56 A/K (from -50 °C) [22]
Reduction of continuous current depending on altitude Starting at 500 m above sea level	 6.6 A_{eff} per 1000 m	
Peak current	132 A_{eff}	
Rated switching frequency	5 kHz	
Possible switching frequencies [8]	5/10/20 kHz	
Electrical stress of the connected motor in accordance with IEC TS 60034-25	Limit value curve A	
Protective measures / safeguards Overload protection Short circuit and ground fault	 Yes Yes	
Max. output frequency	600 Hz [9]	
Design U, V, W, PE Shield connection	 M8 threaded bolt Yes	
Terminal connection cross section Flexible and fine wire lines With wire tip sleeves Approbation data UL/C-UL-US CSA	 6 to 50 mm² [10] In preparation In preparation	
Terminal cable cross-section dimension of the shield connection	12 to 50 mm [11]	
Max. motor line length depending on the switching frequency Switching frequency 5 kHz Switching frequency 10 kHz Switching frequency 20 kHz	 25 m 25 m 25 m	
Motor holding brake connection		
Quantity	1	
Output voltage [12]	24 VDC +5.8% / -0% [13]	
Continuous current	4.2 A	
Max. internal resistance	0.15 Ω	
Extinction potential	Approx. 30 V	
Max. extinction energy per switching operation	3 Ws	

Table 59: 8BVI0660HCSS.000-1, 8BVI0660HWSS.000-1 - Technical data

Product ID	8BVI0660HCSS.000-1	8BVI0660HWSS.000-1
Max. switching frequency	0.5 Hz	
Protective measures / safeguards		
Overload and short circuit protection	Yes	
Cable breakage monitoring	Yes	
Undervoltage monitoring	Yes	
Response threshold for cable breakage monitoring	Approx. 0.5 A	
Response threshold for undervoltage monitoring	24 VDC +0% / -4%	
Encoder interfaces [14]		
Quantity	1	
Type	EnDat 2.2 [15]	
Connections	9-pin DSUB socket	
Displays	UP/DN LEDs	
Electrical isolation		
Encoder - ACOPOSmulti	No	
Encoder monitoring	Yes	
Max. encoder cable length	100 m Depending on the cross section of the supply wires on the encoder cable [16]	
Encoder supply		
Output voltage	Typ. 12.5 V	
Load capability	350 mA	
Protective measures / safeguards		
Short circuit protection	Yes	
Overload protection	Yes	
Synchronous serial interface		
Signal transfer	RS485	
Data transfer rate	6.25 Mbit/s	
Max. power consumption per encoder interface	P_{SMC} [W] = 19 V * $I_{Encoder}$ [A] [17]	
Trigger inputs		
Quantity	2	
Wiring	Sink	
Electrical isolation		
Input - Inverter module	Yes	
Input - Input	Yes	
Input voltage		
Rated	24 VDC	
Maximum	30 VDC	
Switching threshold		
Low	<5 V	
High	>15 V	
Input current at rated voltage	Approx. 10 mA	
Switching delay		
Positive edge	52 μs ± 0.5 μs (digitally filtered)	
Negative edge	53 μs ± 0.5 μs (digitally filtered)	
Modulation compared to ground potential	Max. ±38 V	
Operating conditions		
Permitted mounting orientations		
Hanging vertically	Yes	
Lying horizontally	Yes	
Standing horizontally	No	
Installation at altitudes above sea level		
Rated	0 to 500 m	
Maximum [18]	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 [19]	
Environmental conditions		
Temperature		
Operation		
Rated	5 to 40°C	
Maximum [20]	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 [21]		
Width	213.5 mm	
Height	317 mm	
Depth		
Wall mounting	-	263 mm

Table 59: 8BVI0660HCSS.000-1, 8BVI0660HWSS.000-1 - Technical data

Product ID	8BVI0660HCSS.000-1	8BVI0660HWSS.000-1
Cold-plate	212 mm	-
Feed-through mounting	209 mm	-
Weight	Approx. 8 kg	Approx. 10.2 kg
Module width	4	

Table 59: 8BVI0660HCSS.000-1, 8BVI0660HWSS.000-1 - Technical data

1) Valid in the following conditions: Bus voltage 750 VDC, switching frequency 5 kHz, 40°C ambient temperature, installation altitudes <500 m above sea level, no derating dependent on cooling type.
2) I_M ... Current on the motor connection [A].
3) P_{SMC1} ... Max. power consumption P_{SMC} [W] of the SMC module in SLOT1 (see the section "Encoder interfaces")
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)
4) B&R 8BCM motor cables must be used when cabling the motor connections.
5) Valid in the following conditions: DC bus voltage 750 VDC, minimum permissible coolant flow volume (3 l/min). The temperature specifications are based on the return temperature of the cold-plate mounting plate.
6) Value for the nominal switching frequency.
7) The module cannot supply the full continuous current at this switching frequency. This unusual value for the return temperature, at which a derating of the continuous current must be accounted for, 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 low return-temperatures.
8) B&R recommends operating the module at nominal switching frequency. Operating the module at a higher switching frequency for application-specific reasons reduces the continuous current and increases the CPU load.
9) The module's electrical output frequency (SCTRL_SPEED_ACT * MOTOR_POLEPAIRS) is monitored to protect against dual-use in accordance with EC 428/2009 | 3A225. If the electrical output frequency of the module exceeds the limit value of 600 Hz uninterrupted for more than 0.5 s, then the current motion is aborted and error 6060 is output (Power element: Limit speed exceeded).
10) The connection is made with cable lugs using an M8 threaded bolt.
11) The maximum diameter that can be clamped depends on the shield component set.
12) 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.
13) The specified values is only valid under the following conditions:
- The 24 VDC supply for the module is provided by an 8B0C auxiliary supply module, which is installed on the same mounting plate
- Connection between S1 and S2 (activation of the external holding brake) using a jumper with a length of max. 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 deactivated.
If jumpers longer than 10 cm are used to connect S1 and S2 , the output voltage is reduced because of voltage drops on the jumpers.
14) B&R 8BCF EnDat 2.2 cables must be used when cabling the encoder interfaces.
15) An EnDat 2.2 functional safety encoder is required when using ACOPOSmulti with SafeMC! With standard EnDat 2.2 encoders, only the timing of the functions STO, SBC and SS1 is monitored!
16) The maximum encoder cable length l_{max} can be calculated as follows (the maximum permissible encoder 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 [Ωmm²/m] (e.g. for copper: ρ = 0.0178)
17) $I_{Encoder}$ ... Max. power consumption of the connected encoder [A].
18) Continuous operation at altitudes ranging from 500 m to 4,000 m above sea level is possible (taking the continuous current reductions listed into consideration).
19) This value only applies with the factory settings (SLOT2 of the module is sealed by a slot cover shield plate). If SLOT2 on the module is not sealed, then the protection level is reduced to IP10. For this reason, we recommend only removing the slot cover shield plate if an ACOPOSmulti plug-in module is being used in SLOT2.
20) Continuous operation at ambient temperatures ranging from 40°C to max. 55°C is possible (taking the continuous current reductions listed into consideration), but results in a shorter lifespan.
21) The dimensions define the true device dimensions including the respective mounting plate. Make sure to leave additional space above and below the devices for mounting, connections and air circulation.
22) The module cannot supply the full continuous current at this switching frequency. This unusual value for the ambient temperature, at which a derating of the continuous current must be accounted for, ensures that the derating of the continuous current can be determined in the same manner as at other switching frequencies.

Wiring

For details, see section 3.6.3 "Wiring: Safe 4x width inverter modules (single-axis modules)" on page 91

For general information, please see section 6 "Wiring" on page 105

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

General Information

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

- Compact design

Order data

Model number	Short description	Figure
	Cold plate or feed-through mounting	
8BVI0880HCSS.004-1	ACOPOSmulti inverter unit, 88 A, HV, cold plate or feed through mounting, SafeMC EnDat 2.2	
8BVI0880HWSS.004-1	ACOPOSmulti inverter unit, 88 A, HV, wall mounting, SafeMC EnDat 2.2	
	Required accessories	
	Terminal block sets	
8BZVI1650SS.000-1A	Screw clamp terminal block set for ACOPOSmulti modules 8BVI0660HxSS, 8BVI0880HxSS and 8BVI1650HxSS: 1x 8TB2104.203L-00, 1x 8TB2108.2010-00	
	Optional accessories	
	Fan modules	
8BXF001.0000-00	ACOPOSmulti fan unit, replacement fan for ACOPOSmulti modules (8BxP/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/BISS	
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 plug-in 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 shielding components set: 1 shielding plate 4fold type 1; 1 hose clamp, W 9 mm, D 12-22 mm	
8SCS002.0000-00	ACOPOSmulti shielding components set: 1 clamp plate; 2 clamps D 4-13.5 mm; 4 screws	
8SCS003.0000-00	ACOPOSmulti shielding components set: 1 shielding plate 4fold 45°; 8 screws	
8SCS004.0000-00	ACOPOSmulti shielding components set: 1 shielding plate 1fold type 0; 2 hose clamps, W 9 mm, D 32-50 mm	
8SCS010.0000-00	ACOPOSmulti shielding components set: 1 ACOPOSmulti shielding plate SK14-20; 1 shielding clamp SK20	
	Terminal blocks	
8TB2104.203L-00	Screw clamp terminal block 4-pin, single-row, pitch: 5.08 mm, labeling 3: T- T+ B- B+, coding L: 1010	
8TB2106.2010-00	Screw clamp terminal block 6-pin, single-row, pitch: 5.08 mm, labeling 1: numbered consecutively	
8TB2108.2010-00	Screw clamp terminal block 8-pin, single-row, pitch: 5.08 mm, labeling 1: numbered consecutively	

Table 60: 8BVI0880HCSS.004-1, 8BVI0880HWSS.004-1 - Order data

Technical data

Product ID	8BVI0880HCSS.004-1	8BVI0880HWSS.004-1
General information		
B&R ID code	0xB450	0xB451
Cooling and mounting method	Cold plate or feed-through mounting	Wall mounting
Slots for plug-in modules	2	
Certification c-UL-us	In preparation	
DC bus connection		
Voltage Rated	750 VDC	
Continuous power consumption [1]	65 kW	

Table 61: 8BVI0880HCSS.004-1, 8BVI0880HWSS.004-1 - Technical data

Product ID	8BVI0880HCSS.004-1	8BVI0880HWSS.004-1
Power loss depending on the switching frequency [2]		
Switching frequency 5 kHz	$[0.03 \cdot I_M^2 + 7.9 \cdot I_M + 90]$ W	
Switching frequency 10 kHz	$[0.11 \cdot I_M^2 + 11 \cdot I_M + 185]$ W	
Switching frequency 20 kHz	$[0.17 \cdot I_M^2 + 27 \cdot I_M + 310]$ 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 * $P_{Fan8B0M...}$ [3]	
Design	ACOPOSmulti backplane	
24 VDC output		
Quantity	2	
Output voltage		
DC bus voltage (U_{DC}): 260 ... 315 VDC	25 VDC * (U_{DC}/315)	
DC bus voltage (U_{DC}): 315 ... 800 VDC	24 VDC ±6%	
Fuse protection	250 mA (slow-blow) electronic, automatic reset	
Motor connection [4]		
Quantity	1	
Continuous power per motor connection [1]	64 kW	
Continuous current per motor connection [1]	88 A_{eff}	
Reduction of continuous current depending on the switching frequency [5]		
Switching frequency 5 kHz	No reduction [6]	1.4 A/K (from 41 °C) [6]
Switching frequency 10 kHz	1.36 A/K (from 27 °C)	0.92 A/K (from -5 °C) [22]
Switching frequency 20 kHz	0.75 A/K (from -37 °C) [7]	0.56 A/K (from -90 °C) [22]
Reduction of continuous current depending on altitude		
Starting at 500 m above sea level	8.8 A_{eff} per 1000 m	
Peak current	176 A_{eff}	
Rated switching frequency	5 kHz	
Possible switching frequencies [8]	5/10/20 kHz	
Electrical stress of the connected motor in accordance with IEC TS 60034-25	Limit value curve A	
Protective measures / safeguards		
Overload protection	Yes	
Short circuit and ground fault	Yes	
Max. output frequency	600 Hz [9]	
Design		
U, V, W, PE	M8 threaded bolt	
Shield connection	Yes	
Terminal connection cross section		
Flexible and fine wire lines		
With wire tip sleeves	6 to 50 mm² [10]	
Approbation data		
UL/C-UL-US	In preparation	
CSA	In preparation	
Terminal cable cross-section dimension of the shield connection	12 to 50 mm [11]	
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 [12]	24 VDC +5.8% / -0% [13]	
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 / safeguards		
Overload and short circuit protection	Yes	
Cable breakage monitoring	Yes	
Undervoltage monitoring	Yes	
Response threshold for cable breakage monitoring	Approx. 0.5 A	
Response threshold for undervoltage monitoring	24 VDC +0% / -4%	
Encoder interfaces [14]		
Quantity	1	
Type	EnDat 2.2 [15]	
Connections	9-pin DSUB socket	
Displays	UP/DN LEDs	
Electrical isolation		

Table 61: 8BVI0880HCSS.004-1, 8BVI0880HWSS.004-1 - Technical data

Product ID	8BVI0880HCSS.004-1	8BVI0880HWSS.004-1
Encoder - ACOPOSmulti	No	
Encoder monitoring	Yes	
Max. encoder cable length	100 m Depending on the cross section of the supply wires on the encoder cable [16]	
Encoder supply		
Output voltage	Typ. 12.5 V	
Load capability	350 mA	
Protective measures / safeguards		
Short circuit protection	Yes	
Overload protection	Yes	
Synchronous serial interface		
Signal transfer	RS485	
Data transfer rate	6.25 Mbit/s	
Max. power consumption per encoder interface	P_{SMC} [W] = 19 V * $I_{Encoder}$ [A] [17]	
Trigger inputs		
Quantity	2	
Wiring	Sink	
Electrical isolation		
Input - Inverter module	Yes	
Input - Input	Yes	
Input voltage		
Rated	24 VDC	
Maximum	30 VDC	
Switching threshold		
Low	<5 V	
High	>15 V	
Input current at rated voltage	Approx. 10 mA	
Switching delay		
Positive edge	52 μs ± 0.5 μs (digitally filtered)	
Negative edge	53 μs ± 0.5 μs (digitally filtered)	
Modulation compared to ground potential	Max. ±38 V	
Operating conditions		
Permitted mounting orientations		
Hanging vertically	Yes	
Lying horizontally	Yes	
Standing horizontally	No	
Installation at altitudes above sea level		
Rated	0 to 500 m	
Maximum [18]	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 [19]	
Environmental conditions		
Temperature		
Operation		
Rated	5 to 40°C	
Maximum [20]	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 [21]		
Width	213.5 mm	
Height	317 mm	
Depth		
Wall mounting	-	263 mm
Cold-plate	212 mm	-
Feed-through mounting	209 mm	-
Weight	Approx. 8 kg	Approx. 10.2 kg
Module width	4	

Table 61: 8BVI0880HCSS.004-1, 8BVI0880HWSS.004-1 - Technical data

1) Valid in the following conditions: Bus voltage 750 VDC, switching frequency 5 kHz, 40°C ambient temperature, installation altitudes <500 m above sea level, no derating dependent on cooling type.
2) I_M ... Current on the motor connection [A].
3) P_{SMC1} ... Max. power consumption P_{SMC} [W] of the SafeMC module in SLOT1 (see the section "Encoder interfaces")
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)
4) B&R 8BCM motor cables must be used when cabling the motor connections.

5) Valid in the following conditions: DC bus voltage 750 VDC, minimum permissible coolant flow volume (3 l/min). The temperature specifications are based on the return temperature of the cold-plate mounting plate.
6) Value for the nominal switching frequency.
7) The module cannot supply the full continuous current at this switching frequency. This unusual value for the return temperature, at which a derating of the continuous current must be accounted for, 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 low return-temperatures.
8) B&R recommends operating the module at nominal switching frequency. Operating the module at a higher switching frequency for application-specific reasons reduces the continuous current and increases the CPU load.
9) The module's electrical output frequency (SCTRL_SPEED_ACT * MOTOR_POLEPAIRS) is monitored to protect against dual-use in accordance with EC 428/2009 | 3A225. If the electrical output frequency of the module exceeds the limit value of 600 Hz uninterrupted for more than 0.5 s, then the current motion is aborted and error 6060 is output (Power element: Limit speed exceeded).
10) The connection is made with cable lugs using an M8 threaded bolt.
11) The maximum diameter that can be clamped depends on the shield component set.
12) 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.
13) The specified values is only valid under the following conditions:
- The 24 VDC supply for the module is provided by an 8B0C auxiliary supply module, which is installed on the same mounting plate
- Connection between S1 and S2 (activation of the external holding brake) using a jumper with a length of max. 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 deactivated.
If jumpers longer than 10 cm are used to connect S1 and S2 , the output voltage is reduced because of voltage drops on the jumpers.
14) B&R 8BCF EnDat 2.2 cables must be used when cabling the encoder interfaces.
15) An EnDat 2.2 functional safety encoder is required when using ACOPOSmulti with SafeMC! With standard EnDat 2.2 encoders, only the timing of the functions STO, SBC and SS1 is monitored!
16) The maximum encoder cable length l_{max} can be calculated as follows (the maximum permissible encoder 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 [Ωmm²/m] (e.g. for copper: ρ = 0.0178)
17) $I_{Encoder}$ ... Max. power consumption of the connected encoder [A].
18) Continuous operation at altitudes ranging from 500 m to 4,000 m above sea level is possible (taking the continuous current reductions listed into consideration).
19) This value only applies with the factory settings (SLOT2 of the module is sealed by a slot cover shield plate). If SLOT2 on the module is not sealed, then the protection level is reduced to IP10. For this reason, we recommend only removing the slot cover shield plate if an ACOPOSmulti plug-in module is being used in SLOT2.
20) Continuous operation at ambient temperatures ranging from 40°C to max. 55°C is possible (taking the continuous current reductions listed into consideration), but results in a shorter lifespan.
21) The dimensions define the true device dimensions including the respective mounting plate. Make sure to leave additional space above and below the devices for mounting, connections and air circulation.
22) The module cannot supply the full continuous current at this switching frequency. This unusual value for the ambient temperature, at which a derating of the continuous current must be accounted for, ensures that the derating of the continuous current can be determined in the same manner as at other switching frequencies.

Wiring

For details, see section 3.6.3 "Wiring: Safe 4x width inverter modules (single-axis modules)" on page 91

For general information, please see section 6 "Wiring" on page 105

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

Overview of pin assignments

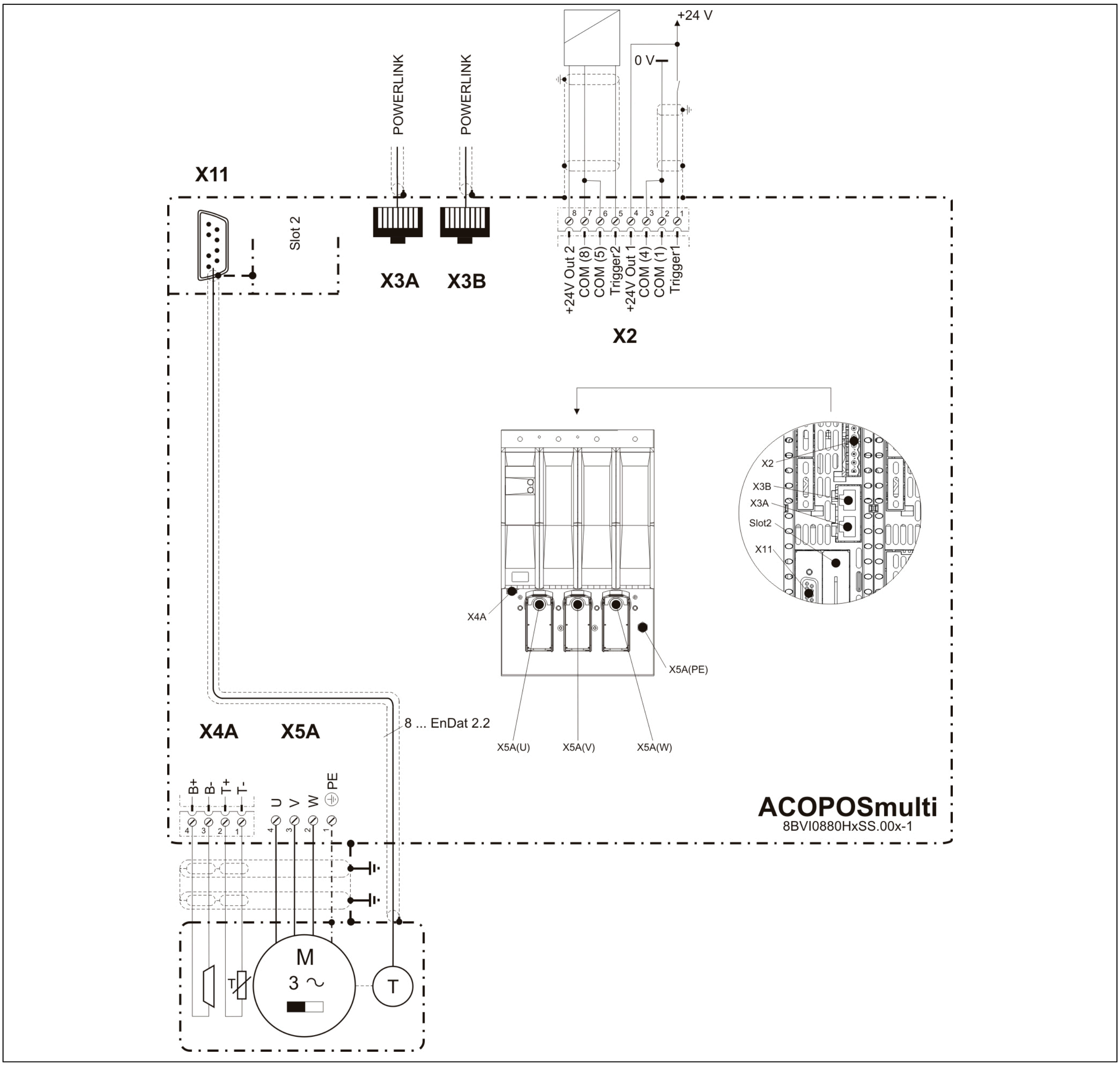


Figure 10: Overview of pin assignments

Pin assignments - X2 plug

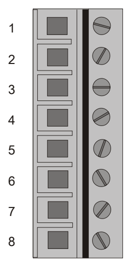
X2	Pin	Name	Function
	1	Trigger 1	Trigger 1
	2	COM (1)	Trigger 1 0 V
	3	COM (2)	+24 V output 1 0 V
	4	+24V Out 1	+24 V output 1
	5	Trigger 2	Trigger 2
	6	COM (5)	Trigger 2 0 V
	7	COM (8)	+24 V output 2 0 V
	8	+24V Out 2	+24 V output 2

Table 62: Pin assignments - X2 plug

Pin assignments - X3A, X3B plugs

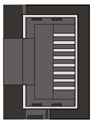
X3A, X3B	Pin	Bezeichnung	Funktion
	1	RXD	Receive Signal
	2	RXD\	Receive Signal inverted
	3	TXD	Transmit Signal
	4	Shield	Shield
	5	Shield	Shield
	6	TXD\	Transmit Signal inverted
	7	Shield	Shield
	8	Shield	Shield

Table 63: Pin assignments - X3A, X3B plugs

Pin assignments X4A plug

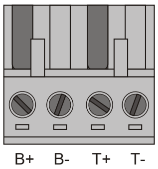
X4A	Name	Function
	T-	Axis 1: Temperature sensor -
	T+	Axis 1: Temperature sensor +
	B- [1)]	Axis 1: Brake -
	B+ [1)]	Axis 1: Brake +

Table 64: Pin assignments - X4A plug

1) The 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 24V. (i.e. safe pulse disabling is activated) However, the brake always remains on because of the short-circuit to 24 V!

This can lead to dangerous situations because the motor holding brake is not able to stop the spin-out movement!

Appropriate wiring measures must be implemented to ensure that the SBC output B+ is not shorted to 24V!

Danger!

The SBC output

- **must not be wired to multiple modules!**
- **must not be wired as open emitter!**
- **must not be wired as open collector!**

Information:

The transistors for the SBC output stage are tested cyclically. When output channels are activated , this test causes 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 isolated circuits. Therefore, these connections are only allowed to be connected to devices or components with at least safe 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!

Pin assignments - X5A plug

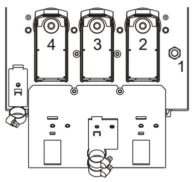
X5A	Name	Function
	1	Axis 1: Protective ground conductor
	2	Axis 1: Motor connection W
	3	Axis 1: Motor connection V
	4	Axis 1: Motor connection U

Table 65: Pin assignments - X5A plug

Warning!

B&R 8BCM motor cables must be used when cabling the motor connections.

Cable installation for motor connections U, V, W

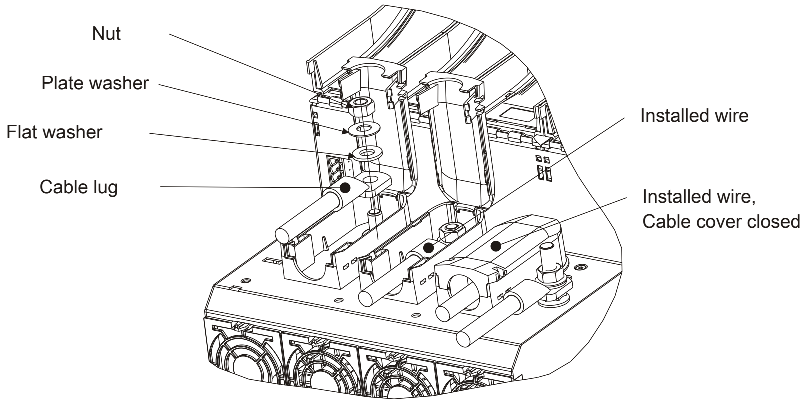


Figure 11: Cable installation - X5A

Cable installation connection PE (1 wire)

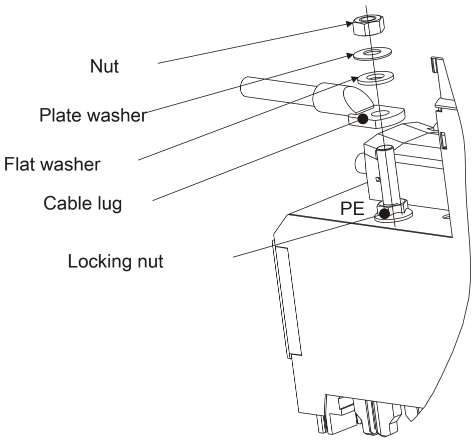
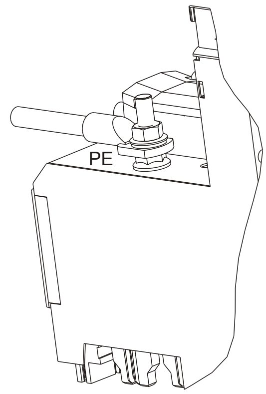
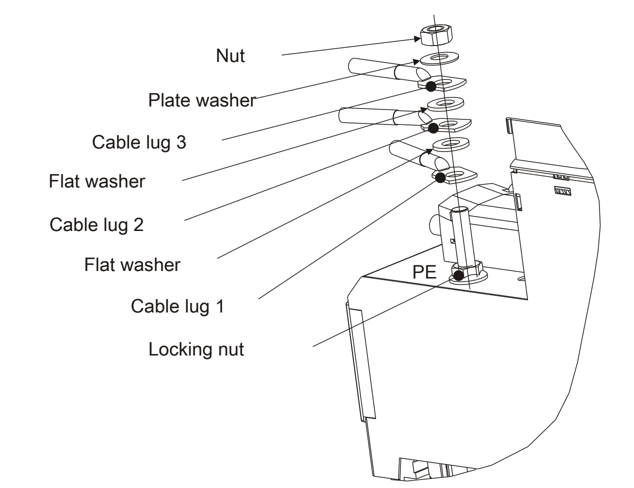
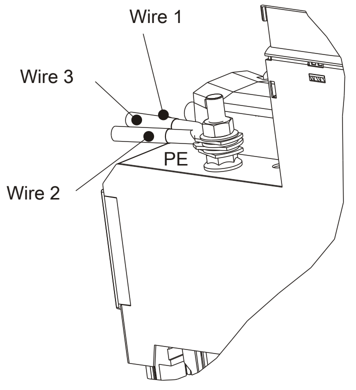
 Overview of installation material for PE connection (1 wire)	 Installed wire

Table 66: Cable installation connection PE (1 wire)

Cable installation connection PE (3 wire)



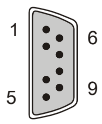
Overview of installation material for PE connection (3 wire)



Installed wire

Table 67: Cable installation connection PE (3 wire)

Pin assignments - SafeMC module

Image	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\	Inverted data input
		9	T\	Inverted clock output

Information:

The SafeMC module must only be used together with 8BCF EnDat 2.2 cables!

Note:

The SafeMC modules cannot be exchanged! The SafeMC modules together with the 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

General Information

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

Order data

Model number	Short description	Figure
	Cold plate or feed-through mounting	
8BVI1650HCSS.000-1	ACOPOSmulti inverter unit, 165 A, HV, cold plate or feed through mounting, SafeMC EnDat 2.2	
	Required accessories	
	Terminal block sets	
8BZVI1650SS.000-1A	Screw clamp terminal block set for ACOPOSmulti modules 8BVI0660HxSS, 8BVI0880HxSS and 8BVI1650HxSS: 1x 8TB2104.203L-00, 1x 8TB2108.2010-00	
	Optional accessories	
	Fan modules	
8BXF001.0000-00	ACOPOSmulti fan unit, replacement fan for ACOPOSmulti modules (8BxP/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/BISS	
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 plug-in 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 shielding components set: 1 shielding plate 4fold type 1; 1 hose clamp, W 9 mm, D 12-22 mm	
8SCS002.0000-00	ACOPOSmulti shielding components set: 1 clamp plate; 2 clamps D 4-13.5 mm; 4 screws	
8SCS003.0000-00	ACOPOSmulti shielding components set: 1 shielding plate 4fold 45°; 8 screws	
8SCS004.0000-00	ACOPOSmulti shielding components set: 1 shielding plate 1fold type 0; 2 hose clamps, W 9 mm, D 32-50 mm	
8SCS010.0000-00	ACOPOSmulti shielding components set: 1 ACOPOSmulti shielding plate SK14-20; 1 shielding clamp SK20	
	Terminal blocks	
8TB2104.203L-00	Screw clamp terminal block 4-pin, single-row, pitch: 5.08 mm, labeling 3: T- T+ B- B+, coding L: 1010	
8TB2108.2010-00	Screw clamp terminal block 8-pin, single-row, pitch: 5.08 mm, labeling 1: numbered consecutively	

Table 68: 8BVI1650HCSS.000-1 - Order data

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
Certification c-UL-us	 In preparation
DC bus connection	
Voltage Rated	 750 VDC
Continuous power consumption 1)	In preparation
Power loss depending on the switching frequency 2) Switching frequency 5 kHz Switching frequency 10 kHz Switching frequency 20 kHz	 In preparation In preparation 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 * $P_{Fan8B0M...}$ 3)
Design	ACOPOSmulti backplane
24 VDC output	
Quantity	2
Output voltage DC bus voltage (U_{DC}): 260 ... 315 VDC DC bus voltage (U_{DC}): 315 ... 800 VDC	 25 VDC * (U_{DC}/315) 24 VDC ±6%
Fuse protection	250 mA (slow-blow) electronic, automatic reset
Motor connection 4)	
Quantity	1
Continuous power per motor connection 1)	120 kW
Continuous current per motor connection 1)	165 A_{eff}
Reduction of continuous current depending on the switching frequency Switching frequency 5 kHz Switching frequency 10 kHz Switching frequency 20 kHz	 3.1 A/K (from 53 °C) 5) 1.8 A/K (from 17 °C) 1.2 A/K (from -60 °C) 6)
Reduction of continuous current depending on altitude Starting at 500 m above sea level	 16.5 A_{eff} per 1000 m
Peak current	330 A_{eff}
Rated switching frequency	5 kHz
Possible switching frequencies 7)	5/10/20 kHz
Electrical stress of the connected motor in accordance with IEC TS 60034-25	Limit value curve A
Protective measures / safeguards Overload protection Short circuit and ground fault	 Yes Yes
Max. output frequency	600 Hz
Design U, V, W, PE Shield connection	 M8 threaded bolt Yes
Terminal connection cross section Flexible and fine wire lines With wire tip sleeves Approbation data UL/C-UL-US CSA	 6 to 95 mm² 8) In preparation In preparation
Terminal cable cross-section dimension of the shield connection	12 to 50 mm 9)
Max. motor line length depending on the switching frequency Switching frequency 5 kHz Switching frequency 10 kHz Switching frequency 20 kHz	 25 m 25 m 25 m
Motor holding brake connection	
Quantity	1
Output voltage 10)	24 VDC +5.8% / -0% 11)
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

Table 69: 8BVI1650HCSS.000-1 - Technical data

Product ID	8BVI1650HCSS.000-1
Protective measures / safeguards Overload and short circuit protection Cable breakage monitoring Undervoltage monitoring	 Yes Yes Yes
Response threshold for cable breakage monitoring	Approx. 0.5 A
Response threshold for undervoltage monitoring	24 VDC +0% / -4%
Encoder interfaces [12]	
Quantity	1
Type	EnDat 2.2 [13]
Connections	9-pin DSUB socket
Displays	UP/DN LEDs
Electrical isolation Encoder - ACOPOSmulti	 No
Encoder monitoring	Yes
Max. encoder cable length	100 m Depending on the cross section of the supply wires on the encoder cable [14]
Encoder supply Output voltage Load capability Protective measures / safeguards Short circuit protection Overload protection	 Typ. 12.5 V 350 mA Yes Yes
Synchronous serial interface Signal transfer Data transfer rate	 RS485 6.25 Mbit/s
Max. power consumption per encoder interface	P_{SMC} [W] = 19 V * $I_{Encoder}$ [A] [15]
Trigger inputs	
Quantity	2
Wiring	Sink
Electrical isolation Input - Inverter module Input - Input	 Yes Yes
Input voltage Rated Maximum	 24 VDC 30 VDC
Switching threshold Low High	 <5 V >15 V
Input current at rated voltage	Approx. 10 mA
Switching delay Positive edge Negative edge	 52 µs ± 0.5 µs (digitally filtered) 53 µs ± 0.5 µs (digitally filtered)
Modulation compared to ground potential	Max. ±38 V
Operating conditions	
Permitted mounting orientations Hanging vertically Lying horizontally Standing horizontally	 Yes Yes No
Installation at altitudes above sea level Rated Maximum [16]	 0 to 500 m 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 [17]
Environmental conditions	
Temperature Operation Rated Maximum [18] Storage Transport	 5 to 40°C 55°C -25 to 55°C -25 to 70°C
Relative humidity Operation Storage Transport	 5 to 85% 5 to 95% Max. 95% at 40°C
Mechanical characteristics	
Dimensions [19] Width Height Depth	 427.5 mm 317 mm

Table 69: 8BVI1650HCSS.000-1 - Technical data

Product ID	8BVI1650HCSS.000-1
Cold-plate	212 mm
Feed-through mounting	209 mm
Weight	Approx. 19.5 kg
Module width	8

Table 69: 8BVI1650HCSS.000-1 - Technical data

1) Valid in the following conditions: Bus voltage 750 VDC, switching frequency 5 kHz, 40°C ambient temperature, installation altitudes <500 m above sea level, no derating dependent on cooling type.
2) I_M ... Current on the motor connection [A].
3) P_{SMC1} ... Max. power consumption P_{SMC} [W] of the SafeMC module in SLOT1 (see the section "Encoder interfaces")
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)
4) B&R 8BCM motor cables must be used when cabling the motor connections.
5) Value for the nominal switching frequency.
6) The module cannot supply the full continuous current at this switching frequency. This unusual value for the return temperature, at which a derating of the continuous current must be accounted for, 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 low return-temperatures.
7) B&R recommends operating the module at nominal switching frequency. Operating the module at a higher switching frequency for application-specific reasons reduces the continuous current and increases the CPU load.
8) The connection is made with cable lugs using an M8 threaded bolt.
9) The maximum diameter that can be clamped depends on the shield component set.
10) 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.
11) The specified values is only valid under the following conditions:
- The 24 VDC supply for the module is provided by an 8B0C auxiliary supply module, which is installed on the same mounting plate
- Connection between S1 and S2 (activation of the external holding brake) using a jumper with a length of max. 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 deactivated.
If jumpers longer than 10 cm are used to connect S1 and S2 , the output voltage is reduced because of voltage drops on the jumpers.
12) B&R 8BCF EnDat 2.2 cables must be used when cabling the encoder interfaces.
13) An EnDat 2.2 functional safety encoder is required when using ACOPOSmulti with SafeMC! With standard EnDat 2.2 encoders, only the timing of the functions STO, SBC and SS1 is monitored!
14) The maximum encoder cable length l_{max} can be calculated as follows (the maximum permissible encoder 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 [Ωmm²/m] (e.g. for copper: ρ = 0.0178)
15) $I_{Encoder}$ ... Max. power consumption of the connected encoder [A].
16) Continuous operation at altitudes ranging from 500 m to 4,000 m above sea level is possible (taking the continuous current reductions listed into consideration).
17) This value only applies with the factory settings (SLOT2 of the module is sealed by a slot cover shield plate). If SLOT2 on the module is not sealed, then the protection level is reduced to IP10. For this reason, we recommend only removing the slot cover shield plate if an ACOPOSmulti plug-in module is being used in SLOT2.
18) Continuous operation at ambient temperatures ranging from 40°C to max. 55°C is possible (taking the continuous current reductions listed into consideration), but results in a shorter lifespan.
19) The dimensions define the true device dimensions including the respective mounting plate. Make sure to leave additional space above and below the devices for mounting, connections and air circulation.

Wiring

For details, see section 3.7.2 "Wiring: Safe 8x width inverter modules (single-axis modules)" on page 99

For general information, please see section 6 "Wiring" on page 105

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

Overview of pin assignments

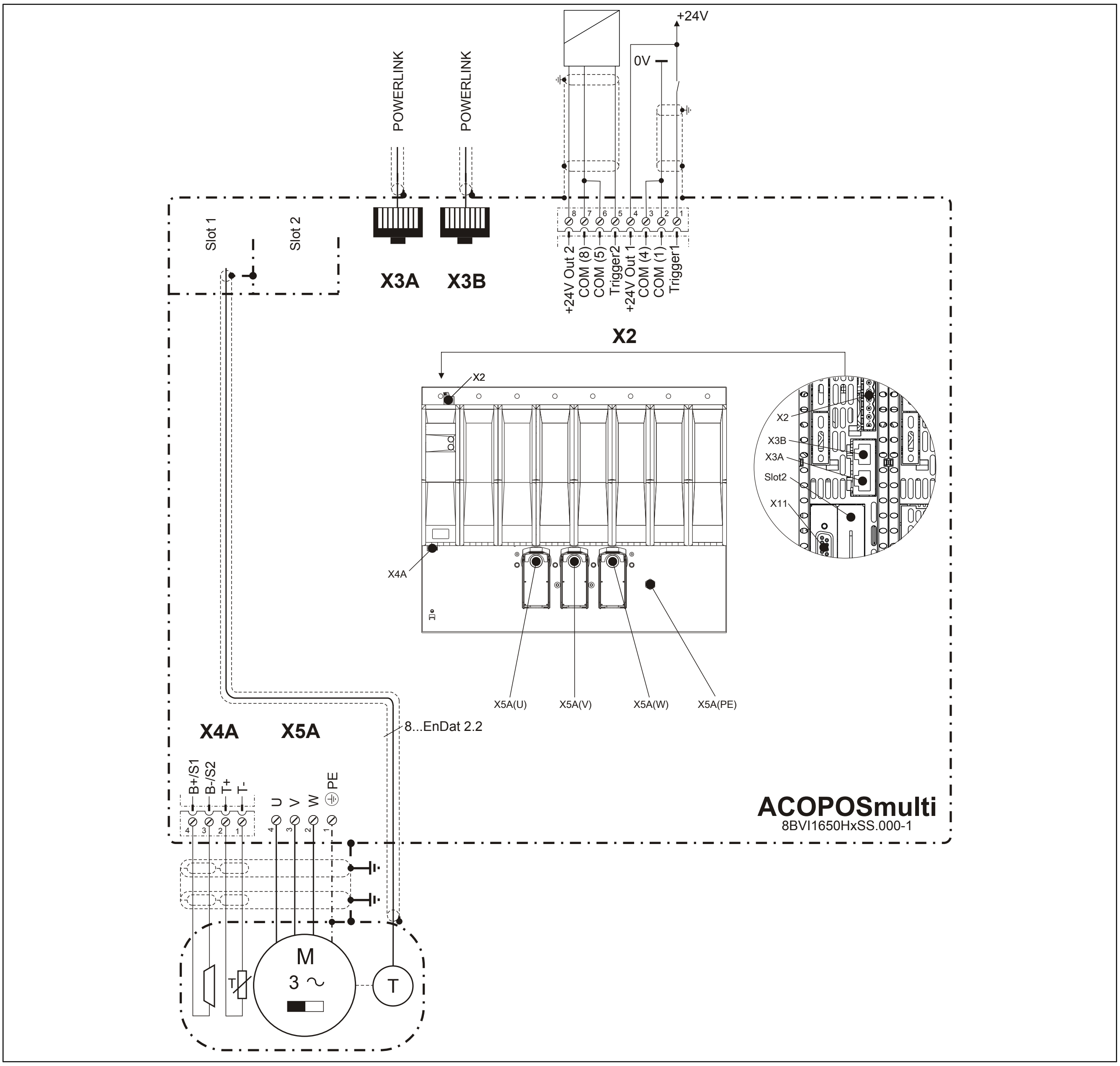


Figure 12: Overview of pin assignments

Pin assignments - X2 plug

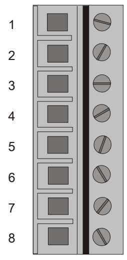
X2	Pin	Name	Function
	1	Trigger 1	Trigger 1
	2	COM (1)	Trigger 1 0 V
	3	COM (2)	+24 V output 1 0 V
	4	+24V Out 1	+24 V output 1
	5	Trigger 2	Trigger 2
	6	COM (5)	Trigger 2 0 V
	7	COM (8)	+24 V output 2 0 V
	8	+24V Out 2	+24 V output 2

Table 70: Pin assignments - X2 plug

Pin assignments - X3A, X3B plugs

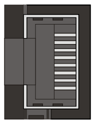
X3A, X3B	Pin	Bezeichnung	Funktion
	1	RXD	Receive Signal
	2	RXD\	Receive Signal inverted
	3	TXD	Transmit Signal
	4	Shield	Shield
	5	Shield	Shield
	6	TXD\	Transmit Signal inverted
	7	Shield	Shield
	8	Shield	Shield

Table 71: Pin assignments - X3A, X3B plugs

Pin assignments X4A plug

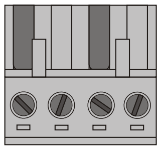
X4A	Name	Function
	T-	Axis 1: Temperature sensor -
	T+	Axis 1: Temperature sensor +
	B- [1)]	Axis 1: Brake -
	B+ [1)]	Axis 1: Brake +

Table 72: Pin assignments - X4A plug

1) The 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 24V. (i.e. safe pulse disabling is activated) However, the brake always remains on because of the short-circuit to 24 V!

This can lead to dangerous situations because the motor holding brake is not able to stop the spin-out movement!

Appropriate wiring measures must be implemented to ensure that the SBC output B+ is not shorted to 24V!

Danger!

The SBC output

- **must not be wired to multiple modules!**
- **must not be wired as open emitter!**
- **must not be wired as open collector!**

Information:

The transistors for the SBC output stage are tested cyclically. When output channels are activated , this test causes 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 isolated circuits. Therefore, these connections are only allowed to be connected to devices or components with at least safe 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!

Pin assignments - X5A plug

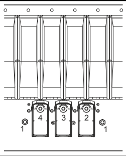
X5A	Pin	Name	Function
	1	PE	Axis 1: Protective ground conductor
	2	W	Achse 1: Motor connection W
	3	V	Achse 1: Motor connection V
	4	U	Achse 1: Motor connection U
	Nut torque M8: 12 Nm		

Table 73: Pin assignments X5A plug

Warning!

B&R 8BCM motor cables must be used when cabling the motor connections.

Cable installation for motor connections U, V, W

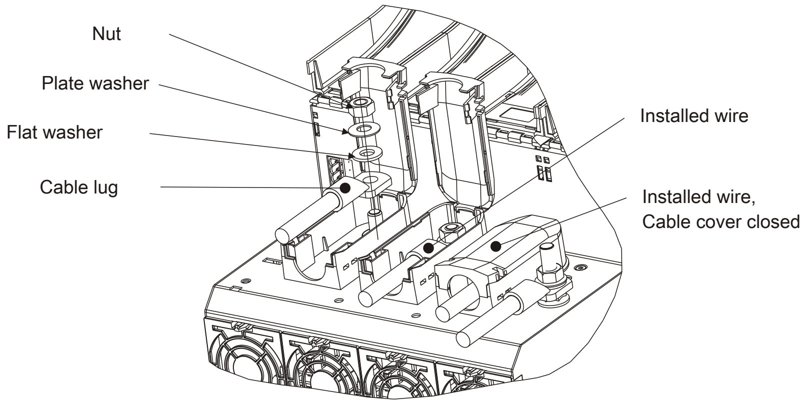


Figure 13: Cable installation - X5A

Cable installation connection PE (1 wire)

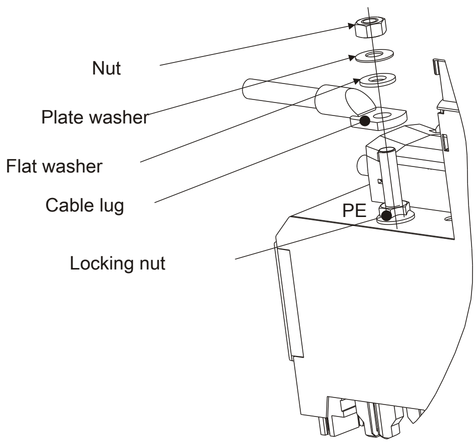
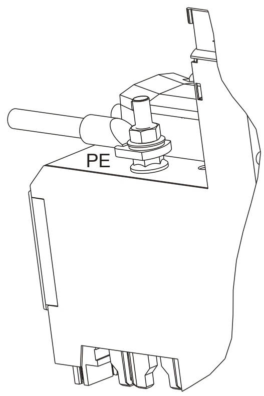
 Overview of installation material for PE connection (1 wire)	 Installed wire

Table 74: Cable installation connection PE (1 wire)

Cable installation connection PE (3 wire)

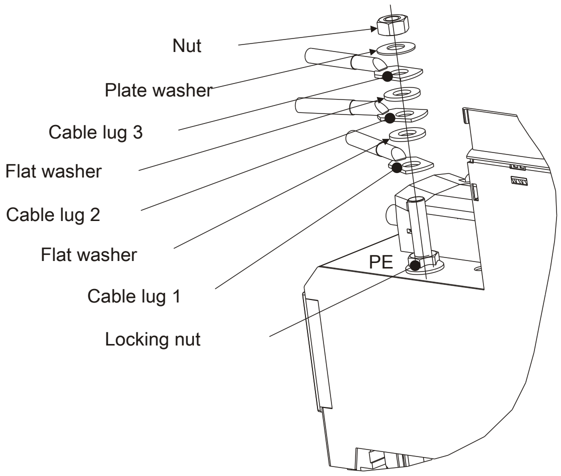
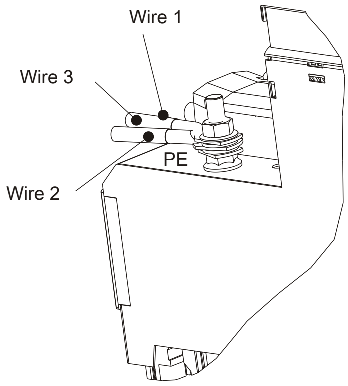
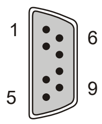
 Overview of installation material for PE connection (3 wire)	 Installed wire

Table 75: Cable installation connection PE (3 wire)

Pin assignments - SafeMC module

Image	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\	Inverted data input
		9	T\	Inverted clock output

Information:

The SafeMC module must only be used together with 8BCF EnDat 2.2 cables!

Note:

The SafeMC modules cannot be exchanged! The SafeMC modules together with the inverter module form a single unit. In the event of an error, the entire inverter module must be replaced.

4 Installation

See ACOPOSmulti User's Manual MAACPM-ENG, "Installation" chapter.

5 Dimensioning

See ACOPOSmulti User's Manual MAACPM-ENG, "Sizing" chapter.

6 Wiring

6.1 General Information

6.1.1 Electromagnetic compatibility of the 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 meets the requirements for harmonized EMC product standard IEC 61800-3:2004 for industry (second environment).

Additional EMC measures must be implemented by the manufacturer of machines or systems if the product standards for the machine has lower limits or if the machine should conform to generic standard IEC 61000-6-4. Proof of conformity to the necessary limits must be provided according to the documentation for use of the EMC directives from the manufacturer or distributor of the machine or system.

Additional EMC measures are needed when operating ACOPOSmulti drive systems in a living area or when connecting ACOPOSmulti drive systems to a low voltage system which supplies buildings in living areas without an intermediate transformer (first environment).

Installation notes

1. The control cabinet or the system must be constructed appropriately.
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 are to be equipped with corresponding suppressor elements such as varistors, RC elements or damping diodes.
4. All electrical connections are to be kept as short as possible.
5. Cable shields are to be attached to the designated shield terminals and the plug housing.
6. Shielded cables with copper mesh or tinned copper mesh are to be used. Twisting or extending the protective mesh using single conductors is not allowed.
7. Unused cable conductors are to be grounded on both sides if possible.

6.1.2 Overview

Passive power supply

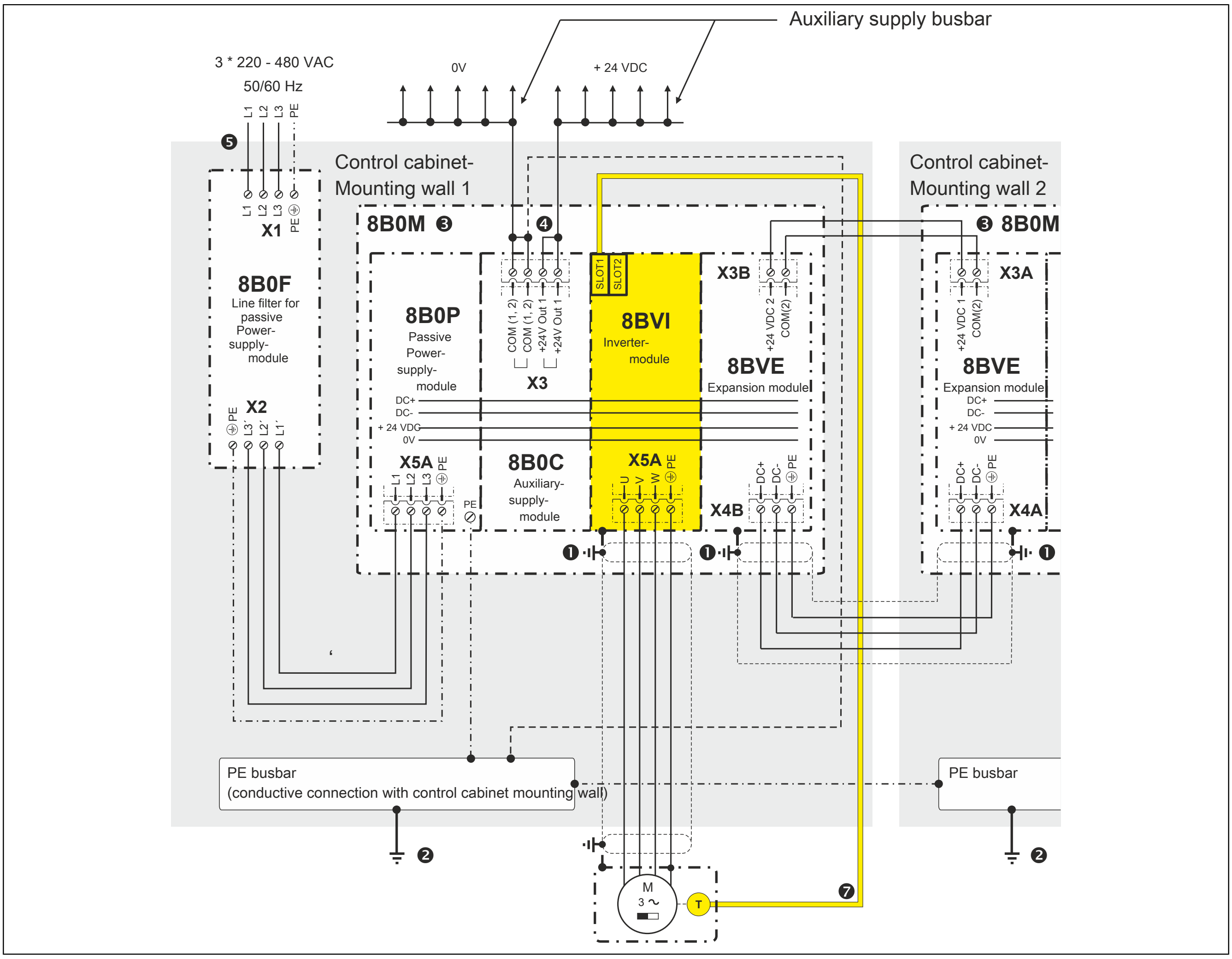


Figure 14: Overview of ground/shield for ACOPOSmulti drive system (passive power supply)

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 plug 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 in the power mains line (5), this cannot be parallel to the connection between the line filter and power supply module.
7 B&R 8BCF EnDat 2.2 cables must be used when cabling the encoder interfaces.

Active power supply

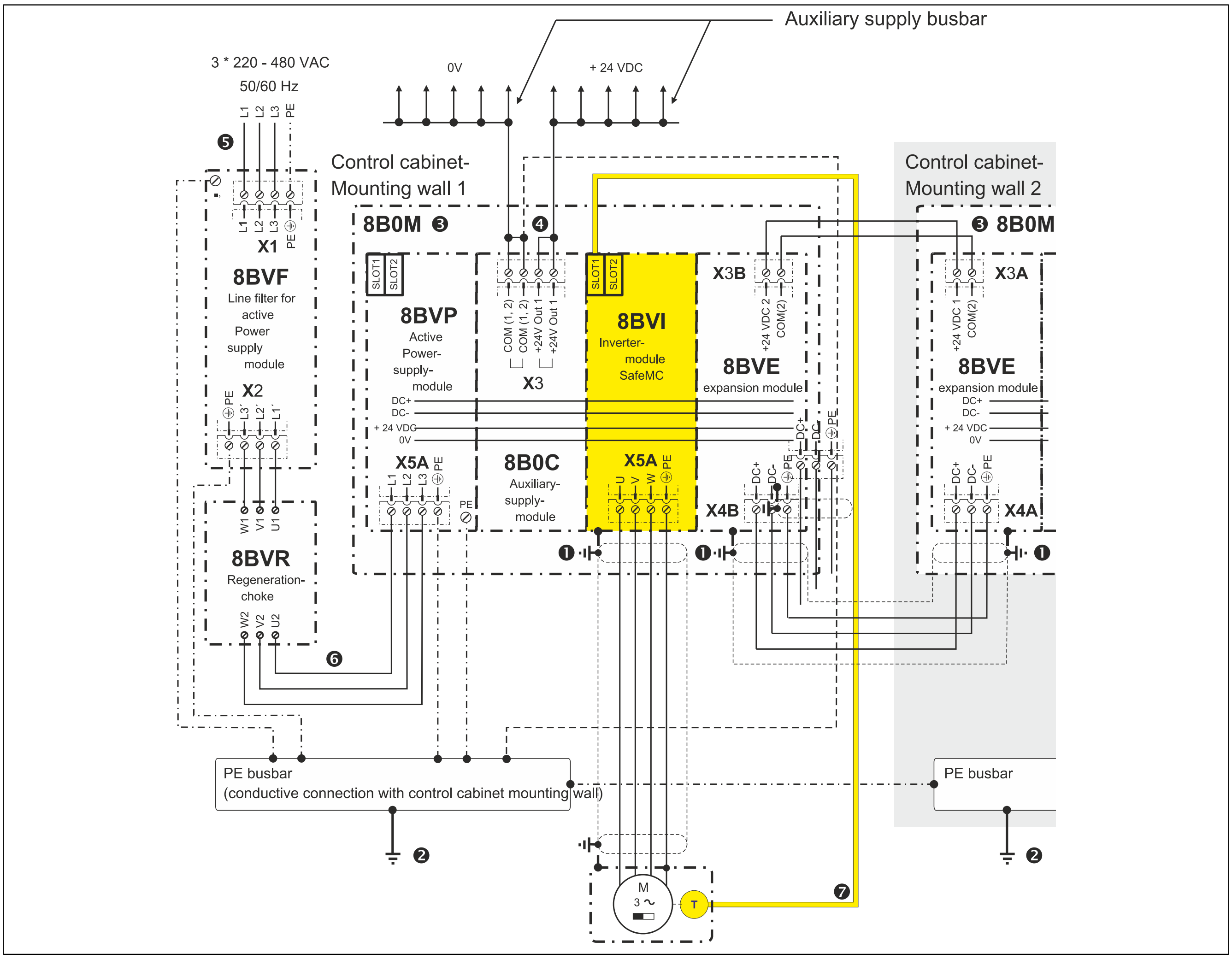


Figure 15: Overview of ground/shield for ACOPOSmulti drive system (active power supply)

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 plug 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 in the power mains line (5), this cannot be parallel to the connection between the line filter and power supply module.
7 B&R 8BCF EnDat 2.2 cables must be used when cabling the encoder interfaces.

Danger!

One of the two COM connections (1, 2) on the X3 plug 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).

6.1.3 Connection diagrams for ground and shield connections

8BVI inverter modules with SafeMC (single-axis modules)

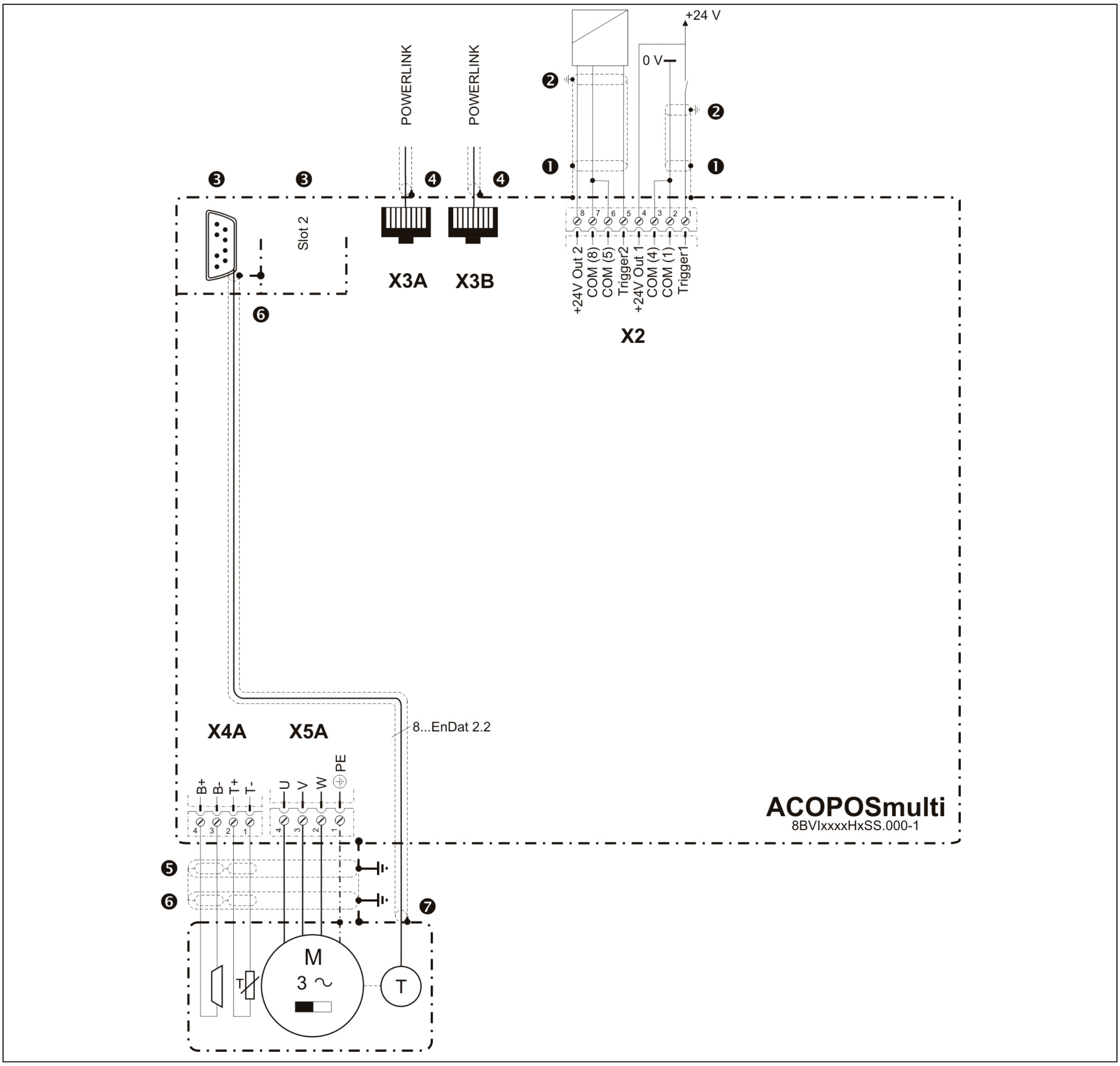


Figure 16: Ground connections and shield connections for 8BVI inverter modules with SafeMC

1. Both trigger inputs are only filtered internally with approx. 50µs. Make sure the cable shield is grounded properly. The optional shield set 8SCS002.0000-00 can be used with this.
2. The cable shield must be attached to the shield connector.
3. All mounting brackets on ACOPOSmulti plug-in modules automatically come in contact with the housing when inserted in the module slot.
   By default, open module slots on ACOPOSmulti inverter modules with SafeMC are closed with the shielding set 8SCS005.0000-00.

Figure 17: Use of the shield set 8SCS005.0000-00

4. **Cable connection via DSUB plug:**
   The cable shield must be sufficiently connected using the designated clamp in the metallic or metal-plated DSUB plug housing. The DSUB plug fastening screws must be tightened.

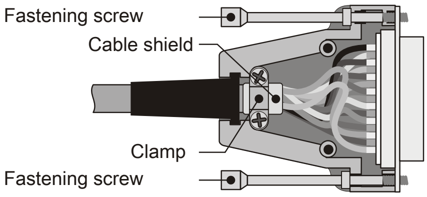


Figure 18: Cable shielding in DSUB housing

Cable connection via terminals:
The cable shield must be connected to the ACOPOSmulti module housing using the optional shield set 8SCS002.0000-00.

Cable connection via RJ45 plug:
Grounding the cable shield as well provides an improvement in EMC properties. Grounding should take place on both sides, extensively and near to the connector. The optional shield set 8SCS002.0000-00, available from B&R, can be used on the ACOPOSmulti module.

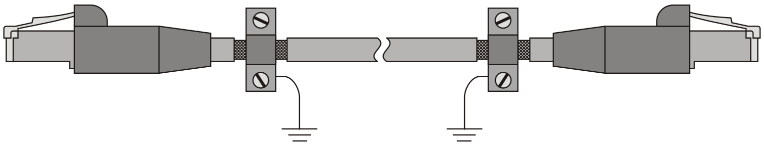


Figure 19: Grounding the POWERLINK cable shielding

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 with 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 using the motor plug 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 plug and connected to ground via the machine.

   For external encoders, the cable shield of the encoder cable must be connected (on the encoder side) with the machine and therefore with ground using the encoder plug.

6.1.4 Isolation and high-voltage test

Insulation resistance in accordance with EN 60204

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

Motor connection of ACOPOSmulti inverter modules (X5A/X5B)

> **Warning!**
>
> **An insulation test is not permitted to be carried out on the motor connection (X5A/X5B) of ACOPOSmulti inverter modules because that 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 insulation resistance is measured!**

B&R motors and B&R motor cables

In principle, an insulation resistance measurement can be carried out on B&R motor cables and B&R motors. However, the insulation resistance can be lower than 1 MΩ depending on the motor that is connected. The 50 kΩ minimum value required by the EN 60204 section18.3 standard is exceeded.

> **Warning!**
>
> **An insulation test is not permitted to be carried out on the motor connection (X5A/X5B) of ACOPOSmulti inverter modules because that 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 insulation resistance is measured!**

High voltage test

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, and at least 1000VAC (50/60 Hz). Components that cannot handle this test voltage must be disconnected before carrying out the high voltage test.

Motor connection of 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 because that would destroy the ACOPOSmulti inverter modules!**

B&R motors and B&R motor cables

In principle, a high voltage test 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 because that 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!**

Typical procedure

Isolation test

a) Remove the motor cable from the X5A/X5B connection of 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 test

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

Chapter 3 • System characteristics

1 SafeMC Module

1.1 General Information

The SafeMC module is an integrated part of the safe ACOPOSmulti with SafeMC.
One SafeMC module is integrated for each safe axis in the safe drive; this means that one SafeMC module is built into in a safe single-axis module, or two SafeMC modules in a safe double-axis module!

One SafeMC module corresponds with one safe node and performs the safety functions on the drive.

Information:

A safe double-axis module contains two SafeMC modules. This corresponds with 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 SafeMC module! This means that a standard ACOPOS-multi axis cannot be retrofitted!

1.2 Safety functions

The following safety functions are supported by the SafeMC module:

Safety function	Starting in safety release	EN ISO 13849-1	EN 61508/EN 62061	Safe encoder evaluation required
Safe Torque Off (STO)	R 1.3	Pl e	SIL 3	No
Safe Torque Off One Channel (STO1)	R 1.3	Pl d	SIL 2	No
Safe Operation Stop (SOS)	R 1.3	Pl d	SIL 2	Yes
Safe Stop 1 (SS1)	R 1.3	PL e (time monitored) Pl d	SIL 3 (time monitored) SIL 2	no (time monitored) Yes
Safe Stop 2 (SS2)	R 1.3	Pl d	SIL 2	Yes
Safely Limited Speed (SLS)	R 1.3	Pl d	SIL 2	Yes
Safe Maximum Speed (SMS)	R 1.3	Pl d	SIL 2	Yes
Safe Direction (SDI)	R 1.3	Pl d	SIL 2	Yes
Safely Limited Increment (SLI)	R 1.3	Pl d	SIL 2	Yes
Safe Brake Control (SBC)	R 1.3	Pl d	SIL 2	No
Safely Limited Position (SLP)	R 1.4	Pl d	SIL 2	Yes
Safe Maximum Position (SMP)	R 1.4	Pl d	SIL 2	Yes
Safe referencing	R 1.4	Pl d	SIL 2	Yes

Table 76: Safety functions and corresponding safety levels

Details about the individual safety functions can be found in section Chapter 4 "Safety technology" on page 123!

2 Integrated safety technology

Seamless integration of safety technology in the standard application is a reality with B&R's safety technology products. Fixed wiring is replaced by safe data transfer via the existing machine bus system. Flexibly configured or programmed safety behavior adapts optimally to various safety situations. Complete diagnostics of safety components via the machine bus system provide detailed data about the status of the machine.

Insufficient safety regarding manipulation and the inadequacy of current safety solutions allow dangerous behavior when operating the machine. New safety technology possibilities provide considerable potential for improvement here. While working to improve the safety of machines, 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 current and expected future demands on safety components.

Safety shut-offs do not always have to involve a full machine shutdown. 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 can be used in safety applications up to:

- EN ISO 13849, PL e
- IEC 62061, SIL 3
- IEC 61508, SIL 3
- IEC 61511, SIL 3

The actual level of safety achieved depends on the respective safety function!

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 modern, integrated and intelligent safety bus technology. POWERLINK and openSAFETY accomplish this all using standard Ethernet mechanisms. This allows these protocols to be combined with all conventional and, more importantly, newer Ethernet profiles. openSAFETY is the fastest and most flexible real-time safety bus system on the market.

The reduction to one cable allows for transfer of safe data 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 safe and standard applications are things of the past. Smart-safe reactions instead of hard machine stops provide advantages for processes, help to avoid manipulation and increase the value of machines.

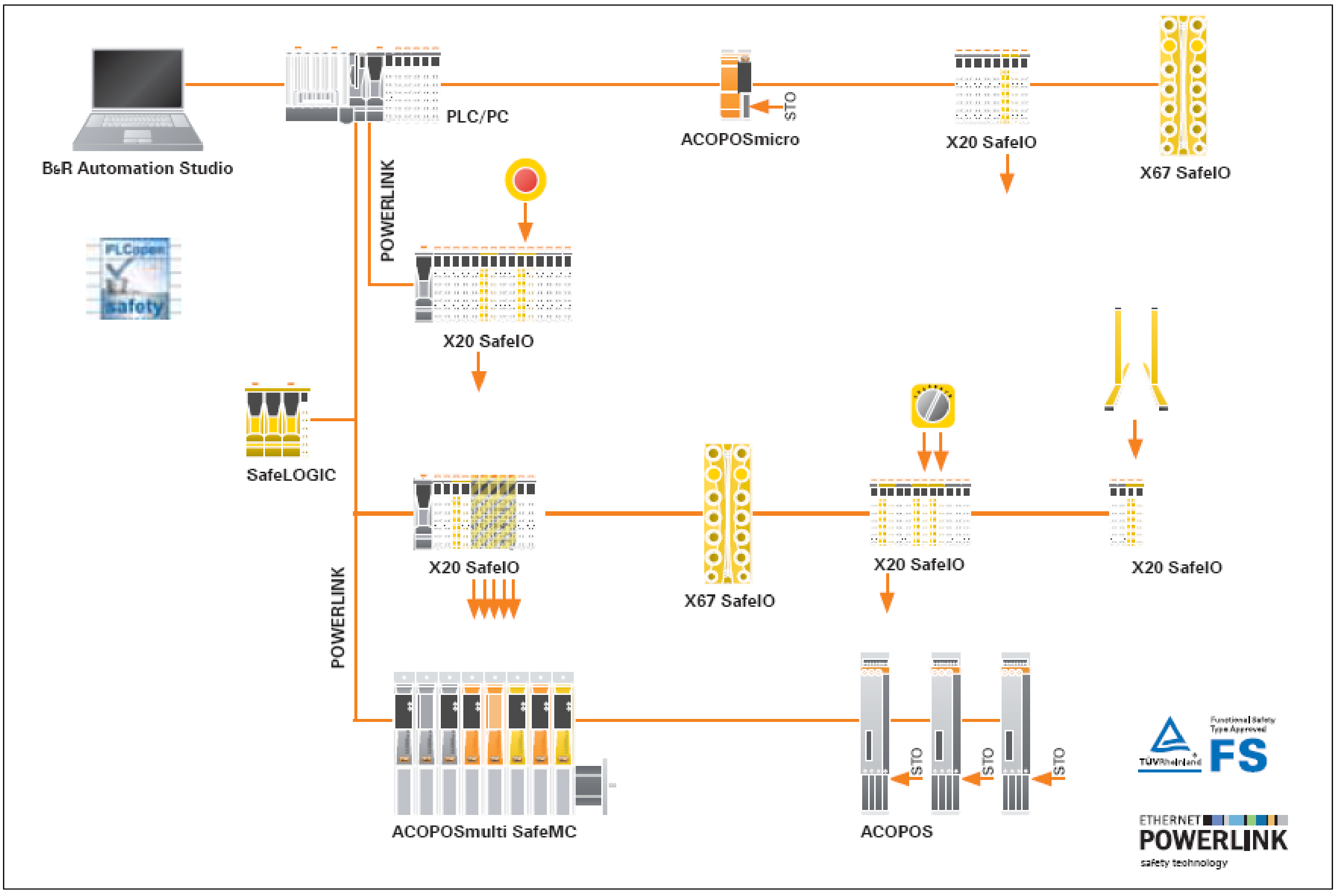


Figure 20: Integrated Safety Technology - Topology

3 System requirements

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

- POWERLINK V2
- Automation Studio V3.0.80 or higher
- Automation Runtime V3.00 or higher
- ACP10 software V2.180 or higher (for Safety Release R1.3)
- ACP10 software V2.250 or higher (for Safety Release R1.4)
- SG4 CPUs

4 System limits

The following limitations exist when using SafeMC modules:

- One SafeMC module corresponds with one safe node. One SafeMC module is integrated in a single-axis inverter module, which means **one safe node.** Two SafeMC modules are integrated in a dual-axis inverter module, which means **two safe nodes**. Additionally, each inverter module corresponds with **one POWERLINK node**.
- A SafeMC module can only securely communicate with one (1) SafeLOGIC module with SafeMC Support (X20SL8010, X20SL8011). It is not possible for a SafeMC module to securely communicate with several SafeLOGIC modules or with other safe modules (other SafeIO, SafeMC, etc.).
- A SafeLOGIC plus can securely communicate with a maximum of 100 safe nodes, while a SafeLOGIC standard can securely communicate with a maximum of 20 safe nodes (SafeIO, safe ACOPOSmulti, additional SafeLOGIC modules, etc.).
- A SafeLOGIC plus module with SafeMC support can communicate with max. 80 SafeMC modules, a SafeLOGIC standard module with max. 10.
- A SafeLOGIC plus can exchange data with a maximum of 50 POWERLINK nodes, while a SafeLOGIC standard can exchange data with a maximum of 10 POWERLINK nodes (CPU, bus controller with SafeIO, safe ACOPOSmulti, additional SafeLOGIC modules, etc.).
- Additionally, a SafeLOGIC plus can function as a gateway between several SafeLOGIC modules. This means that it can securely communicate with a maximum of 10 other SafeLOGIC modules (SafeLOGIC standard or SafeLOGIC plus).
- Communication between two SafeLOGIC modules is limited to 16 variables per data direction. The available variable types include SafeINT, SafeDINT, SafeUINT, SafeUDINT and SafeBOOL. In the interest of limiting to 8 variables, 8 SafeBOOL variables together are counted as one.
- In a safety-related application, a maximum of 20 SafeLOGIC devices can interact.
- The output side payload size of the SafeLOGIC is limited to 1490 bytes. Among other things, this limitation reduces the resulting number of usable SafeIO or SafeMC modules during SafeLOGIC to SafeLOGIC communication.
- The safe state is always initiated in the B&R safety modules by shutting off the output. This property is constructively implemented in the modules and cannot be changed.
  This is particularly important for SafeMC modules because the safe state cuts off the torque on the motor!

Danger!

In cases involving external forces (e.g. hanging loads), this can cause dangerous movement!
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 Safe response time

The safe response time is the time between the arrival of the signal on the input channel and the output of the switch-off signal from the output.

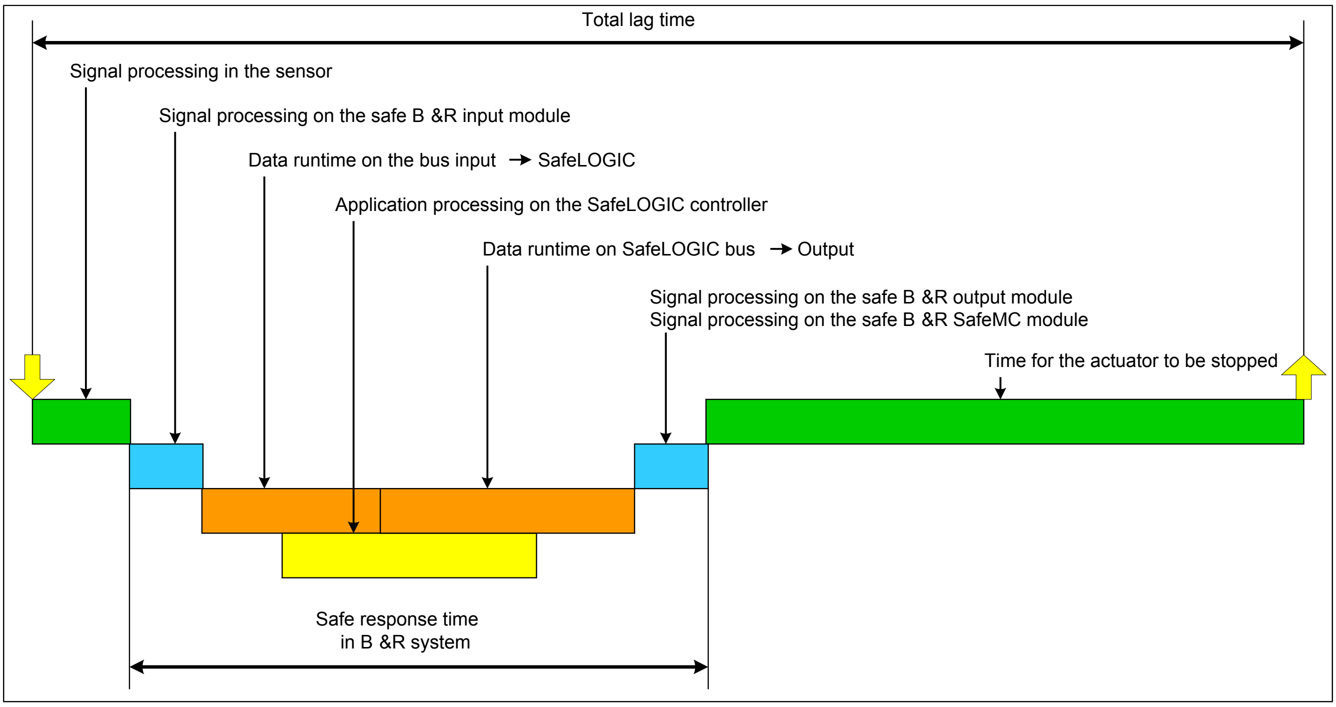


Figure 21: Total lag time

As evident in the figure, the safe response time in the B&R system is comprised of the following partial response times:

- Signal processing on the safe B&R input module
- Data runtime on the bus between the input and SafeLOGIC controller
- Data runtime on the bus between the SafeLOGIC controller and the output
- Signal processing on the safe B&R output module

Danger!

The following sections are dedicated exclusively to the safe 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 reaches 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 configuring external pulse signals
- 400 ms when using safe analog input channels or safe temperature inputs

5.2 Data runtime on the bus

The following relationship must be observed for the data runtime on the bus:

- The data runtime from the input to the SafeLOGIC controller or to the output depends on the sum of the cycle times and CPU copy times taking in effect the transmission path.
- The POWERLINK MN (standard CPU) settings are important for the actual timing on the bus, but they cannot be used from a safety standpoint because the values can be changed at any time in the course of modifications outside of the safety application.

- In the SafeLOGIC controller, data runtimes are monitored on the bus using POWERLINK safety services. The time needed to process the application on the SafeLOGIC controller is accounted for in this test (system dependent). Monitoring is defined in SafeDESIGNER using the parameters in the "Safety_Response_Time" parameter group.

Information:

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

5.3 Signal processing on the B&R output module

The duration of signal processing on the output module amounts to the following:

- with FET technology the max. is 800 µs
- with relay channels the max. is 50 ms

5.4 Signal processing in the safe B&R SafeMC module

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

However, in addition to the signal processing, the duration of the communication between the POWERLINK interface and the SafeMC module must also be accounted for. 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 the safety measures.

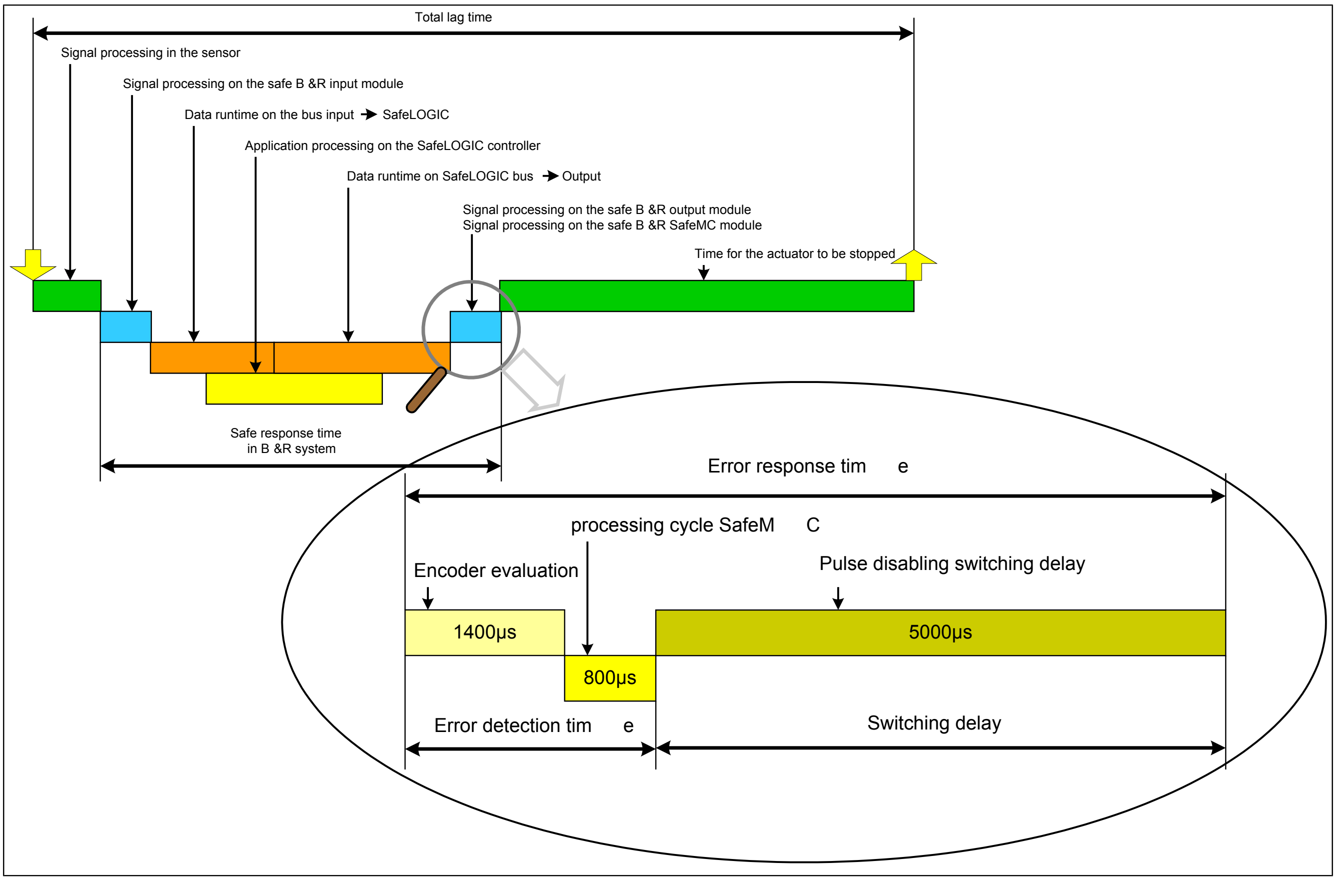


Figure 22: Safe error response time

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

The safe error response time includes:

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

Danger!

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

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

The speed resulting from this must be considered together with the speed when the safety function is violated in order to determine the maximum possible speed at the time of spin-out!

Furthermore, if an error occurs, the error response time must be used when determining the remaining distance, in order to determine the maximum distance by which a monitored position limit can be exceeded!

5.5 Calculation of the safe response times

The safe response time can be calculated with the response time calculator. This tool can be opened with 'Project/ Response time calculator'.

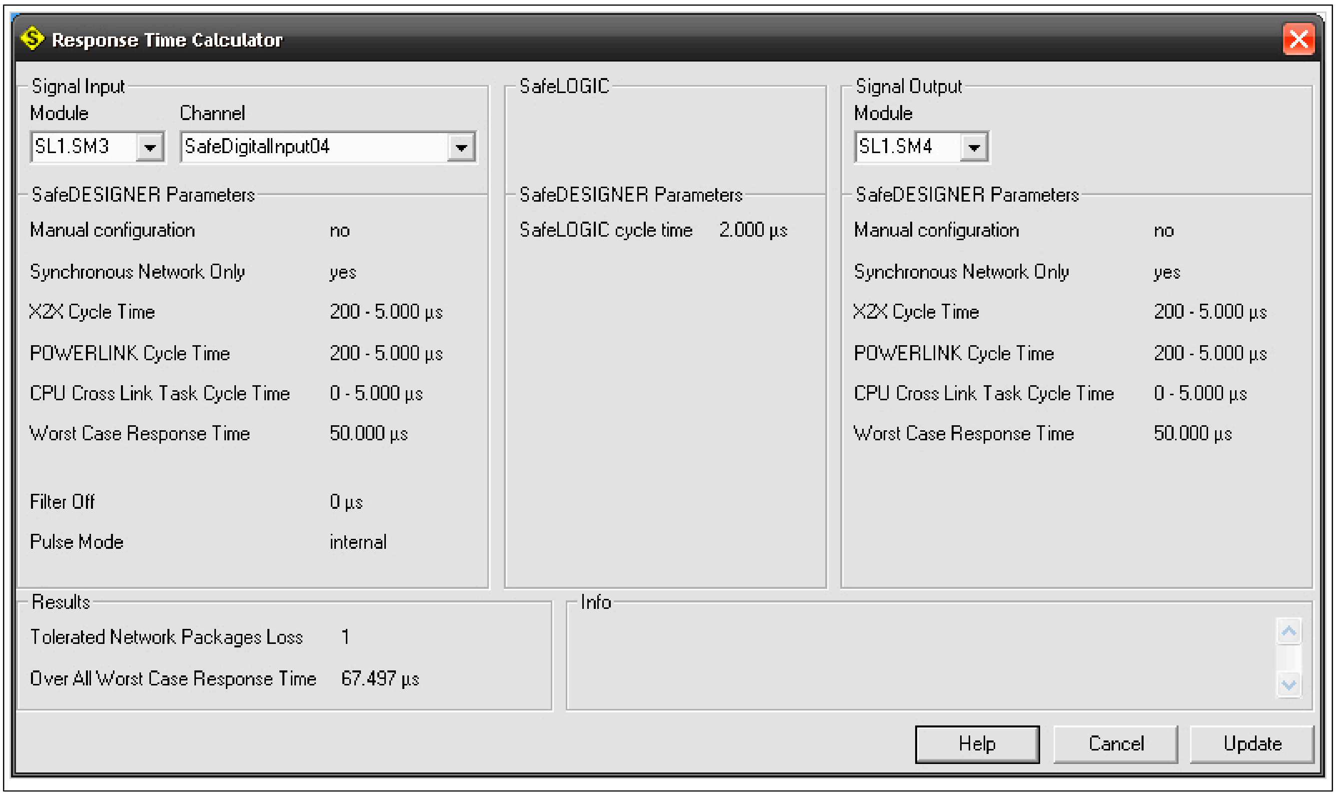


Figure 23: Response time calculator

The response time calculator takes the values set in SafeDESIGNER and uses them to calculate the entire response time and the tolerated package 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 shown in SafeDESIGNER automatically, and the entire 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	Meaning	Corresponding SafeDESIGNER parameters
Only synchronous networks	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 in the SafeLOGIC.	Min_Powerlink_CycleTime_us - Max_Powerlink_CycleTime_us
CPU cross-communication cycle time	0–30,000 µs	Cycle time entry of the CPU cross link task for checking the data runtime in the SafeLOGIC controller.	Min_CPU_CrossLinkTask_CycleTime_us - Max_CPU_CrossLinkTask_CycleTime_us
Response time	3000-500000 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 used on the input module.	Filter_Off_us
	1–500,000 µs	A switch-off filter is used on the input module.	
External pulse	External	"External clock signals" mode is used on the input module.	Pulse_Mode = external
	Internal	"External clock signals" mode is used on the input module.	Pulse_Mode = internal
	None	"External clock signals" mode is not 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 77: Information 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 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 possibilities of the CPU_CrossLinkTask for monitoring the runtime of 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 78: Meaning of the min./max. CPU parameters

Output fields:

Output field	Value	Meaning	Corresponding SafeDESIGNER parameters
Package loss on the network	0-10	Number of lost packets that are tolerated without switching off the safety application.	-
Total response time	- -	Resulting safe response time on the B&R system.	-

Table 79: Output fields in the "Response time calculator"

5.6 Parameters for the safe response time in SafeDESIGNER

Generally, the parameters for safe response time are configured the same for all stations involved in the application. This is why these parameters are configured for the SafeLOGIC controller in the SafeDESIGNER.

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

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

Parameters	Description	Default value	Units
Manual_Configuration	Generally, the parameters for safe response time are configured the same for all stations involved in the application. This is why these parameters are configured for the SafeLOGIC controller in the SafeDESIGNER. For application situations in which individual safety functions require optimum response time behavior, the parameters for safe response time can be configured individually on the respective module.	No	-

Table 80: Parameters for the safe response time in SafeDESIGNER

<table>
<tr><th>Parameters</th><th>Description</th><th>Default value</th><th>Units</th></tr>
<tr><td></td><td colspan="3"><table><tr><th>Parameter value</th><th>Description</th></tr><tr><td>Yes</td><td>The individual data from the group 'Safety_Response_Time' on the module is used to calculate the safe response time for the module's signals.</td></tr><tr><td>No</td><td>The generally configured parameters for the safe response time from the group 'Safety_Response_Time' on the SafeLOGIC are valid for the module.</td></tr></table></td></tr>
<tr><td rowspan="2">Synchronous_Network_Only</td><td>This parameter determines the synchronization properties of the underlying network.</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 safe 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 with the maximum duration of communication between the SafeMC module and the POWERLINK interface.
• Permissible values: 200–30000 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 safe response time.
• Permissible values: 200–30000 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 safe response time. A value of 0 means that a copy task was not included for the response time.
• Permissible values: 0–30000 µs</td><td>5000</td><td>µs</td></tr>
<tr><td>Min_X2X_CycleTime_us</td><td>This parameter corresponds with the minimum duration of communication between the SafeMC module and the POWERLINK interface.
• Permissible values: 200–30000 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 safe response time.
• Permissible values: 200–30000 µs</td><td>200</td><td>µs</td></tr>
<tr><td>Min_CPU_CrossLinkTask_Cy-cleTime_us</td><td>This parameter specifies the minimum cycle time for the copy task on the CPU used to calculate the safe response time. A value of 0 means that configurations without copy tasks were included for the response time.
• Permissible values: 0–30000 µs</td><td>0</td><td>µs</td></tr>
<tr><td>Worst_Case_Re-sponse_Time_us</td><td>This parameter specifies the limit value for monitoring the safe response time.
• Permissible values: 3000 - 500000 µs</td><td>50000</td><td>µs</td></tr>
</table>

Table 80: Parameters for the safe response time in SafeDESIGNER

5.7 Minimum signal lengths

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

Danger!

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

The switch-on filter can be used to extend the low phase of a signal on the input module.

On the SafeLOGIC controller, the low phases of the signals can be extended with restart inhibit functions or the signals can be extended with the Timer function blocks.

6 Detection of errors within the module

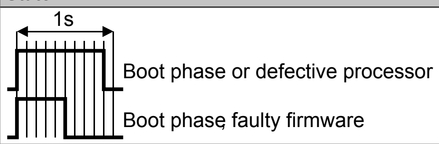
The red "SE" LED makes it possible to evaluate the following error states:

- 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 DC (Diagnostic Coverage) 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 reached, e.g. if the module in the application has not been configured, then the module will remain in the boot state.

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

LED	Color	State
SE	Red	

Danger!

Operating the safety module in its boot state is not permitted.

Chapter 4 • Safety technology

1 Integrated safety technology in the ACOPOSmulti with SafeMC

1.1 General Information

Implementing the safety functions integrated in the drive opens up whole new possibilities for guaranteeing the safety of people while maintaining maximum availability of the machine.
The inverter modules with integrated safety technology - "ACOPOSmulti with SafeMC" - 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 SafeMC module, the POWERLINK cycle time on the ACOPOSmulti with SafeMC must be set to 800 µs or a whole-number multiple of 800 µs.

The products are intended for use worldwide, in industries such as:

- Automotive industry
- Electrical industry
- Beverages industry
- Food stuffs industry
- Glass & 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 only shows the currently typical areas of use, and is not a complete list.

Danger!

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

Such risks include, in particular, 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 The safe power transmission

The safe power transmission basically consists of a safe inverter module, an encoder cable and a motor with a safe position encoder.

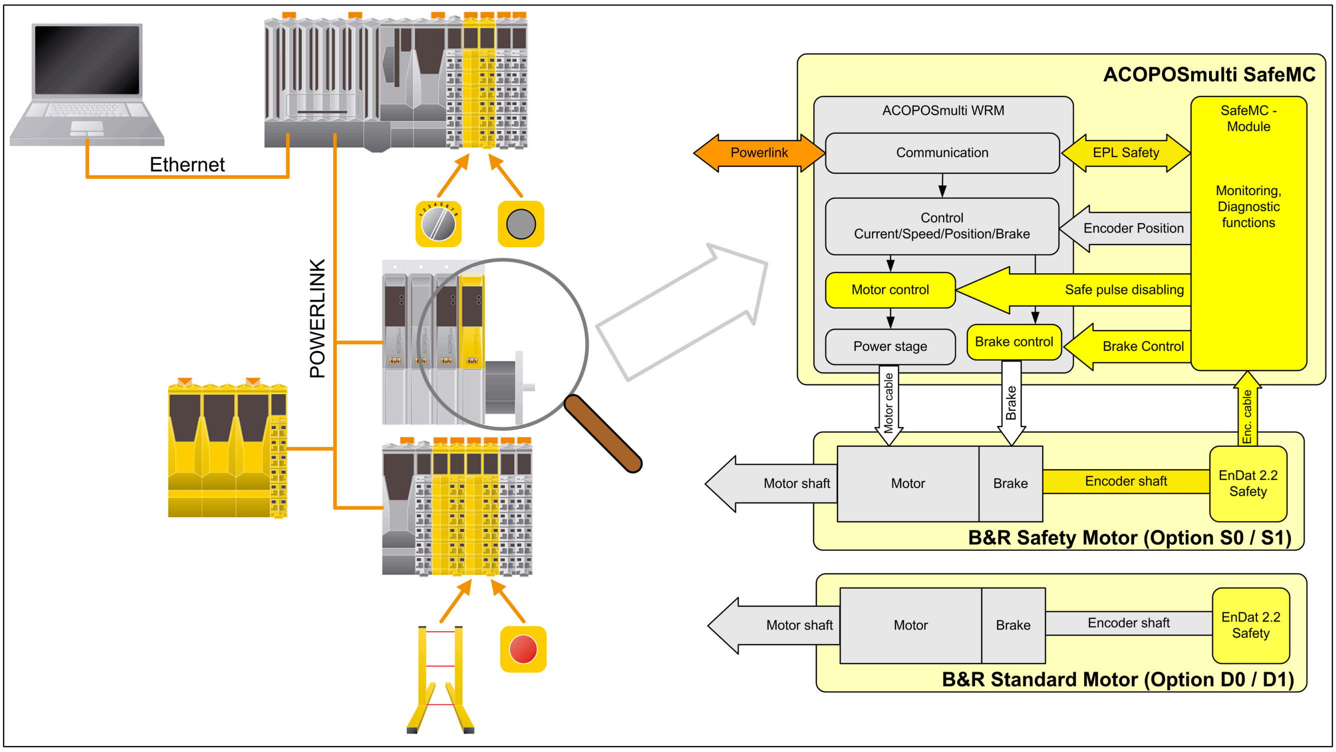


Figure 24: The safe power transmission

Safe inverter module

The safe inverter module consists basically of a standard ACOPOSmulti inverter with an additional safe monitoring module - the SafeMC module - per axis.
This means that one safe single-axis module contains one SafeMC module and is equal to one POWERLINK node and one safe node.
On the other hand, one two-axis module contains two SafeMC modules and is therefore equal to one POWERLINK node and two safe nodes!

Just like before, actual control is via the standard application and not safety-oriented. However, the addition of the SafeMC module provides safety-oriented monitoring of specific limits based on the requirements. If these limits are exceeded, the SafeMC module activates safe pulse disabling and the motor holding brake output is switched to 0 V.

Encoder cable

The encoder cable is connected to the SafeMC module with a DSUB plug. Please note the instructions in the "Cable connection via DSUB plug" section under "Wiring / General information / Connection diagrams for ground and shield connections / 8BVI inverter modules with SafeMC (single-axis modules)" on page 108.

Information:

The SafeMC module can only be used together with 8BCF EnDat 2.2 cables!

Motor with a safe position encoder

In order to be able to use all safety functions, an EnDat 2.2 functional safety encoder from Heidenhain absolutely must be used! With standard EnDat 2.2 encoders, only safety functions STO, SBC, and SS1 are available with time monitoring!

B&R safety motors (encoder option S0/S1)

For these motors, the EnDat 2.2 functional safety encoder is installed strictly according to 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 (encoder option S0/S1) are only allowed to be replaced by B&R!

If the encoder is replaced but not by B&R, mechanical errors such as encoder slippage or shaft breakage can no longer be ruled out.

B&R standard motors (encoder option D0/D1)

For these motors, the SafeMC module can sufficiently detect encoder slippage or encoder shaft breakage in some applications. Here, the application must meet all requirements specified in section 2.3.2 "Safe monitoring without elimination of errors" on page 130, and all limitations listed in this section must be taken into consideration. In these circumstances, B&R standard motors can also be used for safety applications!

1.3 Bias current fail-safe

The integrated safety technology in the ACOPOSmulti with SafeMC uses the bias current fail-safe. 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 bias current fail-safe 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 a "fail-safe".

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

Danger!

In cases involving external forces (e.g. hanging loads), this can cause dangerous movement! 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!

When there is a failure, torque and force are removed from the drive, and there are no electrical pulses transmitted to the motor. Pulse disabling is active.

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 spin out. The remanent movement and time in the worst case scenario must be considered in all calculations for the machine's safety circuit.

Danger!

An error can result in forward movement followed by spin-out. When estimating the distance and time that results from the forward movement/spin-out muss, the worst case scenario (i.e. the currently 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 the safety functions

Danger!

The respective C-standards for the applications must be adhered to!

Danger!

Take note that multiple errors in the IGBT bridge can cause a short forward movement. The maximum rotary angle Φ of the forward movement on the motor shaft depends on the motor used.

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

This short forward movement can be ruled out as error due to the improbability that this would occur and due to general technical experience, among other things.

2.1 Safe pulse disabling

The safe pulse disabling in ACOPOSmulti with SafeMC has the exact same structure as in the standard ACOPOS-multi inverter modules.

The difference is that external wiring is not required. Instead, pulse disabling is activated within the module through the SafeMC module. Control takes place over two channels and is tested by the SafeMC module.

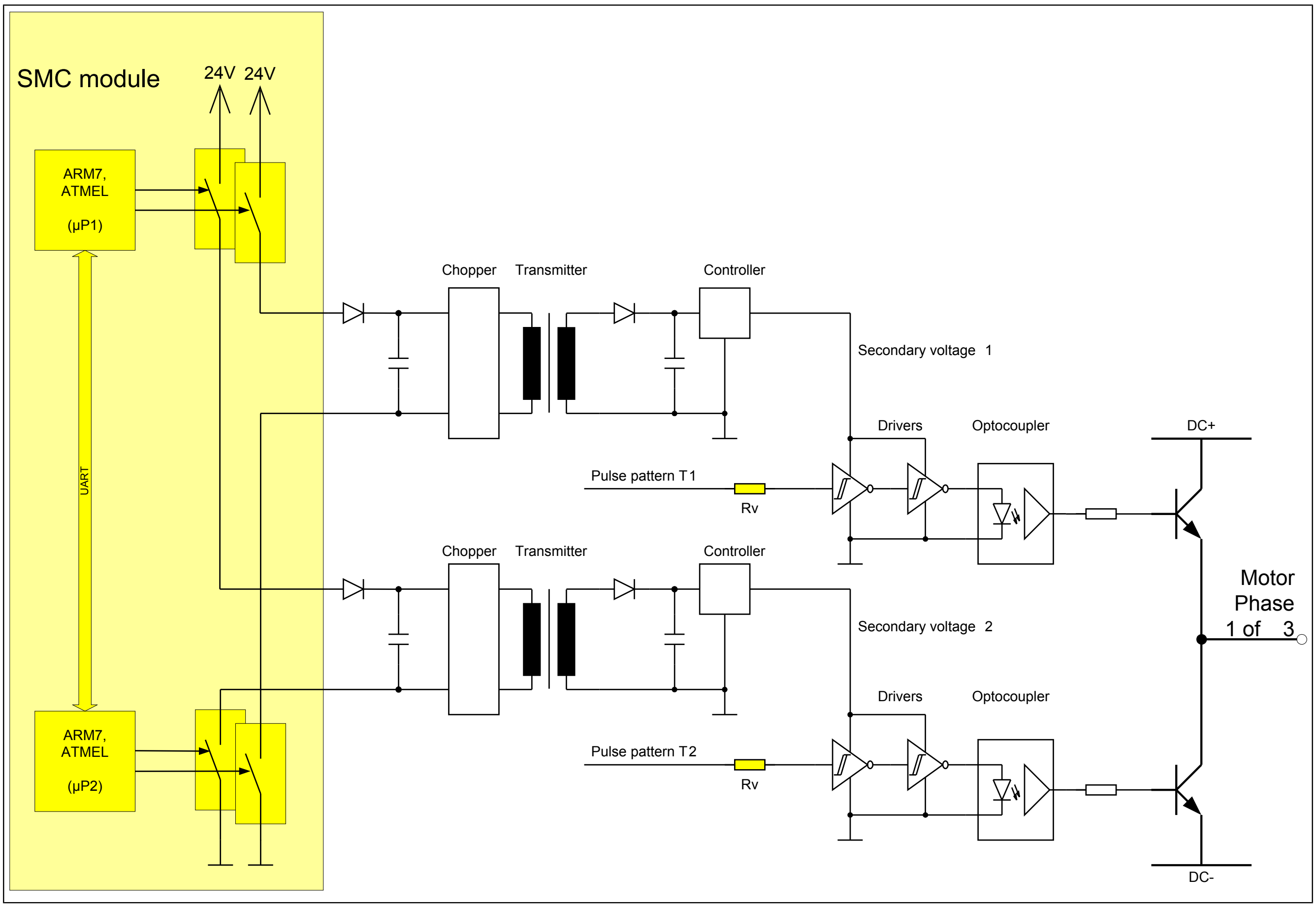


Figure 25: Control of safe pulse disabling

Information:

Safe pulse disabling of the ACOPOSmulti is controlled directly by the SafeMC module. External wiring is not possible. This also means it is not possible to make wiring errors!

2.2 Safe motor holding brake output

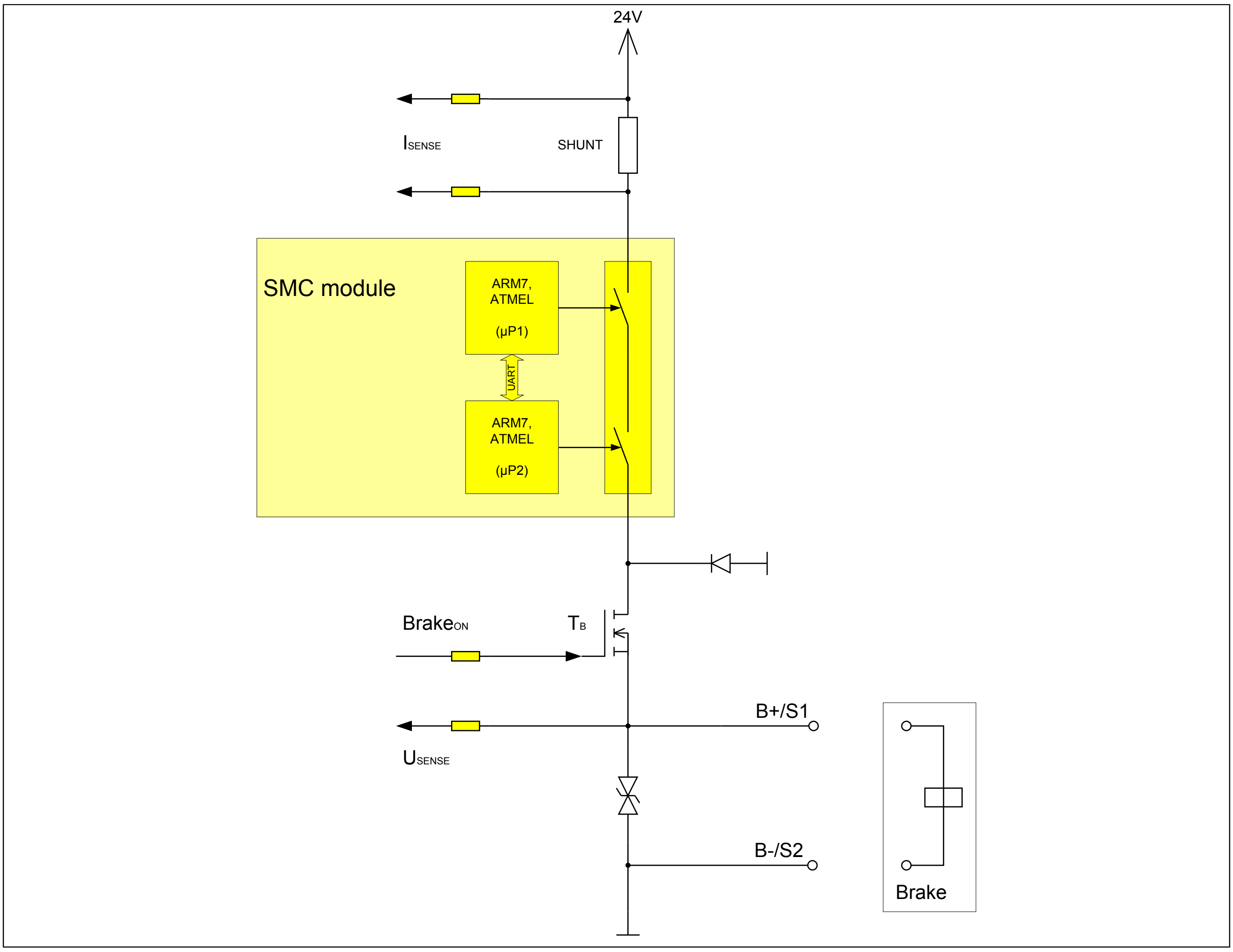


Figure 26: Circuit of safe motor holding brake output

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	Effect	Safety function according to category 3/SIL 2/PL d maintained?
Short-circuit: B+ and B-	Error not detected by module-internal testing. However, this is not critical because 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 SafeMC module to change to the acknowledgeable error state. Safe pulse disabling is activated, the brake always remains open due to the short-circuit to 24 V! **This is a critical error and therefore must 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 because the motor holding brake is not released in this case (remains engaged).	YES, The motor holding brake output remains in the safe state.

Table 81: Wiring error in safe motor holding brake output

Danger!

The functional fail safe state is activated if the SBC output B+ is shorted to 24V. (i.e. safe pulse disabling is activated) However, the brake always remains on because of the short-circuit to 24 V!
This can lead to dangerous situations because the motor holding brake is not able to stop the spin-out movement!
Appropriate wiring measures must be implemented to ensure that the SBC output B+ is not shorted to 24V!
For a double-axis module, it is therefore especially important to prevent a cross-circuit between the two B+ connections of the two axes!

Danger!

The SBC output

- **must not be wired to multiple modules!**
- **must not be wired as open emitter!**
- **must not be wired as open collector!**

Information:

The transistors for the SBC output stage are tested cyclically. When output channels are activated , this test causes low-pulses on the output with a maximum length of 600µs.
This must be taken into consideration when choosing the motor holding brake!

2.3 EnDat 2.2 functional safety encoder

The concept of the integrated safety functions in the ACOPOSmulti with SafeMC 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 or encoder shaft breakage. Please follow the installation guidelines from Heidenhain for doing this.

In some applications, the SafeMC module is able to sufficiently detect encoder slippage or encoder shaft breakage. Mechanical fault prevention is not necessary for these applications.

Danger!

Some safety-related measurement devices can only be used in the close control loop. This limitation is indicated in the technical data for the respective measurement device.

These sort of safety-related measurement devices can only be used in combination with ACOPOSmulti with SafeMC!

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 will be set to the state, "Functional Fail Safe".

2.3.1 Elimination of errors

Danger!

To ensure safe operation up to and including the motor shaft, any errors on the connection between the motor shaft and encoder must be identified and prevented.
There are specific guidelines that must be followed when installing an EnDat 2.2 Functional Safety encoder from the company Heidenhain.
The motor manufacturer must ensure that these specifications are adhered to.

Danger!

The frictional connection between the cone-shaped shaft of the rotor and EnDat measurement device is dimensioned for maximum rotor acceleration in accordance with the Heidenhain installation instructions. This acceleration value must not be exceeded in the worst case. The maximum acceleration is monitored on the SafeMC module and can be configured using the parameter "*Maximum acceleration*".

Danger!

If the terminal screw for the coupling ring comes loose on installed measurement devices, then the form-fit pin will be the only thing holding the encoder to the motor housing. A movement in accordance with the installation tolerances is possible. The encoder is not able to record this movement. This remnant movement must be accounted for in the safety functions.

2.3.2 Safe monitoring without elimination of errors

Note:

This function is only available in safety release R1.4 and higher!

In some applications, the mechanical elimination of errors is not needed and can be replaced by the safety-oriented "Encoder Monitoring" in the SafeMC module.

Danger!

Safety Release 1.4 or higher is required in order to use safety-oriented monitoring of the encoder-motor connection!

Danger!

Only the safety functions (SS1, SS2, SLS, SMS, SLI, SDI), in which the safe speed and/or the safe incremental position are monitored can be used.

Danger!

The application must meet the following requirements for safety-oriented monitoring of the encoder-motor connection:

- **Encoder connection monitoring can only be used for encoders that are integrated in a closed loop 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 set position change (Alive Testing) must be enabled in the safe application and sufficiently strict limits must be monitored!**
- **The safety functions SLP and/or SMP 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 effectively.**
- **There is no way to monitor the encoder connection if the set value remains constant.**
- **An encoder connection error 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 SafeMC module (overridden). When lag errors occur, only the error reactions STO or STO1 are possible with induction stop.**

Danger!

Take note that a slip on the encoder shaft connection can cause a short forward movement.

The maximum rotary angle φ of the forward movement on the motor shaft depends on the motor used. For permanently excited synchronous motors, φ = 360°/2 p_z (for B&R standard motors, p_z = 3 and the angle is therefore 60°).

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 the maximum acceleration $a_{max} = \frac{M_{max}}{J}\left[\frac{rad}{s^2}\right]$ **and the number of motor pole pairs** p_z

Danger!

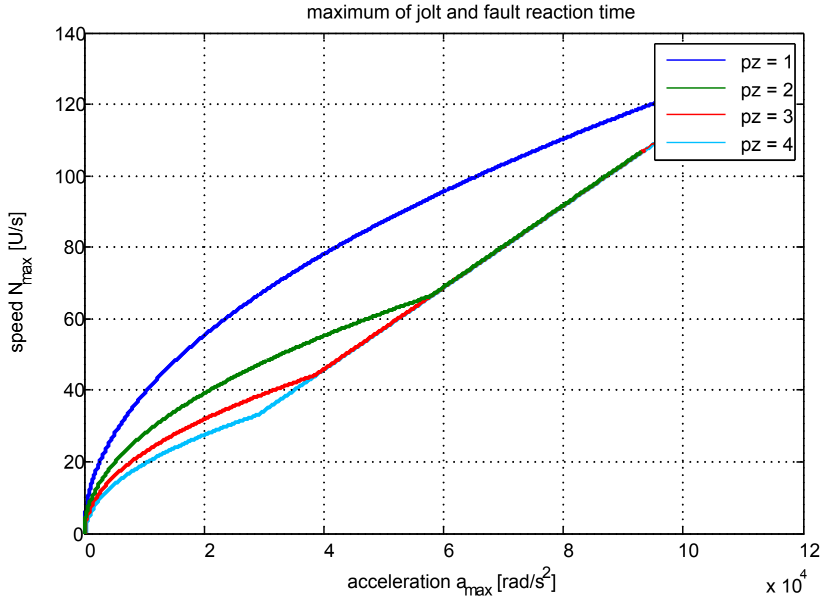
When viewing the worst-case scenario for a safety function, the highest value of the maximum speed of the forward movement n_{Jolt} **and the speed must be used as maximum speed due to the maximum error response time** $n_{T_{worstcase}}$.

$$n_{max} = max(n_{Jolt}, n_{T_{worstcase}}) = max\left(\frac{1}{2\pi}\sqrt{\frac{6a_{max}}{p_z}}, \frac{T_{worstcase}}{2\pi} \cdot a_{max}\right)$$

with the 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 spin-out!**

$$n_{worstcase} = n_{LIM} + n_{max}$$



Information:

In order to check the plausibility of the set value 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 15min.
If this is not done, then the module changes to the error state "Functional Fail Safe", which must be confirmed. The function block output *S_NotErrFUNC* is reset and the drive becomes torque-free and force-free, causing it to spin out!
An error will cause a synchronous axis to lose its synchronicity.

Danger!

In cases involving external forces (e.g. hanging loads), this can cause dangerous movement!
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 24h timeout begins after successfully checking the plausibility of the set value.
The timeout is reset any time the set position changes by more than twice the position lag error tolerance.
If the set position does not change during 24h of continuous controller operation, then the module changes to the acknowledgeable error state "Functional Fail Safe". The function block output *S_NotErrFUNC* is reset and the drive becomes torque-free and force-free, causing it to spin out! An error will cause a synchronous axis to lose its synchronicity.

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 SafeMC module.	Activated
Encoder Speed Monitoring	Activated/ Deactivated	Activates/deactivates the monitoring of the speed error generated on the SafeMC module.	Activated
Set position alive testing	Activated/ Deactivated	Activates/deactivates the monitor that detects whether the set position generated on the ACOPOSmulti is frozen.	Activated
Encoder Monitoring Tolerances			
Encoder Monitoring Position Tolerance	[units]	Position lag error tolerance for encoder monitoring	0
Encoder Monitoring0 Speed Tolerance	[units/s]	Speed error tolerance for encoder monitoring	0

Table 82: Encoder Monitoring safety function parameters

Danger!

The machine manufacturer is responsible for deciding 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!

Activation of 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 monitor cannot be used for safety purposes and a mechanical solution for detecting errors must be implemented!

Configuration rule for position lag error limit

The position lag error limit 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 limit accordingly higher.

Danger!

The position lag error limit cannot be higher than half of one pole length!

When the safety function is enabled, the size of the position lag error limit value ds_{lim} affects how long it will take to look for errors and therefore also the error response time and estimation of the remaining distance.

This must be accounted for by the machine manufacturer in the risk analysis!

Information:

Provide a reserve of 1 unit at parameter "encoder monitoring position tolerance" because of rounding errors.

Configuration rule for speed error limit

The speed error limit 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 set values (e.g. at maximum acceleration) and then setting the speed error limit accordingly higher.

Danger!

When the safety function is enabled, the size of the speed error limit value ds_{lim} affects how long it will take to look for errors and therefore also the error response time and estimation of the remaining distance.

This must be accounted for by the machine manufacturer in the risk analysis!

Information:

Provide a reserve of 1 unit/s at parameter "encoder monitoring speed tolerance" because of rounding errors.

2.3.3 Safe encoder counting range

The safe encoder counting range can be found in the data sheet of the respective encoder. On the rotary encoders ECN 1325 single-turn and EQN 1337 multi-turn, this range corresponds with the single-turn range. See excerpt from the data sheet:

	Absolute	
	ECN 1325 **Singleturn**	**EQN 1337** **Multiturn**
Safety-related data	Applicable as single-encoder system in the control loop for applications of the control category SIL 2 (Safety Integrated Level) as in DIN EN IEC 61 508 PL d (Performance Level) as in DIN EN ISO 13 849 Category 3 according to EN 954-1 Safe in the singleturn range	

Note:

The manufacturer's latest data sheet is applicable. The user is responsible for obtaining this information from the manufacturer.

3 Safety characteristics

The safety characteristics were 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 evaluation. The actual brake must still be calculated 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), 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 and safe position detection are also accounted for.
  The encoder's safety-related characteristics must still be taken into account!

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 according to EN ISO 13849	Cat. 4			
	Maximum performance level acc. EN ISO 13849	PL e			
	Maximum safety integrity level acc. IEC 62061	SIL 3			
	Maximum safety integrity level acc. IEC 61508	SIL 3			
	PFH (Probability of Failure per Hour)	$<5*10^{-10}$			
	PFD (Probability of dangerous Failure on demand) with a Proof Test Interval of 20 years	$<9*10^{-05}$			
	PT (Proof Test interval) [2]	Max. 20 years			
	DC (Diagnostic Coverage)	>95%			
	MTTFd (Mean Time To Failure - dangerous) [3]	2500 years			

Table 83: Safety characteristics 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 the 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 established by Apfeld, R.; Bömer, T.; Hauke, M.; Huelke, M.; Schaefer, M.: Praktische Erfahrungen mit der DIN EN ISO 13849-1.openautomation (2009) Nr. 6, S. 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 according to EN ISO 13849	Cat. 3			
	Maximum performance level acc. EN ISO 13849	PL d			
	Maximum safety integrity level acc. IEC 62061	SIL 2			
	Maximum safety integrity level acc. IEC 61508	SIL 2			
	PFH (Probability of Failure per Hour)	$<8*10^{-09}$			
	PFD (Probability of dangerous Failure on demand) with a Proof Test Interval of 20 years	$<1,4*10^{-03}$			
	PT (Proof Test interval) [2]	Max. 20 years			
	DC (Diagnostic Coverage)	>94 %			
	MTTFd (Mean Time To Failure - dangerous)	>167 years	>157 years	>143 years	>85 years

Table 84: Safety characteristics 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 the 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 according to EN ISO 13849	Kat 3			
	Maximum performance level acc. EN ISO 13849	PL d			
	Maximum safety integrity level acc. IEC 62061	SIL 2			
	Maximum safety integrity level acc. IEC 61508	SIL 2			
	PFH (Probability of Failure per Hour)	$<1*10^{-08}$			
	PFD (Probability of dangerous Failure on demand) with a Proof Test Interval of 20 years	$<1,75*10^{-03}$			
	PT (Proof Test interval) [2]	Max. 20 years			
	DC (Diagnostic Coverage)	>95%			
	MTTFd (Mean Time To Failure dangerous)	>153 years	>135 years	>117 years	>56 years

Table 85: Safety characteristics 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 the 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), Safe Maximum Speed (SMS), Safely Limited Position (SLP), Safe Maximum Position (SMP), Safe referencing	Maximum safety category according to EN ISO 13849	Cat. 3			
	Maximum performance level acc. EN ISO 13849	PL d			
	Maximum safety integrity level acc. IEC 62061	SIL 2			
	Maximum safety integrity level acc. IEC 61508	SIL 2			
	PFH (Probability of Failure per Hour)	$<5*10^{-9}$			
	PFD (Probability of dangerous Failure on demand) with a Proof Test Interval of 20 years	$<8,75*10^{-04}$			
	PT (Proof Test interval) [2]	Max. 20 years			
	DC (Diagnostic Coverage)	>95%			
	MTTFd (Mean Time To Failure - dangerous)	>109 years	>100 years	>89 years	>49 years

Table 86: Safety characteristics Safe Operating Stop (SOS), Safe Stop 1 (SS1), Safe Stop 2 (SS2), Safely Limited Speed (SLS), Safe Direction (SDI), Safely Limited Increments (SLI), 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 the 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.

Danger!

To determine the overall PFH value of the safety function, the PFH value of the EnDat 2.2 FS encoder used must be taken into account.

$$PFH_{TOTAL} = PFH_{SOS,SS1,SS2,SLS,SMS,SDI,SLI,SLP,SMP} + PFH_{ENCODER}$$

The value $PFH_{SOS,SS1,SS2,SLS,SMS,SDI,SLI,SLP,SMP}$ can be found in the table above, the value $PFH_{ENCODER}$ can be found in the encoder's data sheet or obtained from the encoder manufacturer!

Danger!

If the technical documentation (product catalog / user's manual) for the measurement device explicitly specifies that the bit error rate must be verified, then the user needs to implement this verification in the application. This verification is not necessary if using B&R EnDat 2.2 8BCF encoder cables and certain B&R motors (safety motors with encoder option S0/S1 or standard motors with encoder option D0/D1).

4 Integrated safety functions

Information:

If a safety function is not used in the application, then the respective input variables should remain open.

The following functions are supported by the SafeMC module:

Safety function	Starting in safety release	EN ISO 13849-1	EN 61508/EN 62061	Safe encoder evaluation required
Safe Torque Off (STO)	R 1.3	Pl e	SIL 3	No
Safe Torque Off One Channel (STO1)	R 1.3	Pl d	SIL 2	No
Safe Operation Stop (SOS)	R 1.3	Pl d	SIL 2	Yes
Safe Stop 1 (SS1)	R 1.3	PL e (time monitored) Pl d	SIL 3 (time monitored) SIL 2	no (time monitored) Yes
Safe Stop 2 (SS2)	R 1.3	Pl d	SIL 2	Yes
Safely Limited Speed (SLS)	R 1.3	Pl d	SIL 2	Yes
Safe Maximum Speed (SMS)	R 1.3	Pl d	SIL 2	Yes
Safe Direction (SDI)	R 1.3	Pl d	SIL 2	Yes
Safely Limited Increment (SLI)	R 1.3	Pl d	SIL 2	Yes
Safe Brake Control (SBC)	R 1.3	Pl d	SIL 2	No
Safely Limited Position (SLP)	R 1.4	Pl d	SIL 2	Yes
Safe Maximum Position (SMP)	R 1.4	Pl d	SIL 2	Yes
Safe referencing	R 1.4	Pl d	SIL 2	Yes

Table 87: Safety functions and corresponding safety levels

4.1 Fail Safe state

If an error in the hardware or firmware occurs, then the safe inverter module changes to a non-acknowledgeable error state; the Fail Safe state. The log book entry in Automation Studio provides more detailed information about the pending error. This log book can also be evaluated in the standard application.
If there is a hardware defect, then the module must be replaced.

Note:

The SafeMC modules cannot be exchanged! The SafeMC modules together with the inverter module form a single unit. In the event of an error, the entire inverter module must be replaced.

However, the error can also have been caused by a configuration mistake. If this is the case, then the safe configuration must be checked and reloaded to the SafeLOGIC. This must then be followed by a PowerOff/PowerOn cycle to get the module back to the "Operational" state.

Danger!

Safe pulse disabling is always active in Fail Safe state (i.e. torque and power are switched off on the motor). The motor holding brake output is always switched to 0 V in this state!

Danger!

Constantly lit LEDs "SE" indicate a fail safe state that cannot be acknowledged. 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 measures for repair are initiated after an error occurs as successive errors can result in dangerous situations.

Danger!

The motor holding brake is engaged in Fail Safe state. The motor holding brake will suffer mechanical wear if the drive is in motion just before the safe state. This must be considered when selecting and sizing the motor holding brake (E-stop capability).

4.2 Functional Fail Safe state

If a monitored limit is exceeded or an encoder error occurs during operation, then the SafeMC module (as long as the safe encoder is required for the safety functions being used) changes to an acknowledgeable error state; the Functional Fail Safe state.
Information about the error can be found in the logbook entry in Automation Studio. This log book can also be evaluated in the functional application.

Danger!

The motor holding brake is engaged in Functional Fail Safe state. The motor holding brake will suffer mechanical wear if the drive is in motion just before the safe state. This must be considered when selecting and sizing the motor holding brake (E-stop capability).

Danger!

The error response time described in the manual affects the remnant movement in the event of error! This must be accounted for when planning the safety equipment (e.g. distances, monitored limits, etc.)

The following parameters are provided in SafeDESIGNER for configuring the Functional Fail Safe state:

Parameter	Unit	Description	Default value
General settings			
Channel selection for One Channel STO (STO1)	HighSide/LowSide	Selection of 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 between STO1 and STO (and SBC) in the Functional Fail Safe state	0
Delay time until the brake engages	[µs]	Delay time until the brake engages Switching of the second enable channel is delayed if STO1 and delayed STO and SBC are configured for Functional Fail Safe.	0

Table 88: Functional Fail Safe state configuration parameters

"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.

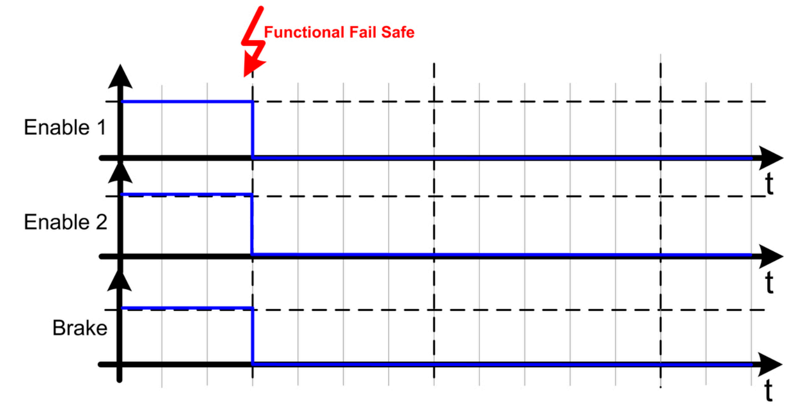


Figure 27: Functional Fail Safe - Configuration of STO

"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 configured time "Delay time for STO in Functional Fail Safe" ($T_{STO\ Delay}$) 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" ($T_{Brake\ engage}$) has expired.

Chapter 4
Safety technology

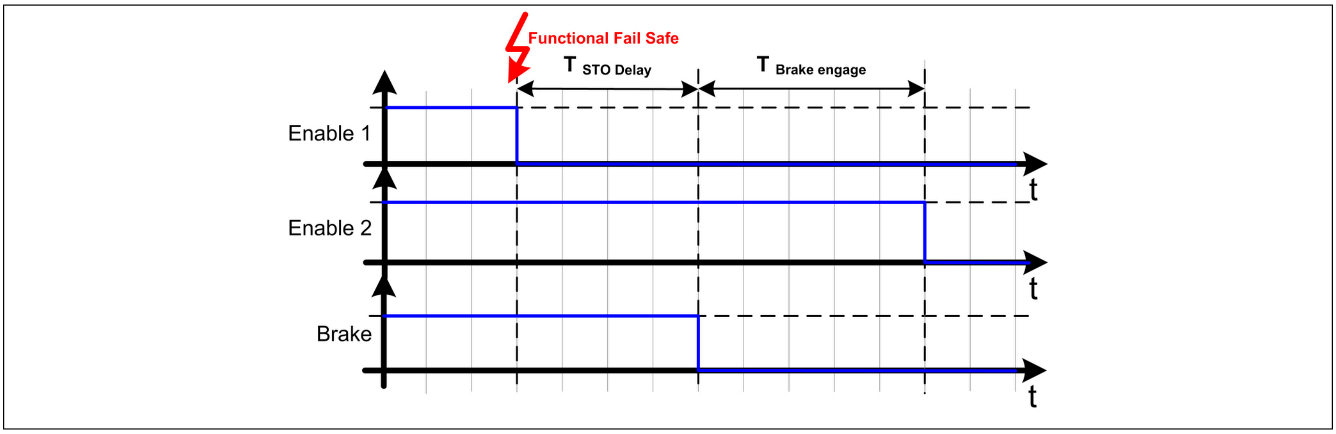


Figure 28: Functional Fail Safe - Configuration of STO1 and STO with time delay

This makes it possible for the drive to be decelerated via the short-circuit braking integrated in the ACOPOSmulti for the amount of time in which just one pulse disabling channel is active.
In this case, the time $T_{\text{Brake engage}}$ serves 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!

The short-circuit braking in the ACOPOSmulti is not suitable for safety purposes and can therefore only be used to protect the machine. If release of the motor energy could result in dangerous situations (e.g. with hanging loads), then a mechanical safeguard must also be installed.

4.3 Safe Torque Off, STO

STO is the fundamental safety function of the ACOPOSmulti with SafeMC, since it represents the "fail-safe" principle.
A request from the STO safety function activates safe pulse disabling and switches off the torque and power to the drive. The SafeMC module actively triggers safe pulse disabling.

Danger!

The STO request causes synchronized axes lose their synchronicity.

Danger!

In cases involving external forces (e.g. hanging loads), this can cause dangerous movement!
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!

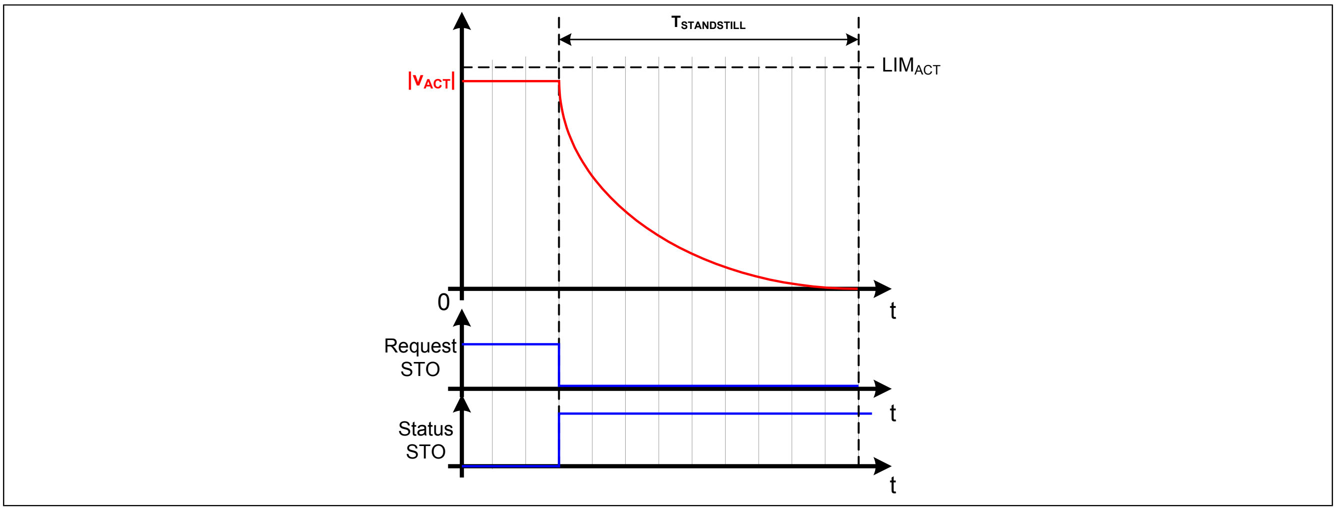


Figure 29: Safe Torque Off, STO

Information:

The functional safe state of the STO function has been achieved when the pulse disabling outputs are switched to 0 V. The respective bit is set once the functional safe state has been achieved.

Danger!

The drive will spin out if it is in motion at the time of the STO request. The resulting remnant movement and time $T_{STANDSTILL}$ 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 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 remnant movement and time $T_{STANDSTILL}$ determines the intervals between the safety features that must be maintained and therefore the size of the machine as well.

Information:

The safety function Safe Torque Off does not require safe encoder evaluation and can therefore also be used without a safe encoder.

Danger!

If the safety function STO is used in the safe application, then the ability to enable/disable it must be tested when commissioning the machine!

4.4 Single-channel Safe Torque Off, STO1

The safety function STO1 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 function has been achieved when the configured pulse disabling output is switched to 0 V.
The respective bit is set once the functional safe state has been achieved.

Parameter	Unit	Description	Default value
General settings			
Channel selection for One Channel STO (STO1)	HighSide/ LowSide	Selection of HighSide or LowSide IGBT in the One-ChannelSTO function	HighSide

Table 89: STO1 safety function parameters

Information:

The two-channel aspect is lost because either only the low side or only the high side of the pulse disabling is activated with STO1.
This results in a lower SIL and Performance Level!

Information:

The safety function Safe Torque Off, single-channel, does not require safe encoder evaluation and can therefore also be used without a safe encoder.

Danger!

If the safety function STO1 is used in the safe application, then the ability to enable/disable it must be tested when commissioning the machine!

4.5 Safe Brake Control, SBC

The SBC function is a safe (time delayed) output whose purpose is to safety-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.

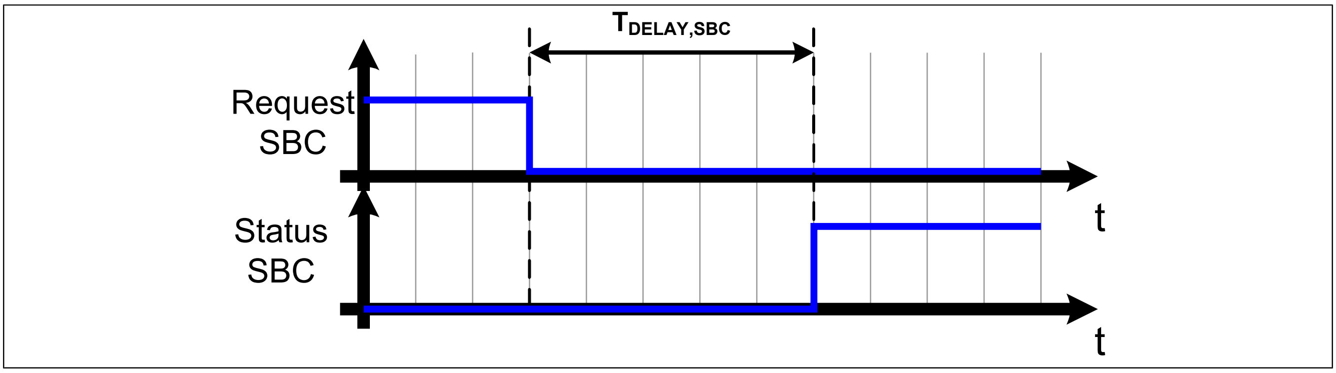


Figure 30: Safe Brake Control, SBC

Only the actuation of the motor holding brake output through the SafeMC module is safely evaluated with SIL 2.

The braking procedure will not be monitored for safety by the SafeMC module.

Information:

The functional safe state of the SBC function has been achieved when the safe motor holding brake ouptput has been switched to 0 V.
The respective bit is set once the functional safe state has been achieved.

The purpose of the delay time $T_{DELAY,SBC}$ is to compensate for the different runtimes of functional and safe applications.

Parameter	Unit	Description	Default value
Safety Additional Parameters			
Delay time to start SBC (us)	[µs]	Delay time between request of SBC and activation of the safety function	0

Table 90: SBC safety function parameters

Information:

The safety function Safe Brake Control does not require safe encoder evaluation and can therefore also be used without a safe encoder.

Danger!

If the safety function SBC is used in the safe application, then the ability to enable/disable it must be tested when commissioning the machine!

Information:

Functional errors will occur (e.g. 6029: Holding brake: Control signal on and output status off), if the holding is released by the standard application but the motor holding brake output is switched to 0 V by the SafeMC module.

4.6 Safe Operating Stop, SOS

When the SOS safety function is active, the safe stop of the drive is monitored. Pulse disabling is not controlled by the SafeMC module.
The drive can remain active and must be kept in standstill by the functional application.

Information:

The safety function Safe Operating Stop requires safe encoder evaluation of the speed and position. If the function is programmed in the safe application and if no safe encoder is detected or an encoder error is detected, then the SafeMC module immediately changes to the Functional Fail Safe state after the function block is activated!

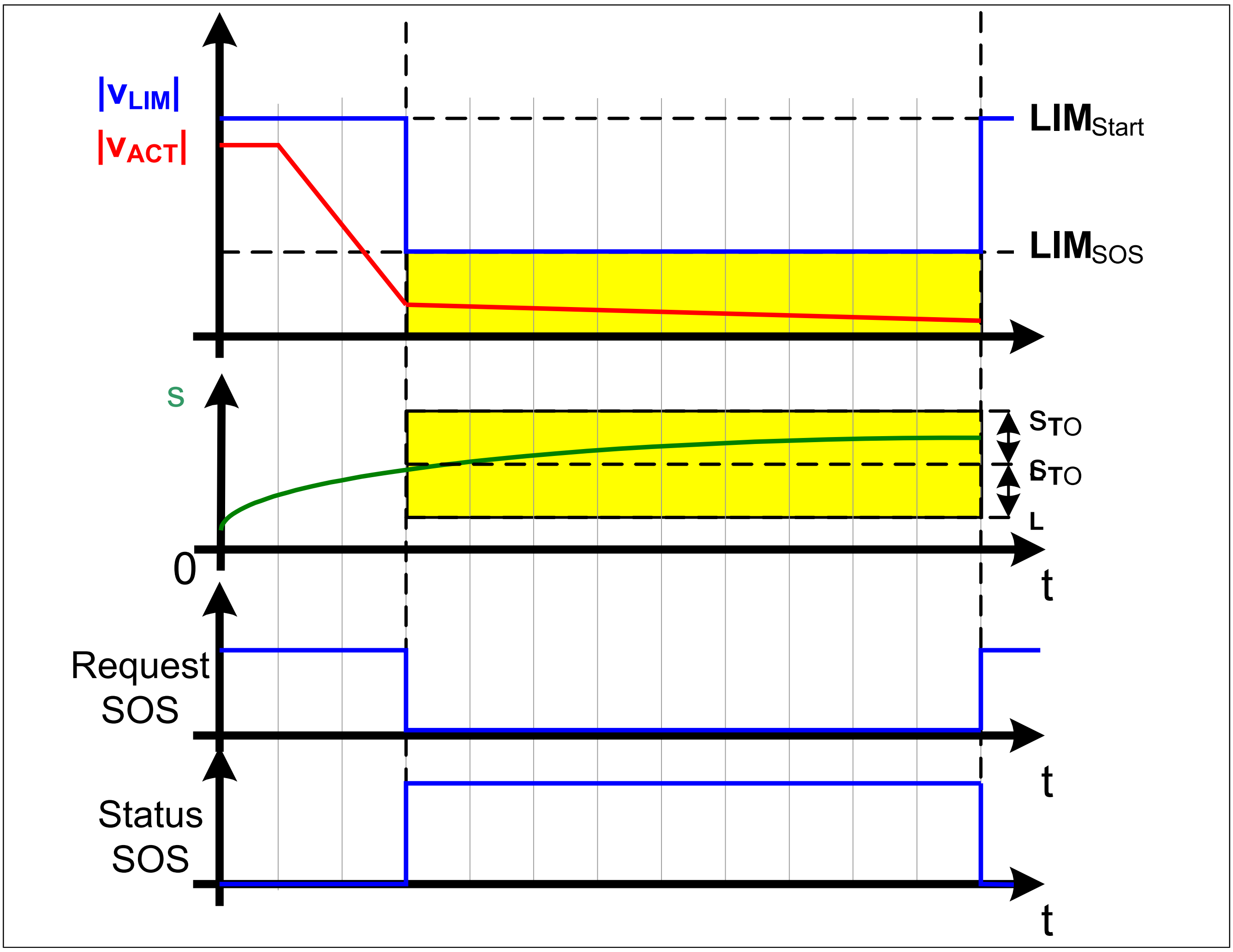


Figure 31: Safe Operating Stop, SOS

To prevent the axis from drifting, both the speed and position are monitored with standstill tolerance limits. The position window is established 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 the request is made, the standstill tolerance position window will be re-established, based on the current position.

Information:

The functional safe state of the SOS function has been achieved when the drive is stopped and the standstill is being monitored for safety.
The respective bit is set once the functional safe state has been achieved.

The standstill tolerances can be configured for each axis in SafeDESIGNER with the following 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 91: SOS safety function parameters

Danger!

In the event of an error, forward movement can occur during the error response time when monitoring the standstill tolerance window. Within this amount of time, the drive could accelerate to its maximum before spinning out.
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 a Functional Fail Safe error state which must be acknowledged. When an error occurs, a synchronous axis loses its synchronicity.

Danger!

If a standstill limit (position or speed) is violated, then the module changes to the error state "Functional Fail Safe", which must be confirmed. Torque and power to the drive are switched off, causing the drive to spin out! An error will cause a synchronous axis to lose its synchronicity. This will reset the output on the function block S_NotErrFUNC!

Danger!

If the safety function SOS is used in the safe application, then the ability to enable/disable it must be tested when commissioning the machine!
The configured limits must be violated with the function enabled and the error reaction must be tested accordingly!

Danger!

In cases involving external forces (e.g. hanging loads), this can cause dangerous movement!
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!

4.7 Safe Stop 1, SS1

When there is a request from the SS1 safety function, after the ramp delay, the deceleration process is monitored until standstill. After decelerating, safe pulse disabling is activated and switches off the torque and power to the drive.

Danger!

Synchronous axes lose their synchronicity when SS1 is in its safe state.

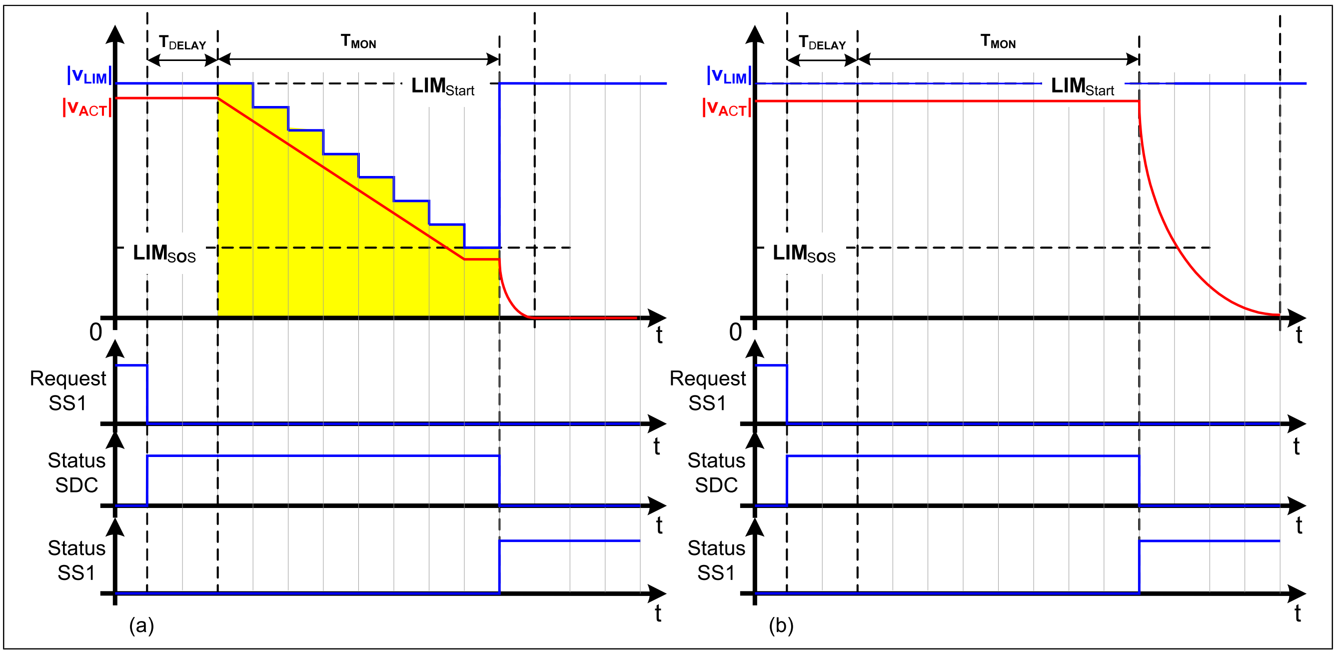


Figure 32: Safe Stop 1, SS1

The deceleration itself is controlled by the functional application, which is not safety-oriented.

The purpose of the ramp delay time T_{DELAY} (parameter "*Delay time to start ramp monitoring (µs)*") is to compensate for the different runtimes of functional and safe applications.

Information:

The functional safe state of the SS1 function has been achieved when the pulse disabling outputs are switched to 0 V. The respective bit is set once the functional safe state has been achieved.

Danger!

In cases involving external forces (e.g. hanging loads), this can cause dangerous movement!
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 following parameters in SafeDESIGNER affect the behavior of the safety function:

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 SS1	Activated/ Deactivated	Activates ramp monitoring (in addition to the time) when the SS1 function is requested	Activated
Early Limit Monitoring	Activated/ Deactivated	Monitoring of the deceleration ramp is prematurely terminated if the value drops below the lower limit for a defined amount of time	Deactivated
Safety Ramp Monitoring Times			
Ramp Monitoring Time for SS1 (us)	[µs]	Deceleration monitoring time for SS1	0
Safety Additional Parameters			
Delay time to start ramp monitoring (us)	[µs]	Delay time between request of ramp monitoring and 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 92: SS1 safety function parameters

Depending on the request for the safety function and its configuration, either only the deceleration time T_{MON} - see figure (b) - or also the deceleration ramp - see figure (a) - can be monitored.
If the monitoring limits are violated during deceleration, then an error state that must be confirmed is entered.

The parameter "*Ramp monitoring for SS1*" configures the behavior of the delay monitor.

4.7.1 SS1 - Stopping procedure with ramp-based monitoring

"Ramp monitoring for SS1" = Activated

With this configuration, the configurable deceleration ramp is monitored in addition to time 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 stopping procedure must be adjusted to the dangerous situation by the functional application.

The slope of the monitoring ramp can be set using the parameter, "*Deceleration Ramp*".

A timer is started when the safety function is requested. Monitoring of the deceleration ramp begins after the delay time for the request "*Delay time to start ramp monitoring (µs)*". 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 if 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.

Early activation of the safety state can be configured using the parameter "*Early Limit Monitoring*" = Activated. 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 is violated during monitoring of the deceleration procedure, then the drive will immediately switch to the acknowledgeable error state Functional Fail Safe.

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 safe application and if no safe encoder is detected or an encoder error is detected, then the SafeMC module immediately changes to the Functional Fail Safe state after the function block is activated!

Danger!

If safe pulse disabling is on (spin-out) and the safety function is in a functionally safe state, the maximum speed at the end of the deceleration ramp must be used to calculate the remaining 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 remaining distance do not present any danger!

Danger!

If the monitored ramp is exceeded, the remaining 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 remaining distance do not present any danger!

Danger!

If the safety function SS1 with ramp monitoring is used in the safe application, then the ability to enable/disable it must be tested when commissioning the machine!
The test should include at least one violation of the monitored ramp and the error reaction must be tested accordingly!

4.7.2 SS1 - Stopping procedure with time-monitoring

"Ramp monitoring for SS1" = Deactivated

This configuration provides true time-monitoring of the delay.
A timer is started when the safety function is requested. Within this time frame, the drive must implement a stopping procedure that is appropriate for the respective dangerous situation using the standard application.
After the delay time for the request, "*Delay time to start ramp monitoring (µs)*" and the monitoring time, "*Ramp Monitoring Time for SS1 (µs)*" have expired, safe pulse disabling is activated and torque is shutoff on the drive.

Information:

With this configuration of the Safe Stop 1 safety function, only the time frame is monitored.
No speed or position window is monitored.
This is why the function can also be used in this configuration without safe encoder!

Danger!

If safe pulse disabling is on (spin-out), the maximum speed after the time frame has expired must be used to calculate the remaining distance!
The drive can move at its physically maximum 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 remaining distance do not present any danger!

Danger!

If the safety function SS1 with true time-monitoring is used in the safe application, then the ability to enable/disable it must be tested when commissioning the machine!
The drive should be accelerated to its maximum during the monitored time frame and the error response tested accordingly!

4.8 Safe Stop 2, SS2

With SS2, after the ramp delay, the deceleration process is monitored until standstill. Then the drive must be kept at standstill by the functional application. Like with SOS, this standstill is monitored by the SafeMC module according to the configured tolerance window LIM_{SOS} and s_{TOL}.

The delay itself must be generated by the non-safety-oriented, functional application by halting the drive in response to the dangerous situation.

Information:

The safety function Safe Stop 2 requires safe encoder evaluation of the speed and position.
If the function is programmed in the safe application and if no safe encoder is detected or an encoder error is detected, then the SafeMC module immediately changes to the Functional Fail Safe state after the function block is activated!

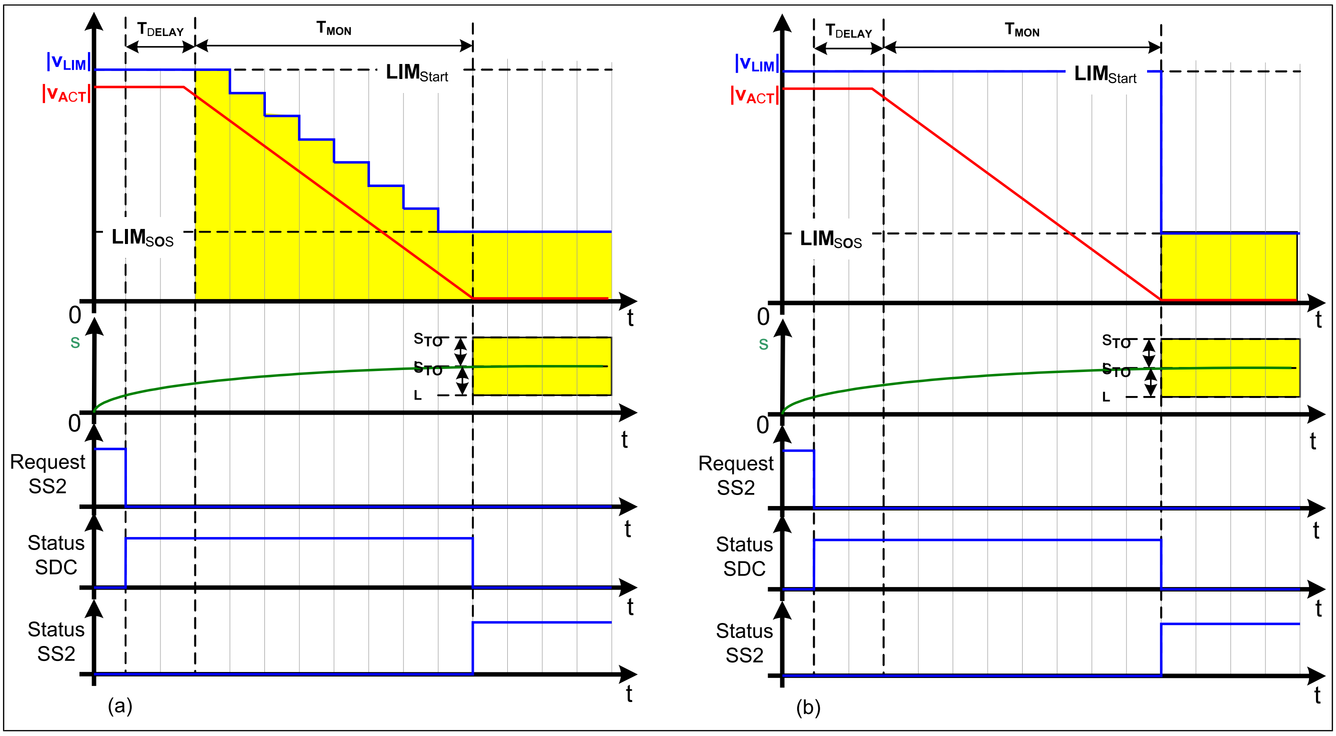


Figure 33: Safe Stop 2, SS2

Danger!

If a standstill limit (position or speed) is violated, then the module changes to the error state "Functional Fail Safe", which must be confirmed. Torque and power to the drive are switched off, causing the drive to spin out! An error will cause a synchronous axis to lose its synchronicity.
This will reset the output on the function block S_NotErrFUNC!

Danger!

In cases involving external forces (e.g. hanging loads), this can cause dangerous movement!
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 T_{DELAY} (parameter "*Delay time to start ramp monitoring (µs)*") is to compensate for the different runtimes of functional and safe applications.

Information:

The functional safe state of the SS2 function has been achieved when the drive is stopped and the standstill is being monitored for safety.
The respective bit is set once the functional safe state has been achieved.

The following parameters in SafeDESIGNER affect the behavior of the safety function:

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 SS2	Activated/ Deactivated	Activates ramp monitoring (in addition to the time) when the SS2 function is activated	Activated
Early Limit Monitoring	Activated/ Deactivated	Monitoring of the deceleration ramp is prematurely terminated if the value drops 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 monitoring time for SS2	0
Safety Additional Parameters			
Delay time to start ramp monitoring (us)	[µs]	Delay time between request of ramp monitoring and 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 93: SS2 safety function parameters

Similar to SS1, either only the deceleration time T_{MON} - see figure 6 (b) - or also the deceleration ramp - see figure 6 (a) - can be monitored depending on the requirements for the safety function.

The parameter "*Ramp monitoring for SS2*" configures the behavior of the delay monitor.

4.8.1 SS2 - Stopping procedure with ramp-based monitoring

"Ramp monitoring for SS2" = Activated

With this configuration, the configurable deceleration ramp is monitored in addition to time 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 stopping procedure must be adjusted to the dangerous situation by the functional application.

The slope of the monitoring ramp can be set using the parameter, "*Deceleration Ramp*".

A timer is started when the safety function is requested. Monitoring of the deceleration ramp begins after the delay time for the request "*Delay time to start ramp monitoring (µs)*". 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 if 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.

Early activation of the safety state can be configured using the parameter "*Early Limit Monitoring*" = Activated. 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 error state Functional Fail Safe.

Danger!

If the monitored ramp or standstill tolerance window is exceeded, the remaining 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 remaining 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. Within this amount of time, the drive could accelerate to its maximum before spinning out.
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 safety function SS2 with ramp monitoring is used in the safe application, then the ability to enable/disable it must be tested when commissioning the machine!
The test should contain at least one violation of the monitored ramp and standstill tolerance window. The error response must be tested accordingly!

4.8.2 SS2 - Stopping procedure with time-monitoring

"Ramp monitoring for SS2" = Deactivated

This configuration provides true time-monitoring of the delay.
A timer is started when the safety function is requested. Within this time frame, the drive must implement a stopping procedure that is appropriate for the respective dangerous situation using the functional application.

After the delay time for the request, "*Delay time to start ramp monitoring (µs)*" and the monitoring time, "*Ramp Monitoring Time for SS2 (µs)*" have expired, the standstill tolerance window will be monitored safely.

Danger!

If the standstill tolerance window is exceeded, the remaining 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 remaining 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. Within this amount of time, the drive could accelerate to its maximum before spinning out.
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 safety function SS2 with time-monitored stopping procedure is used in the safe application, then the ability to enable/disable it must be tested when commissioning the machine!
The test should contain at least one violation of the standstill tolerance window. The error response must be tested accordingly!

4.9 Safely Limited Speed, SLS

The safety function SLS is used to monitor a specified speed limit LIM_{SLSx} (parameter "*Safe Speedlimit 1, 2, 3, 4 for SLS (units/s)*"). Depending on the application, deceleration can also be monitored until the limit is reached.

Four different speed limits can be monitored on the SafeMC 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 contains the four different inputs "S_RequestSLSx", [x = 1..4].

The standard (non safety-oriented) application must use a closed-loop control appropriate for the level of danger to decelerate the movement and then maintain the respective speed limit.

Information:

The safety function SLS requires safe encoder evaluation of the speed. If the function is programmed in the safe application and if no safe encoder is detected or an encoder error is detected, then the SafeMC module immediately changes to the Functional Fail Safe state after the function block is activated!

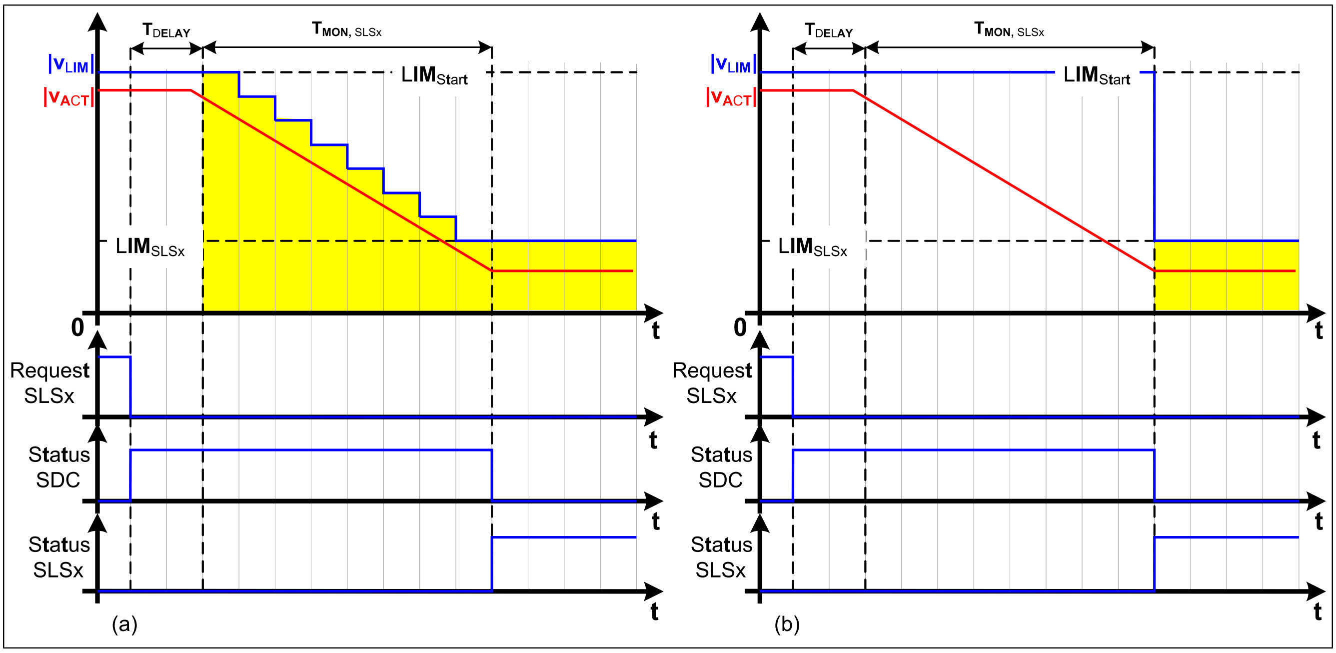


Figure 34: Safely Limited Speed, SLS

Danger!

In cases involving external forces (e.g. hanging loads), this can cause dangerous movement!
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 changes to the error state "Functional Fail Safe", which must be confirmed.
Torque and power to the drive are switched off, causing the drive to spin out!
An error will cause a synchronous axis to lose its synchronicity! This will reset the output on the function block S_NotErrFUNC!

The purpose of the ramp delay time T_{DELAY} is to compensate for the different runtimes of functional and safe applications.

If the delay time $T_{mon,\ SLS}$ is set to 0, then the speed limit will be monitored right after the request is made for the safety function.

Information:

The functional safe state of the SLS function has been achieved if the drive has not exceeded a defined speed limit and this limit is being monitored for safety. The respective bit is set once the functional safe state has been achieved.

The following parameters in SafeDESIGNER affect the behavior of the safety function:

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 monitoring (in addition to the time) when the SLS function is activated	Activated
Early Limit Monitoring	Activated/ Deactivated	Monitoring of the deceleration ramp is prematurely terminated if the value drops below the lower limit for a defined amount of time	Deactivated
Speed Limits			
Safe Speed-limit 1 for SLS	[units/s]	Speed Limit 1 for SLS	0
Safe Speed-limit 2 for SLS	[units/s]	Speed Limit 2 for SLS	0
Safe Speed-limit 3 for SLS	[units/s]	Speed Limit 3 for SLS	0
Safe Speed-limit 4 for SLS	[units/s]	Speed Limit 4 for SLS	0
Safety Ramp Monitoring Times			
Ramp Monitoring Time for SLS1 (us)	[µs]	Deceleration monitoring time for SLS1	0

Table 94: SLS safety function parameters

Parameter	Unit	Description	Default value
Ramp Monitoring Time for SLS2 (us)	[µs]	Deceleration monitoring time for SLS2	0
Ramp Monitoring Time for SLS3 (us)	[µs]	Deceleration monitoring time for SLS3	0
Ramp Monitoring Time for SLS4 (us)	[µs]	Deceleration monitoring time for SLS4	0
Safety Additional Parameters			
Delay time to start ramp monitoring (us)	[µs]	Delay time between request of ramp monitoring and 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 94: SLS safety function parameters

Like with SS1 and SS2, the deceleration ramp monitoring can be adjusted according to the requirements, so that either only the deceleration time $T_{MON,\ SLSx}$ - see figure 7 (b) - or both the deceleration time and the deceleration ramp - see figure 7 (a) - are monitored.
The parameter "*Ramp monitoring for SLS*" configures the behavior of the delay monitor.

4.9.1 SLS - Stopping procedure with ramp-based monitoring

"Ramp monitoring for SLS" = Activated

With this configuration, the configurable deceleration ramp is monitored in addition to time 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 parameter, "*Deceleration Ramp*".

A timer is started when the safety function is requested. Monitoring of the deceleration ramp begins after the delay time for the request "*Delay time to start ramp monitoring (µs)*". The monitored ramp always begins at the currently monitored limit and is calculated using the configured slope.
If the monitoring ramp reaches the respective speed limit "*Safe Speedlimit 1, 2, 3, 4 for SLS (units/s)*" or if the monitoring time "*Ramp Monitoring Time for SLS1, 2, 3,4 (µs)*" has expired, then the status of the safety function will be set and the enabled speed limit monitored.

Early activation of the safety state can be configured using the parameter "*Early Limit Monitoring*" = Activated. 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!

If the monitored ramp or the enabled safe speed is exceeded, the remaining 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 remaining 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.
Within this amount of time, the drive could accelerate to its maximum before spinning out.
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 safe application, then the ability to enable/disable it must be tested when commissioning the machine!
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!

4.9.2 SLS - Stopping procedure with time-monitoring

"Ramp monitoring for SLS" = Deactivated

This configuration provides true time-monitoring of the delay.
A timer is started when the safety function is requested. Within this time frame, the drive must implement a stopping procedure that is appropriate for the respective dangerous situation using the functional application. After the delay time for the request, "*Delay time to start ramp monitoring (µs)*" and the monitoring time, "*Ramp Monitoring Time for SLS1, 2, 3, 4 (µs)*" have expired, the speed limit will be monitored safely.

Danger!

If the speed limit is exceeded, the remaining 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 remaining 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.
Within this amount of time, the drive could accelerate to its maximum before spinning out.
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 safe application, then the ability to enable/disable it must be tested when commissioning the machine!
The test should contain at least one violation of each speed limit being used.
The error response must be tested accordingly!

4.10 Safe Maximum Speed, SMS

The difference between SMS and SLS is that SMS cannot be actively initiated. It is either activated (parameter "*Safe Maximum Speed*" = Used) or deactivated (parameter "*Safe Maximum Speed*" = Unused) in the configuration.

When activated, the current speed is constantly monitored according to a defined limit (parameter "*Safe Maximum Speed (units/s)*").

Information:

The safety function SMS requires safe encoder evaluation of the speed.
If the function is programmed in the safe application and if no safe encoder is detected or an encoder error is detected, then the SafeMC module immediately changes to the Functional Fail Safe state after the function block is activated!

The following parameters in SafeDESIGNER affect the behavior of the safety function:

Parameter	Unit	Description	Default value
General settings			
Safe Maximum Speed	Used / Unused	SMS safety function activated or deactivated	Used
Speed Limits			
Maximum speed limit for SMS	[units/s]	Speed limit of the maximum speed	0

Table 95: SMS safety function parameters

Danger!

If the monitored speed limit is exceeded, the remaining distance must be calculated based on the error response time.
It must be ensured that the spin-out movement and remaining 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.
Within this amount of time, the drive could accelerate to its maximum before spinning out. 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 SMS is used in the safe application, then it must be tested when commissioning the machine!
The configured limit must be exceeded! The error response must be tested accordingly!**

Danger!

**In cases involving external forces (e.g. hanging loads), this can cause dangerous movement!
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!**

4.11 Safely Limited Increment, SLI

With the SLI safety function, the movement is monitored for a defined number of increments (parameter "*Safe Increments (units)*").

Information:

**The safety function SLI requires safe encoder evaluation of the speed and position.
If the function is programmed in the safe application and if no safe encoder is detected or an encoder error is detected, then the SafeMC module immediately changes to the Functional Fail Safe state after the function block is activated!**

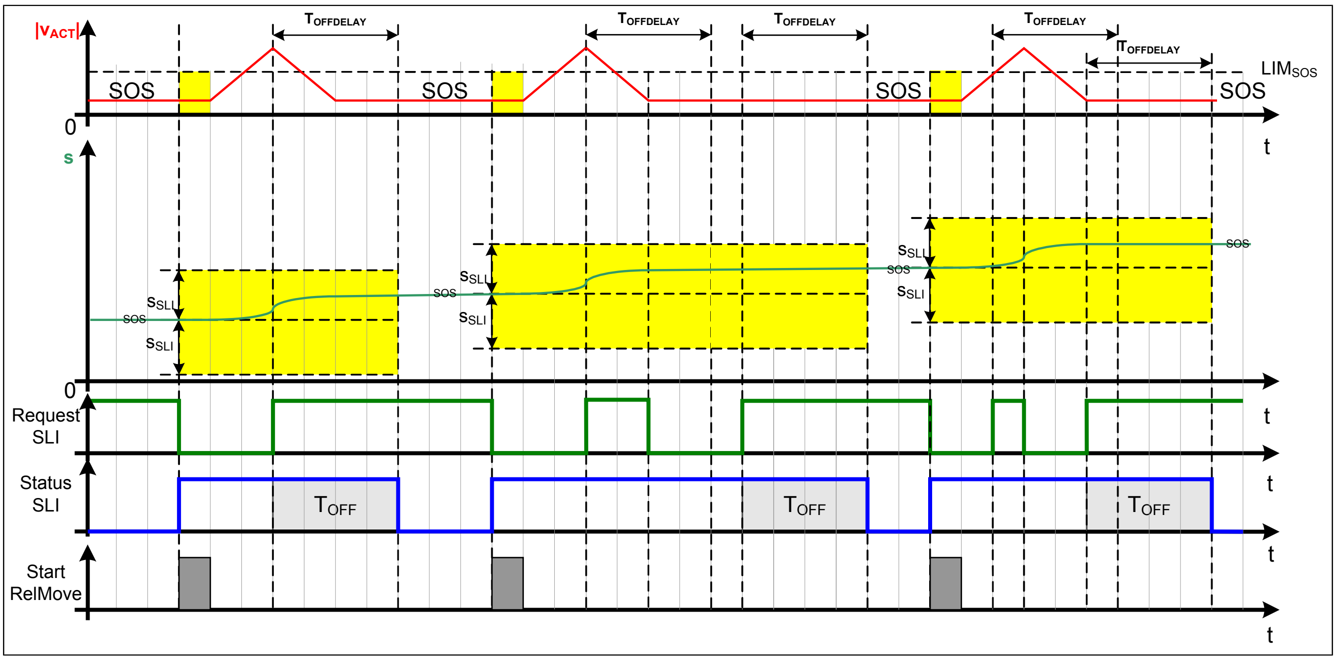


Figure 35: Safely Limited Increment, SLI

Information:

The SLI safety function is only effective when used in combination with at least a second safety function. This could be one of the safety functions such as SOS, SS2, or SLS.

Information:

The functional safe state of the SLI function has been achieved if the drive has not exceeded a defined increment size and this limit is being monitored for safety.
The respective bit is set once the functional safe state has been achieved.

The following parameters in SafeDESIGNER affect the behavior of the safety function:

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 moveable increments when SLI is active	0
SLI OFF Delay	[µs]	Switch off delay of SLI	0

Table 96: SLI safety function parameters

The safe axis must be stopped when the function is activated. To do this, the speed is monitored for adhering to the speed standstill tolerance (parameter "*Speed Tolerance (units /s)*").

A position window is established, which is monitored safely. This position window depends on the configured safe increment size (parameter "*Safe Increments (units)*"). The functional application must guarantee that this position window is not exceeded.

After the safety function is deactivated, the monitor remains active only for the configured time T_{OFF} (parameter "*SLI Off Delay (µs)*". This prevents continuous movement caused by constant inching!

Danger!

If a speed limit for requesting the function or if the position window is violated, then the module changes to the error state "Functional Fail Safe", which must be confirmed.
Torque and power to the drive are switched off, causing the drive to spin out! An error will cause a synchronous axis to lose its synchronicity.
This will reset the output on the function block S_NotErrFUNC!

Danger!

In cases involving external forces (e.g. hanging loads), this can cause dangerous movement!
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.
Within this amount of time, the drive could accelerate to its maximum before spinning out.
The resulting remaining distance must be accounted for when configuring the permissible increments and must not present any danger.
The dangerous movement must be determined by a risk analysis.

Danger!

If the safety function SLI is used in the safe application, then the ability to enable/disable it must be tested when commissioning the machine!
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!

4.12 Safe Direction, SDI

The SDI safety function monitors the defined direction of movement.

Either the positive or the negative direction can be monitored. The two inputs *“S_RequestSDIpos”* and *“S_RequestSDIneg”* provided on the function block can be used for this purpose.

Information:

The safety function SDI requires safe encoder evaluation of the position.
If the function is programmed in the safe application and if no safe encoder is detected or an encoder error is detected, then the SafeMC module immediately changes to the Functional Fail Safe state after the function block is activated!

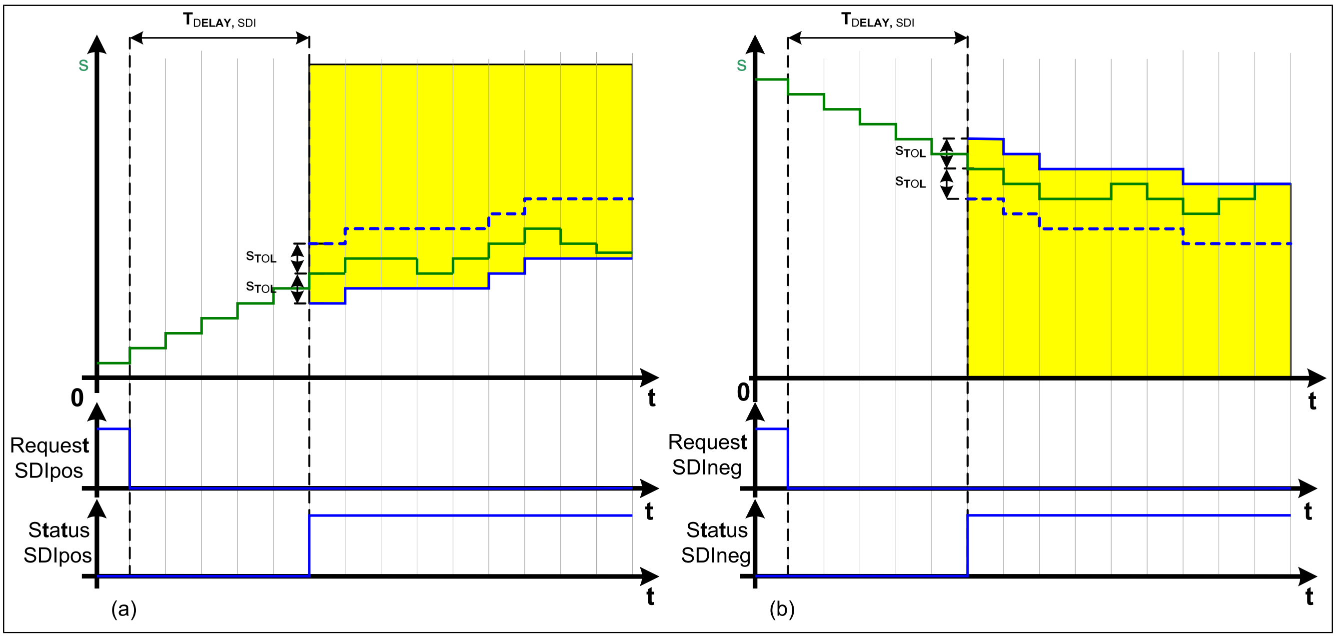


Figure 36: Safe Direction, SDI

Information:

The safe direction 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 function has been achieved if the drive has not violated a defined direction of movement and this direction of movement is being monitored for safety.
The respective bit is set once the functional safe state has been achieved.

The following parameters in SafeDESIGNER affect the behavior of the safety function:

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 request of SDI and activation of the safety function	0

Table 97: SDI safety function parameters

The purpose of the delay time $T_{DELAY,SDI}$ (parameter "*Delay time to start SDI (µs)*") is to compensate for the different runtimes of functional and safe applications.

When monitoring the direction of movement, then standstill tolerance s_{TOL} (parameter "*Position Tolerance (units)*") is not permitted to be exceeded in the forbidden direction of movement. When moving in the permitted direction of movement, the position pointer moves along like a slave pointer.

Danger!

If the safe direction of movement is violated, then the module changes to the error state "Functional Fail Safe", which must be confirmed. Torque and power to the drive are switched off, causing the drive to spin out!
An error will cause a synchronous axis to lose its synchronicity!
This will reset the output on the function block S_NotErrFUNC!

Danger!

In cases involving external forces (e.g. hanging loads), this can cause dangerous movement!
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.
Within this amount of time, the drive could accelerate to its maximum before spinning out. The resulting remaining distance must be accounted for 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 safety function SDI is used in the safe application, then the ability to enable/disable each of the directions of movement that are being used must be tested 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!

4.13 Safe referencing

Note:

The safe homing safety function is only available in safety release R1.4 and higher!

The safety function "safe homing" is used to establish a reference between the encoder position and the machine position.

Depending on the homing mode, it might be necessary for the drive to performing a homing procedure. A reference 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

Information:

Safe homing requires safe evaluation of the position.
If the function is programmed in the safe application and if no safe encoder is detected or an encoder error is detected, then the SafeMC module immediately changes to the Fail Safe state after the function block is activated! The Fail Safe state can only be exited by powering off and then on again!

A positive edge on the control bit *S_RequestHoming* will start safe homing and simultaneously reset the status bit *S_SafePositionValid*.
As soon as the homing procedure is completed, the status bit *S_SafePositionValid* will be set and the control bit *S_RequestHoming* must be reset.
The homing procedure must be complete within the monitoring time $T_{MON,REF}$ (parameter "*Homing Monitoring Time (µs)*"), or else the SafeMC module will change to the Functional Fail Safe state.

The homing procedure will be aborted if the control bit *S_RequestHoming* is reset before the procedure is completed.

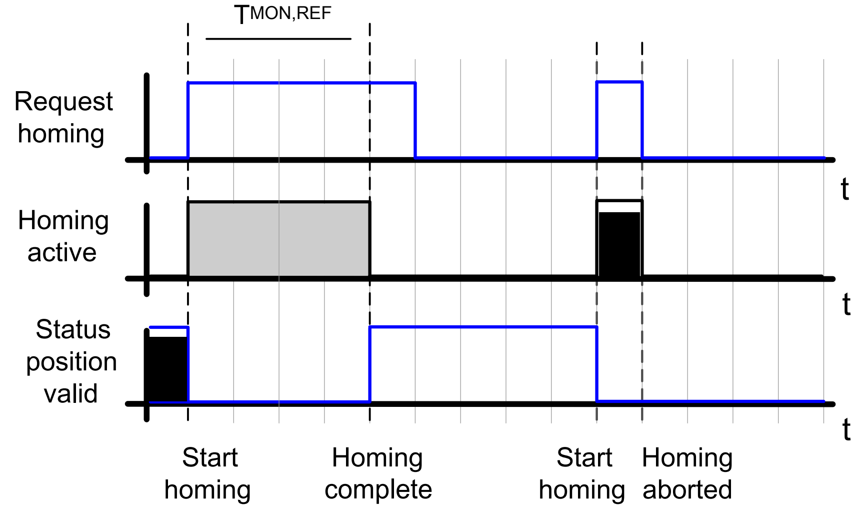


Figure 37: Safe homing

Information:

The safe homing function is a pre-requisite for the safety functions SLP and SMP and for using the safe position. The status S_SafePositionValid will remain set to SAFEFALSE until safe homing has been performed!

The following parameters in SafeDESIGNER affect the behavior of the safety function:

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	Selection of homing mode	Directly
Edge of reference switch	Positve/ Negative	Selection of switching edge for 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.	Positive
Trigger direction	Positve/ Negative	Selection of 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	Selection of whether or not to use a reference pulse for homing	Not Used
Blocking distance (% encoder reference system)	%	Distance within which evaluation of the reference pulse will be suppressed. It is calculated starting at the configured reference switch edge and indicated as a % of the encoder reference system. A single rotation is used as the encoder reference system for rotary encoders.	0

Table 98: Parameters for the "safe homing" safety function

Danger!

If an error occurs during homing procedure, then the module changes to the error state "Functional Fail Safe", which must be confirmed.
The function block output *S_NotErrFUNC* is reset and the drive becomes torque-free and force-free, causing it to spin out!
An error will cause a synchronous axis to lose its synchronicity.

Danger!

If the safe position is used in SafeDESIGNER, then the PositionValid output of the SafeMC_Position 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 usage, then the axis can be referenced using the Direct mode.

4.13.1 Direct mode

The mode Direct is used if the current position of the axis is known and has only to be applied to the SafeMC module.

The following scenario is an example of how this mode can be used:

- A functional homing procedure is initially carried out on the ACOPOS
- It then moves to a specified position
- If the positioning is correct, the operator uses a safe button for confirmation → a safe homing procedure is initiated internally with Direct mode

When referencing with Direct mode, the actual position of the axis is set to the value specified in the parameter "*Home position or home offset*" immediately after the homing command (positive edge on the input *S_RequestHoming*).

The input *S_ReferenceSwitch* will not be evaluated.

The following parameters in SafeDESIGNER directly affect the behavior of the safety function:

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	Selection of homing mode	Directly
Reference pulse	Used/ Not Used	Selection of whether or not to use a reference pulse for homing	Not Used
General settings			
Safe Maximum Position	Used / Unused	Activates the SMP safety function by 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
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 99: Parameters for the "safe homing" safety function - Direct mode

Information:

The axis must be at standstill when the request is made.
The values configured under "Safety Standstill and Direction Tolerances" are monitored to this regard.
If the standstill tolerances are violated, then the module changes to the error state "Functional Fail Safe", which must be confirmed. The function block output *S_NotErrFUNC* is reset and the drive becomes torque-free and force-free, causing it to spin out!

Information:

A reference pulse must not be used in Direct mode!
If a reference pulse is enabled ("*Reference pulse*" = Used), then the system will enter Fail Safe state when checking the configuration during startup.
The Fail Safe state can only be exited by powering off/on and changing the safe application!

Information:

If Safe Maximum Position has been enabled in the configuration (Parameter "*Safe Maximum Position*" = Used), then the value configured on the parameter "*Home position or home offset*" must be within the permissible SMP window (parameters "*Safe Lower Position Limit for SMP (units)*" and "*Safe Upper Position Limit for SMP (units)*").
If this is not the case, then the system will enter Fail Safe state when checking the configuration during startup.
The Fail Safe state can only be exited by powering off/on and changing the safe application!

Danger!

In cases involving external forces (e.g. hanging loads), this can cause dangerous movement!
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!

4.13.2 Reference Switch mode

The mode "Reference Switch" correlates with the referencing modes "Switch Gate", "Abs Switch" and "End Switch" on the ACOPOSmulti.

Information:

If the reference switch input "*S_ReferenceSwitch*" is not wired on the function block, then the SafeMC module will change to Fail Safe state.
The Fail Safe state can only be exited by powering off/on and changing the safe application!

Depending on the configuration, the ACOPOSmulti will pass over the reference switch/limit switch multiple times.

Danger!

The reference switch/limit switch is part of the safety function and must therefore be accounted for in the risk analysis.

Use a debounced, safety-oriented position switch!

The machine manufacturer is responsible for implementing a suitable switch!

After the homing command (positive edge on the input *S_RequestHoming*), the SafeMC module then uses the home switch edge that matches the configuration "*Edge of reference switch*" and "*Trigger direction*", as long as this is passed over below the "*Max Trigger Speed*".
The home switch edge will be ignored if the reference switch is passed over at a speed higher than the "*Max Trigger Speed*".

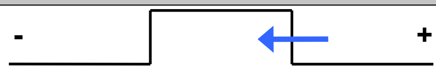
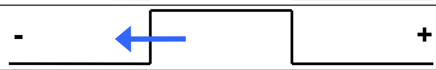
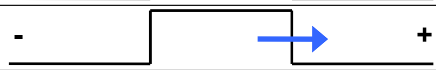
Configuration	Reference switch evaluation
Edge of reference switch = Negative Trigger direction = Negative	
Edge of reference switch = Positive Trigger direction = Negative	
Edge of reference switch = Negative Trigger direction = Positive	
Edge of reference switch = Positive Trigger direction = Positive	

Table 100: Selecting the home switch edge

Information:

After the homing command is made, the homing procedure must be completed within the configured time "*Homing Monitoring Time (µs)*". Otherwise, the module will change to the acknowledgeable error state "Functional Fail Safe".
The function block output *S_NotErrFUNC* is reset and the torque and power to the drive are switched off, causing it to spin out!
An error will cause a synchronous axis to lose its synchronicity.

The following parameters in SafeDESIGNER directly affect the behavior of the safety function:

Parameters	Units	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	Selection of homing mode	Directly
Edge of reference switch	Positive/ Negative	Selection of switching edge for 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.	Positive
Trigger direction	Positive/ Negative	Selection of 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	Selection of whether or not to use a reference pulse for homing	Not Used

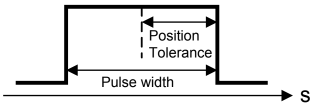
Table 101: Parameters for the "safe homing" safety function - Reference Switch mode

Parameters	Units	Description	Default value
Blocking distance (% encoder reference system)	%	Distance within which evaluation of the reference pulse will be suppressed. It is calculated starting at the configured reference switch edge and indicated as a % of the encoder reference system. A single rotation is used as the encoder reference system for rotary encoders.	0
Position Tolerance	[units]	Position tolerance for standstill and direction monitoring	0

Table 101: Parameters for the "safe homing" safety function - Reference Switch mode

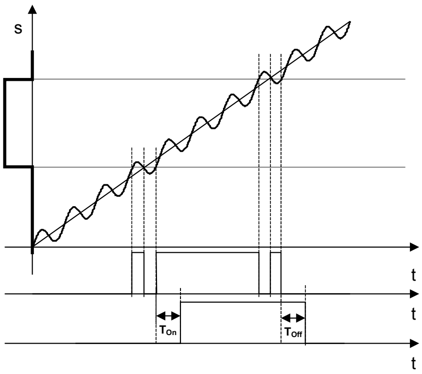
Danger!

The standstill "Position Tolerance" must be smaller 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.



Error in the referenced absolute position due to the delay caused by the filter times must be taken into consideration!

Reference pulse = Not Used

If the reference pulse is disabled, then the reference position will be assumed immediately when the home switch edge is successfully processed.

Reference pulse = Used

This mode is recommended when the positions of ACOPOSmulti and the SafeMC module must match exactly. Processing 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 every single turn overflow.

When "*Reference pulse*" = Used, the reference position will not be entered under the first valid reference pulse after the home switch edge has been reached.

After the valid home switch edge has been processed, the processing of the reference pulse will be suppressed for the distance configured in the parameter "*Blocking distance (% encoder reference system)*". The next reference pulse is only processed once this distance has been passed, at which point the home position is applied.

A valid homing procedure requires that the direction of movement does not change between when the home switch edge is passed and the valid reference pulse and that the speed limit "*Max Trigger Speed*" is not exceeded.

Information:

If the direction of movement does change while searching for the reference pulse, then the reference switch must be passed over again.

Information:

If the speed limit "*Max Trigger Speed*" is exceeded while searching for the reference pulse, then the module changes to the acknowledgeable error state "Functional Fail Safe".
The function block output *S_NotErrFUNC* is reset and the drive becomes torque-free and force-free, causing it to spin out!
An error will cause a synchronous axis to lose its synchronicity.

Danger!

In cases involving external forces (e.g. hanging loads), this can cause dangerous movement!
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!

4.13.3 Mode-Home Offset/Home Offset with Correction

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 homing command *Home Offset* uses this offset directly, while *Home Offset with Correction* mode accounts for any encoder overrun that might occur in the permissible range of movement.
The offset is configured in SafeDESIGNER on the parameter "*Home position or home Offset*".

The input *S_ReferenceSwitch* will not be evaluated.

The following parameters in SafeDESIGNER directly affect the behavior of the safety function:

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	Selection of homing mode	Directly
General settings			
Safe Maximum Position	Used / Unused	Activates the SMP safety function by 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 102: Parameters for the safety function "safe homing" - Modus Home Offset/Home Offset with Correction

Danger!

This homing mode can only be used for absolute encoders (single-turn encoder/multi-turn encoder/linear encoder). Using another encoder for this mode will cause the SafeMC module to change to Fail Safe state.
The Fail Safe state can only be exited by powering off/on and changing the safe application!

Information:

If the security functions SMP and/or SLP 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 larger than the encoder counting range, then the SafeMC module will change to Fail Safe state.
The Fail Safe state can only be exited by powering off/on and changing the safe application!

For more information, see 2.3.3 "Safe encoder counting range" on page 133.

Danger!

In cases involving external forces (e.g. hanging loads), this can cause dangerous movement!
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 well suited for absolute encoders which provide unique position values over the entire movement range. Using the homing offset, the encoder position over the entire movement range can be represented as the correct machine position.

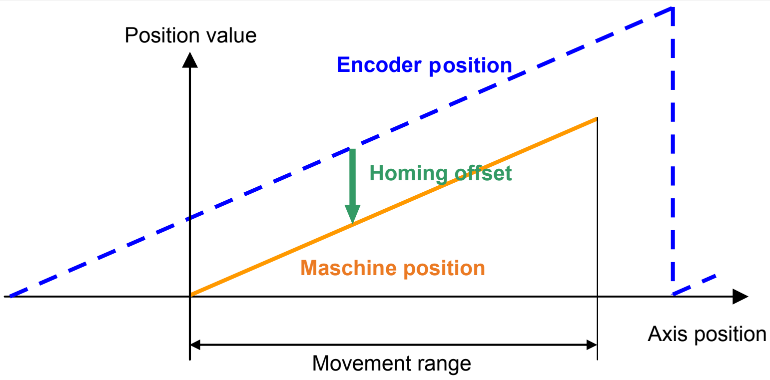


Figure 38: Home Offset referencing method

The Home Offset can be determined by carrying out a calibration move (e.g. Homing with Reference Switch).

Home Offset with Correction

In this homing mode, after setting the Home Offset a check is made to see 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-related encoder counting range is corrected:

Information:

The SMP safety function must be activated when using this mode. If SMP is deactivated, then the SafeMC module will change to Fail Safe state.
The Fail Safe state can only be exited by powering off/on and changing the safe application!

Counting range correction is needed when using absolute encoders if the encoder provides a unique position value over the entire movement range but an encoder overflow occurs within the movement range. Here, the Home Offset depends on if the machine was calibrated at a position to the right or the left of the overflow point.

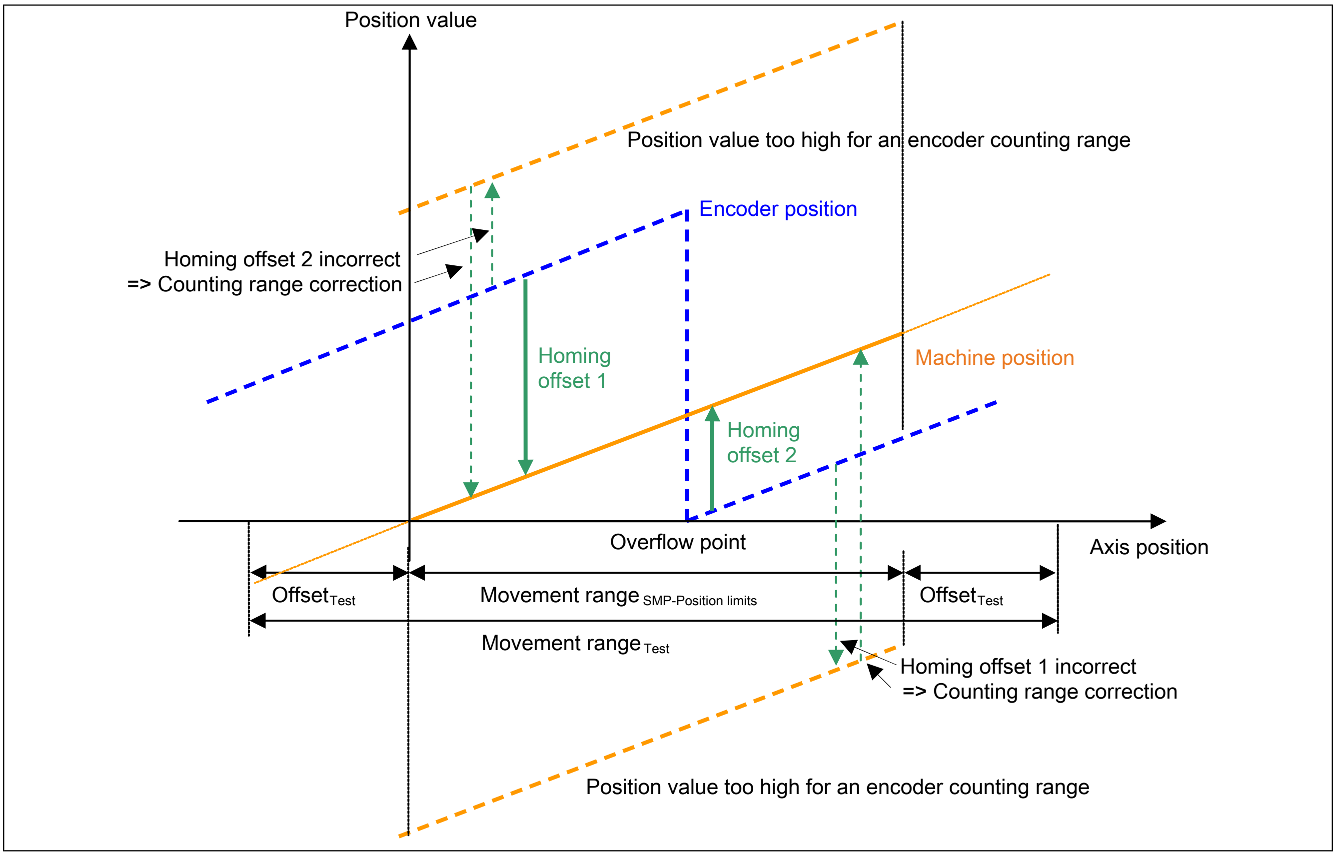


Figure 39: Referencing method - Home Offset with Correction

To the right of the overflow point, Home Offset 1 which is valid for the left side would lead to an incorrect position value. To the left of the overflow point, Home Offset 2 which is valid for the right side would lead to an incorrect position value. This can be compensated for with counting range correction.

Information:

Counting range correction only functions if the encoder range is larger than or equal to the movement range ! Keep in mind that only the safety-related part of the encoder counting range is used.

4.14 Safely Limited Position, SLP

Note:

This function is only available in safety release R1.4 and higher!

The purpose of the SLP safety function is to monitor a specified position window.

The parameters "*Safe Lower Position Limit for SLP*" and "*Safe Upper Position Limit for SLP*" can be used to configured the lower and upper position limits of the monitoring range.

The following parameters in SafeDESIGNER affect the behavior of the safety function:

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 request of SLP and start of monitoring	0

Table 103: SLP safety function parameters

The SLP safety function is requested when the input *S_RequestSLP* is set to SAFEFALSE.

Monitoring of the position window will begin after the amount of time configured in "*Delay time to start SLP*" has expired.

The status bit "*S_SafetyActiveSLP*" will be set to SAFETRUE if no errors occur while monitoring is active.

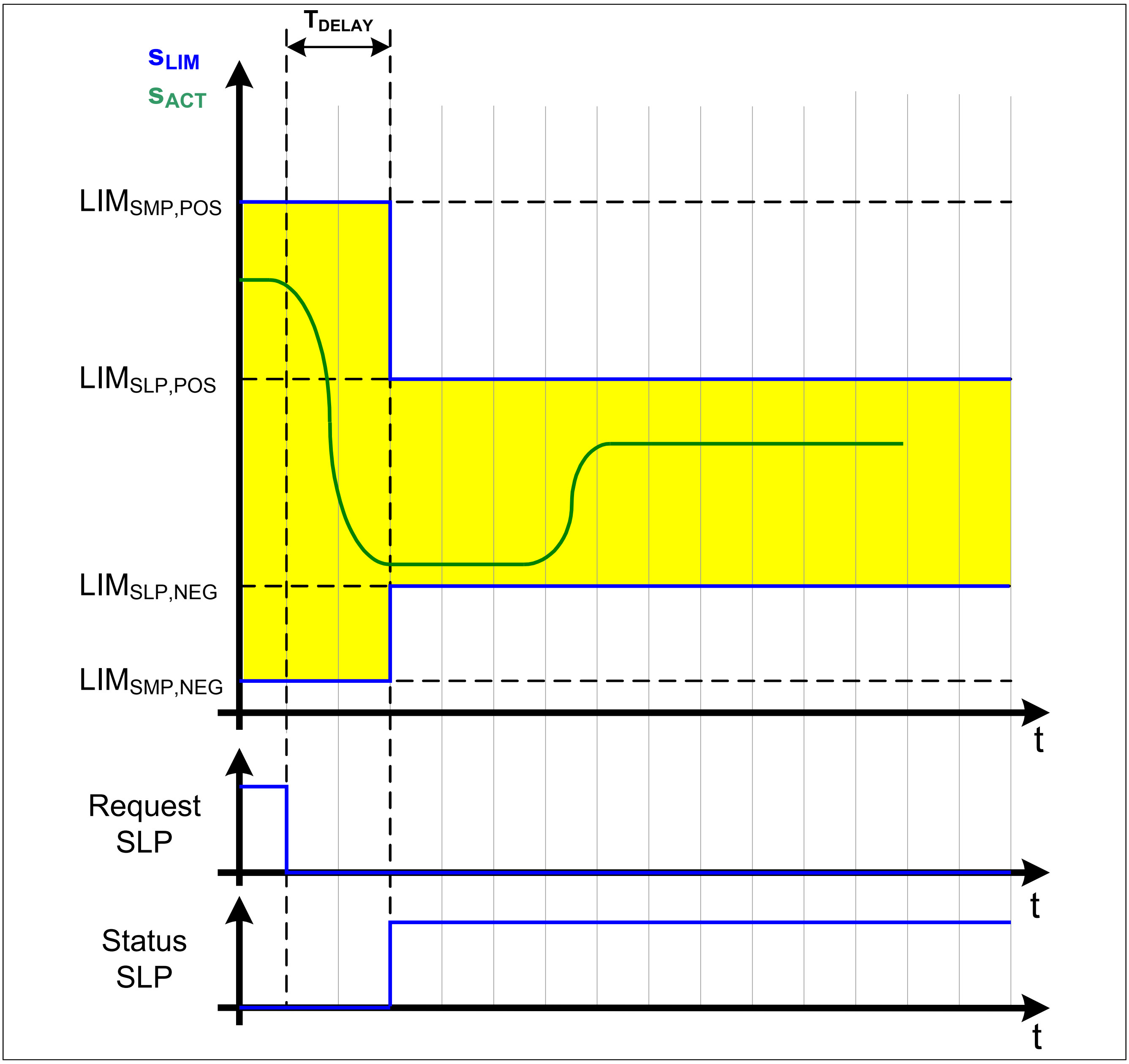


Figure 40: Safely Limited Position, SLP

Information:

The axis must be homed successfully before using the function Safely Limited Position.
If a homing procedure was not completed successfully or if the status "*S_SafePositionValid*" changes, then the request for the SLP safety function will cause the module to change to the acknowledgeable error state "Functional Fail Safe".
Torque and power to the drive are switched off, causing the drive to spin out! An error will cause a synchronous axis to lose its synchronicity.
This will reset the output on the function block *S_NotErrFUNC*!

Danger!

In cases involving external forces (e.g. hanging loads), this can cause dangerous movement!
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 keep shorten the distance remaining when the position window is exceeded as best as possible, a position-dependent speed limit will also be monitored in addition to the position.

Danger!

In the worst case, the monitored position window can be passed while the axis is spinning out. 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 so that the drive will come to a full stop before the limit is reached, using the configured deceleration ramp.

The permitted speed moving toward the upper position limit is

$$v_{LIM,POS} = \sqrt{2(LIM_{SLP,POS} - s) * a}$$

while toward the lower position limit, it is

$$v_{LIM,NEG} = \sqrt{2(s - LIM_{SLP,NEG}) * a}$$

The position-dependent speed limit is illustrated in the following image.

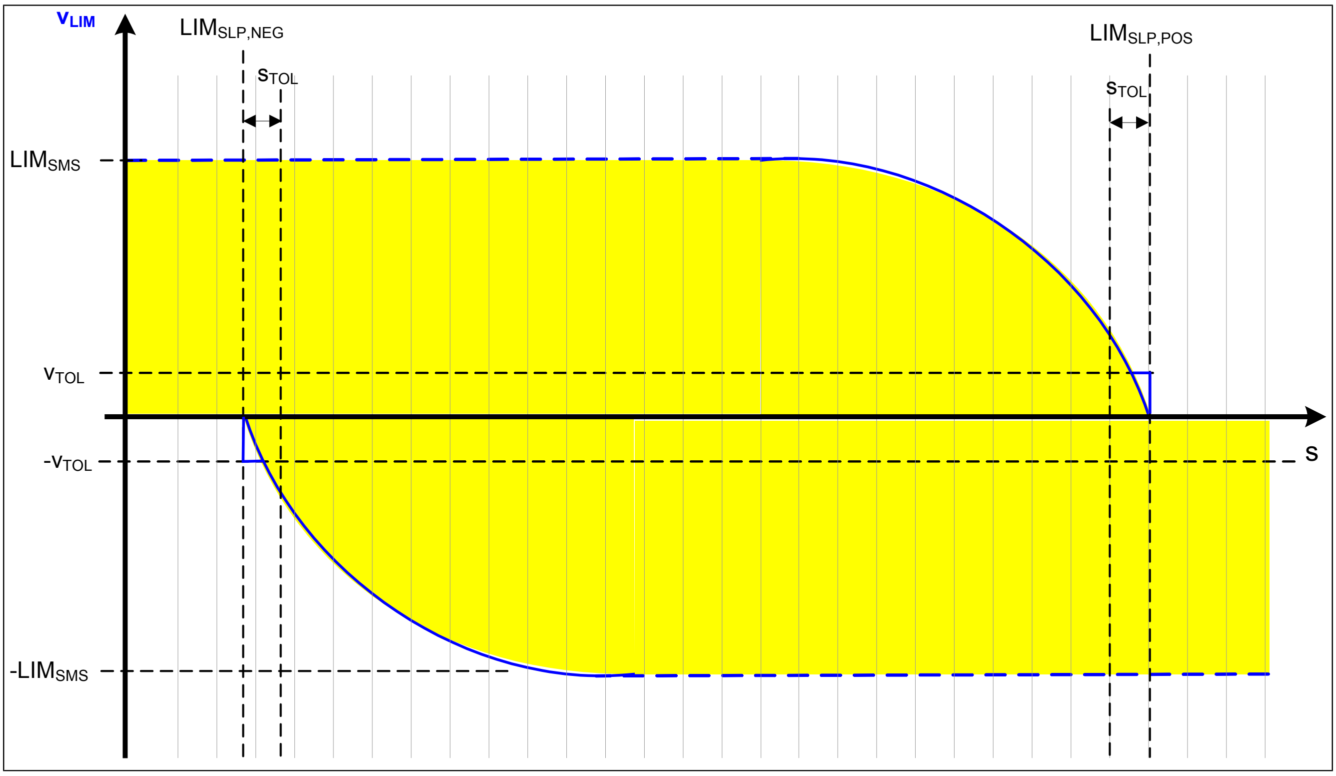


Figure 41: Position-dependent speed window

Danger!

If the position window or position-dependent speed limit is violated or if the status *S_SafePositionValid* changes while the safety function SLP is active, then the module will change to the acknowledgeable error state "Functional Fail Safe".
The function block output *S_NotErrFUNC* is reset and the drive becomes torque-free and force-free, causing it to spin out!
An error will cause a synchronous axis to lose its synchronicity.

Danger!

If the safety function SLP is used in the safe application, then the activation and deactivation of this function 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!

4.15 Safe Maximum Position, SMP

Note:

This function is only available in safety release R1.4 and higher!

The difference between SMP and SLP is that SMP cannot be actively initiated. It is either activated or deactivated by the configuration.

When activated, the current position is constantly monitored according to a defined position window.

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 / Unused	Activates the SMP safety function by 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
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 104: SMP safety function parameters

The parameters "*Safe Lower Position Limit for SMP*" and "*Safe Upper Position Limit for SMP*" can be used to configured the lower and upper position limits of the monitoring range.

The safety function SMP only works with homed axes because it requires a safe absolute position.
When SMP is configured, a 15 minute timeout begins once the pulse disabling is enabled, within which the homing procedure must take place.
After successfully completing the homing procedure and as long as there were no errors during monitoring, the status bit "*S_SafetyActiveSMP*" is set to SAFETRUE.

Information:

The axis must be homed successfully before using the function Safe Maximum Position.
If a homing procedure is not successfully completed within 15 minutes after enabling the pulse disabling or if the status *S_SafePositionValid* changes on an axis that has already been homed or if the position window or position-dependent speed limit is violated, then the module will change to the acknowledgeable error state "Functional Fail Safe".
The function block output *S_NotErrFUNC* is reset and the drive becomes torque-free and force-free, causing it to spin out! An error will cause a synchronous axis to lose its synchronicity.

As with the safety function SLP, the Safe Maximum Position function also monitors a position-dependent speed limit in addition to the position, in order to keep the remaining distance as short as possible if the position window is exceeded. For more information, please refer to "Safely Limited Position, SLP".

Danger!

In the worst case, the monitored position window can be passed while the axis is spinning out. 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.
An attempt to move beyond the standstill tolerance in the unsafe direction (i.e. away from the position window) will cause the module to enter the acknowledgeable error state "Functional Fail Safe".

Danger!

If the safety function SMP is used in the safe 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!

In cases involving external forces (e.g. hanging loads), this can cause dangerous movement!
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 Status LEDs

see "Indicators" on page 18

6 Register description - SafeMC

6.1 Parameters in the I/O configuration of the SafeMC module

Group: Function model

Parameters	Units	Description	Default value
Function model	---	This parameter is reserved for future function expansions	Default

Table 105: SafeMC parameter I/O configuration: Function model

Group: General

<table>
<tr><th>Parameters</th><th>Units</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>Missing module causes service mode to be activated</td></tr><tr><td>Off</td><td>Missing module is ignored</td></tr></table></td><td>Off</td></tr>
<tr><td>Module information</td><td>on/off</td><td>This parameter enables/disables the module-specific information in the I/O mapping:
• SerialNumber
• ModuleID
• Hardware variant
• Firmware version</td><td>Off</td></tr>
<tr><td>SafeLOGIC ID</td><td>---</td><td>For applications with multiple SafeLOGIC devices, this parameter specifies the module's affiliation to SafeLOGIC:
• Permissible values: 1 - 1024</td><td>Assigned automatically</td></tr>
<tr><td>SafeMODULE ID</td><td>---</td><td>This parameter is reserved for future function expansions</td><td>Assigned automatically</td></tr>
</table>

Table 106: SafeMC parameter I/O configuration: General

Group: Extended

Parameters	Units	Description	Default value
Turn-off delay in µs	[µs]	This parameter defines the delay before the SafeMC should turn off if POWERLINK communication is lost	0

Table 107: SafeMC parameter I/O configuration: Extended

6.2 SafeDESIGNER parameters

6.2.1 Safety Release 1.3

Group: Basic

<table>
<tr><th>Parameters</th><th>Units</th><th>Description</th><th>Default value</th></tr>
<tr><td>Min_required_FW_Rev</td><td>Basic Release/
Test Version</td><td>This parameter is reserved for future function expansions.</td><td>Basic release</td></tr>
<tr><td>Optional</td><td>No/
Yes/
Startup</td><td>The module can be optionally configured using this parameter. Optional modules do not have to be present, i.e. SafeLOGIC 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 start-up and safe communication to the SafeLOGIC device must be properly established
(SafeModulOk = SAFETRUE).
Processing of the safe application on the SafeLOGIC device is delayed after start-up until this state is achieved for all modules with "Optional = No".
After start-up, module problems are indicated by a quickly blinking MXCHG LED on the SafeLOGIC device. 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 start-up, which means the safe 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 device.
After start-up, module problems are NOT indicated by a quickly blinking MXCHG LED on the SafeLOGIC device. An entry is NOT made in the logbook.</td></tr>
<tr><td>Startup</td><td>This module is optional; the system determines how to proceed during start-up.
If, during start-up, it's determined that the module is physically present (regardless of if it's in Operational mode or not), then the module behaves as if "Optional = No" is set.
If, during start-up, it's determined that the module is not physically present, the module behaves as if "Optional = Yes" is set.</td></tr>
</table></td><td>No</td></tr>
<tr><td>External_UDID</td><td>No/
Yes-CAUTION</td><td>This parameter enables the option on the module of determining the expected UDID externally from the CPU.
<table>
<tr><th>Value</th><th>Description</th></tr>
<tr><td>Yes-CAUTION</td><td>The UDID is determined by the CPU. SafeLOGIC must be restarted when the UDID is changed.</td></tr>
<tr><td>No</td><td>The UDID is determined by a teach-in procedure during startup.</td></tr>
</table></td><td>No</td></tr>
</table>

Table 108: SafeMC parameter group: Basic

Danger!

If the "External_UDID = Yes-CAUTION" function 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 and handle this situation properly using additional safety measures.

Group: Safety_Response_Time

<table>
<tr><th>Parameters</th><th>Units</th><th>Description</th><th>Default value</th></tr>
<tr><td>Manual_Configuration</td><td>Yes/No</td><td>This parameter makes it possible to manually configure the safe response time for the module.
Generally, the parameters for safe response time are configured the same for all stations involved in the application. This is why these parameters are configured for the SafeLOGIC controller in the SafeDESIGNER. For application situations in which individual safety functions require optimum response time behavior, the parameters for safe response time can be configured individually on the respective module.
<table>
<tr><th>Value</th><th>Description</th></tr>
<tr><td>Yes</td><td>Data from the module's "Safety_Response_Time" group is used to calculate the safe response time for the module's signals.</td></tr>
<tr><td>No</td><td>The parameters for safe response time are taken from the "Safety_Response_Time" in the SafeLOGIC.</td></tr>
</table></td><td>No</td></tr>
</table>

Table 109: SafeMC parameter group: Safety_Response_Time

<table>
<tr><th>Parameters</th><th>Units</th><th>Description</th><th>Default value</th></tr>
<tr><td>Synchronous_Network_Only</td><td>Yes/No</td><td>This parameter determines the synchronization properties of the underlying network.
<table>
<tr><th>Value</th><th>Description</th></tr>
<tr><td>Yes</td><td>In order to calculate the safe 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></tr>
<tr><td>Max_X2X_CycleTime_us</td><td>[µs]</td><td>This parameter corresponds with the maximum duration of communication between the SafeMC module and the POWERLINK interface.
• Permissible values: 200 - 30000 µs</td><td>1600</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 safe response time.
• Permissible values: 200 - 30000 µs</td><td>5000</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 in the CPU used to calculate the safe response time. A value of 0 means that a copy task was not included for the response time.
• Permissible values: 0 - 30000 µs</td><td>5000</td></tr>
<tr><td>Min_X2X_CycleTime_us</td><td>[µs]</td><td>This parameter corresponds with the minimum duration of communication between the SafeMC module and the POWERLINK interface.
• Permissible values: 200 - 30000 µs</td><td>600</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 safe response time.
• Permissible values: 200 - 30000 µs</td><td>200</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 safe response time. A value of "0" means that configurations without copy tasks are also included for the response time.
• Permissible values: 0 - 30000 µs</td><td>0</td></tr>
<tr><td>Worst_Case_Response_Time_us</td><td>[µs]</td><td>This parameter specifies the limit value for monitoring the safe response time.
• Permissible values: 3000 - 50000 µs</td><td>50000</td></tr>
</table>

Table 109: SafeMC parameter group: Safety_Response_Time

Group: Encoder Unit System

<table>
<tr><th>Parameters</th><th>Units</th><th>Description</th><th>Default value</th></tr>
<tr><td>Number of encoder revolutions</td><td>---</td><td>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).
To do this, the relationship between a whole number multiple of this unit (units per x-revolutions) and a certain number of encoder revolutions (x-revolutions) has to be previously defined.</td><td>1</td></tr>
<tr><td>Units per number of encoder revolutions</td><td>[units]</td><td>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).
To do this, the relationship between a whole number multiple of this unit (units per x-revolutions) and a certain number of encoder revolutions (x-revolutions) has to be previously defined.</td><td>1000</td></tr>
<tr><td>Counting direction</td><td>Default/
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></tr>
<tr><td>Maximum speed to normalize the speed range</td><td>[units/s]</td><td>Maximum speed to which the displayed speed should be normalized
The safe speed signal is a signed 2 byte value.
A speed v_{phys} that is higher than the value range must be scaled before it can be displayed.
v_{scaled}= (v_{phys} * 32767) / MaxSpeedToNormalizeTheSpeedRange</td><td>32767</td></tr>
</table>

Table 110: SafeMC parameter group: Encoder Unit System

Information:

The physical drive speed cannot exceed the value set on the parameter *Maximum speed to normalize the speed range [units/s]*, or else the SafeMC module will change to the error state!

Danger!

False configuration of the unit system can cause 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: Safety deceleration ramp

Parameters	Units	Description	Default value
Deceleration Ramp [units/s²]	[units/s²]	Slope of the deceleration ramp to be monitored	1073676289

Table 111: SafeMC parameter group: Safety deceleration ramp

Group: General settings

<table>
<tr><th>Parameters</th><th>Units</th><th>Description</th><th>Default value</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 is activated</td></tr><tr><td>Unused</td><td>SMS is deactivated</td></tr></table></td><td>Used</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 changes to the state, "Operational" (start reset). The Reset input does not have to be actuated!</td></tr><tr><td>Unused</td><td>After startup, the module gets stuck in an Init state, until a positive edge is detected on the Reset input.</td></tr></table></td><td>Unused</td></tr>
<tr><td>Channel selection for One Channel STO (STO1)</td><td>HighSide/
LowSide</td><td>Selection of 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 high side IGBTs are actuated with the function STO1.</td></tr><tr><td>LowSide</td><td>The low side IGBTs are actuated with the function STO1.</td></tr></table></td><td>HighSide</td></tr>
<tr><td>Ramp monitoring for SS1</td><td>Activated/
Deactivated</td><td>Activates ramp monitoring (in addition to the time) when the SS1 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 SS1 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 SS1 function, only a configurable time is monitored</td></tr></table></td><td>Activated</td></tr>
<tr><td>Ramp monitoring for SS2</td><td>Activated/
Deactivated</td><td>Activates ramp monitoring (in addition to the time) when the SS2 function is activated<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></tr>
<tr><td>Ramp monitoring for SLS</td><td>Activated/
Deactivated</td><td>Activates ramp monitoring (in addition to the time) when the SLS function is activated<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></tr>
<tr><td>Early Limit Monitoring</td><td>Activated/
Deactivated</td><td>Deceleration ramp monitoring is terminated prematurely if the value drops 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></tr>
</table>

Table 112: SafeMC parameter group: General settings

Danger!

The parameter "Automatic Reset at Startup" activates/deactivates the restart inhibit during startup or when a network failure occurs.

If the parameter "Automatic Reset at Startup" is set to "Used", then the module automatically changes to "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. The user must implement additional measures to ensure correct, safety-related functionality.

Group: Encoder Monitoring

<table>
<tr><th>Parameters</th><th>Units</th><th>Description</th><th>Default value</th></tr>
<tr><td>Encoder Position monitoring</td><td>Activated/
Deactivated</td><td>Activates/deactivates the monitoring of the position lag error generated on the SafeMC 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></tr>
<tr><td>Encoder Speed monitoring</td><td>Activated/
Deactivated</td><td>Activates/deactivates the monitoring of the speed error generated on the SafeMC 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></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 ACOPOSmulti 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></tr>
</table>

Table 113: SafeMC parameter group: Encoder Monitoring

Danger!

To achieve safety level SIL 2 for the safety functions that require safe encoder evaluation, any mechanical errors on the connection between the motor shaft and encoder must be identified and prevented! Simply using the function group "Encoder Monitoring" together with the parameters from the group "Encoder Monitoring Tolerances" is not sufficient for achieving SIL 2.

Information:

The function group "Encoder Monitoring" together with the parameters from the group "Encoder Monitoring Tolerances" is not considered to be suitable for safety purposes because signals from the non-safety-related part of the inverter module are evaluated here. However, it is still recommended to enable this function to help detect potential errors early-on!

Group: Behavior of Functional Fail Safe

<table>
<tr><th>Parameters</th><th>Units</th><th>Description</th><th>Default value</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 is activated immediately or STO1 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 is activated immediately.</td></tr><tr><td>STO1 and STO with time delay</td><td>In the Functional Fail Safe state, STO1 is activated first and then STO and SBC after a delay.</td></tr></table></td><td>STO</td></tr>
<tr><td>Delay for STO in Functional Fail Safe [µs]</td><td>[µs]</td><td>Delay between STO1 and STO (and SBC) in the Functional Fail Safe state</td><td>0</td></tr>
<tr><td>Delay time until the brake engages [µs]</td><td>[µs]</td><td>Activation delay before the brake engages
The second enable channel is activated after this delay if STO1 and delayed STO and SBC is configured for Functional Fail Safe.</td><td>0</td></tr>
</table>

Table 114: SafeMC parameter group: Safety deceleration ramp

Group: Safety Speed Limits

Parameters	Units	Description	Default value
Maximum speed	[units/s]	Speed limit of the maximum speed (SMS)	0
Safe Speed Limit 1 for SLS	[units/s]	Speed Limit 1 for SLS (SLS1)	0
Safe Speed Limit 2 for SLS	[units/s]	Speed Limit 2 for SLS (SLS2)	0
Safe Speed Limit 3 for SLS	[units/s]	Speed Limit 3 for SLS (SLS3)	0
Safe Speed Limit 4 for SLS	[units/s]	Speed Limit 4 for SLS (SLS4)	0

Table 115: SafeMC parameter group: Safety Speed Limits

Danger!

The respectively monitored speed limit must be set in such a manner so 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:

$LIM_{SOS} \leq LIM_{SLS4} \leq LIM_{SLS3} \leq LIM_{SLS2} \leq LIM_{SLS1} \leq LIM_{SMS} \leq$ NormSpeedMax

This is required for setting priority of the safety functions on the SafeMC module.

If this rule is not adhered to, then the SafeMC module immediately changes to the Fail Safe state after startup. The application in SafeDESIGNER must be set accordingly!

Group: Safety Standstill and Direction Tolerances

Parameters	Units	Description	Default value
Speed Tolerance (units /s)	[units/s]	Speed tolerance for standstill monitoring (SOS)	0
Position Tolerance (units)	[units]	Position tolerance for standstill and direction monitoring	0

Table 116: SafeMC parameter group: Safety Standstill and Direction Tolerances

Danger!

The respectively monitored speed limit must be set in such a manner so 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

Parameters	Units	Description	Default value
Safe Increments (units)	[units]	Maximum moveable increments when SLI is active	0
SLI Off Delay (µs)	[µs]	Switch off delay of SLI	0

Table 117: SafeMC parameter group: Safely Limited Increment

Danger!

The maximum increment range must be set in such a manner so 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

Parameters	Units	Description	Default value
Ramp Monitoring Time for SS1	[µs]	Deceleration monitoring time for SS1	0
Ramp Monitoring Time for SS2	[µs]	Deceleration monitoring time for SS2	0
Ramp Monitoring Time for SLS1	[µs]	Deceleration monitoring time for SLS1	0
Ramp Monitoring Time for SLS2	[µs]	Deceleration monitoring time for SLS2	0
Ramp Monitoring Time for SLS3	[µs]	Deceleration monitoring time for SLS3	0
Ramp Monitoring Time for SLS4	[µs]	Deceleration monitoring time for SLS4	0

Table 118: SafeMC parameter group: Safety Ramp Monitoring Times

Group: Safety Additional Parameters

Parameters	Units	Description	Default value
Delay time to start ramp monitoring	[µs]	Delay time between request of ramp monitoring and start of monitoring	0
Delay time to start SDI	[µs]	Delay time between request of SDI and activation of the safety function	0
Delay time to start SBC	[µs]	Delay time between request of SBC and activation of the safety function	0
Early Limit Monitoring time	[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 119: SafeMC parameter group: Safety Additional Parameters

Danger!

The delay parameters cause a delay before the safety function is started. This delay must be accounted for when determining the increments and performing the risk analysis!

Group: Encoder Monitoring Tolerances

Parameters	Units	Description	Default value
Encoder Monitoring Position Tolerance (units)	[units]	Position lag error tolerance for encoder monitoring	0
Encoder Monitoring Speed Tolerance (units/s)	[units/s]	Speed error tolerance for encoder monitoring	0

Table 120: SafeMC parameter group: Encoder Monitoring Tolerances

Danger!

To achieve safety level SIL 2 for the safety functions that require safe encoder evaluation, any mechanical errors on the connection between the motor shaft and encoder must be identified and prevented! Simply using the function group "Encoder Monitoring" together with the parameters from the group "Encoder Monitoring Tolerances" is not sufficient for achieving SIL 2.

Information:

The function group "Encoder Monitoring" together with the parameters from the group "Encoder Monitoring Tolerances" is not considered to be suitable for safety purposes because signals from the non-safety-related part of the inverter module are evaluated here. However, it is still recommended to enable this function to help detect potential errors early-on!

6.2.2 Safety Release 1.4

Group: Basic

<table>
<tr><th>Parameters</th><th>Units</th><th>Description</th><th>Default value</th></tr>
<tr><td>Min_required_FW_Rev</td><td>Basic Release/
Test Version</td><td>This parameter is reserved for future function expansions.</td><td>Basic release</td></tr>
<tr><td>Optional</td><td>No/
Yes/
Startup</td><td>The module can be optionally configured using this parameter. Optional modules do not have to be present, i.e. SafeLOGIC 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 start-up and safe communication to the SafeLOGIC device must be properly established
(SafeModulOk = SAFETRUE).
Processing of the safe application on the SafeLOGIC device is delayed after start-up until this state is achieved for all modules with "Optional = No".
After start-up, module problems are indicated by a quickly blinking MXCHG LED on the SafeLOGIC device. 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 start-up, which means the safe 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 device.
After start-up, module problems are NOT indicated by a quickly blinking MXCHG LED on the SafeLOGIC device. An entry is NOT made in the logbook.</td></tr>
<tr><td>Startup</td><td>This module is optional; the system determines how to proceed during start-up.
If, during start-up, it's determined that the module is physically present (regardless of if it's in Operational mode or not), then the module behaves as if "Optional = No" is set.
If, during start-up, it's determined that the module is not physically present, the module behaves as if "Optional = Yes" is set.</td></tr>
</table></td><td>No</td></tr>
<tr><td>External_UDID</td><td>No/
Yes-CAUTION</td><td>This parameter enables the option on the module of determining the expected UDID externally from the CPU.
<table>
<tr><th>Value</th><th>Description</th></tr>
<tr><td>Yes-CAUTION</td><td>The UDID is determined by the CPU. SafeLOGIC must be restarted when the UDID is changed.</td></tr>
<tr><td>No</td><td>The UDID is determined by a teach-in procedure during startup.</td></tr>
</table></td><td>No</td></tr>
</table>

Table 121: SafeMC parameter group: Basic

Danger!

If the "External_UDID = Yes-CAUTION" function 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 and handle this situation properly using additional safety measures.

Group: Safety_Response_Time

Parameters	Units	Description	Default value
Manual_Configuration	Yes/No	This parameter makes it possible to manually configure the safe response time for the module. Generally, the parameters for safe response time are configured the same for all stations involved in the application. This is why these parameters are configured for the SafeLOGIC controller in the SafeDESIGNER. For application situations in which individual safety functions require optimum response time behavior, the parameters for safe response time can be configured individually on the respective module. **Value** / **Description** Yes: Data from the module's "Safety_Response_Time" group is used to calculate the safe response time for the module's signals. No: The parameters for safe response time are taken from the "Safety_Response_Time" in the SafeLOGIC.	No
Synchronous_Network_Only	Yes/No	This parameter determines the synchronization properties of the underlying network. **Value** / **Description** Yes: In order to calculate the safe response time, networks must be synchronous and their cycle times must either be the same or an integer ratio of the cycle times. No: No requirement for synchronization of the networks.	Yes
Max_X2X_CycleTime_us	[µs]	This parameter corresponds with the maximum duration of communication between the SafeMC module and the POWERLINK interface. • Permissible values: 200 - 30000 µs	1600
Max_Powerlink_CycleTime_us	[µs]	This parameter specifies the maximum POWERLINK cycle time used to calculate the safe response time. • Permissible values: 200 - 30000 µs	5000
Max_CPU_CrossLinkTask_CycleTime_us	[µs]	This parameter specifies the maximum cycle time for the copy task in the CPU used to calculate the safe response time. A value of 0 means that a copy task was not included for the response time. • Permissible values: 0 - 30000 µs	5000
Min_X2X_CycleTime_us	[µs]	This parameter corresponds with the minimum duration of communication between the SafeMC module and the POWERLINK interface. • Permissible values: 200 - 30000 µs	600
Min_Powerlink_CycleTime_us	[µs]	This parameter specifies the minimum POWERLINK cycle time used to calculate the safe response time. • Permissible values: 200 - 30000 µs	200
Min_CPU_CrossLinkTask_CycleTime_us	[µs]	This parameter specifies the minimum cycle time for the copy task on the CPU used to calculate the safe response time. A value of "0" means that configurations without copy tasks are also included for the response time. • Permissible values: 0 - 30000 µs	0
Worst_Case_Response_Time_us	[µs]	This parameter specifies the limit value for monitoring the safe response time. • Permissible values: 3000 - 50000 µs	50000

Table 122: SafeMC parameter group: Safety_Response_Time

Group: Encoder Unit System

Parameters	Units	Description	Default value
Count of physical reference system	---	Rotary encoder unit scale: x-revolutions Linear encoder unit scale: 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). To do this, the relationship between a whole number 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
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). To do this, the relationship between a whole number 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

Table 123: SafeMC parameter group: Encoder Unit System

<table>
<tr><th>Parameters</th><th>Units</th><th>Description</th><th>Default value</th></tr>
<tr><td>Counting direction</td><td>Default/
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></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 will be defined here.
This value is not used for rotary encoders, where the reference system is a single rotation.</td><td>1000000000</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
The safe speed signal is a signed 2 byte value.
A speed v_{phys} that is higher than the value range must be scaled before it can be displayed.
v_{scaled}= (v_{phys} * 32767) / MaxSpeedToNormalizeTheSpeedRange</td><td>32767</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></tr>
</table>

Table 123: SafeMC parameter group: Encoder Unit System

Information:

The physical drive speed cannot exceed the value set on the parameter *Maximum speed to normalize the speed range [units/s]*, or else the SafeMC module will change to the error state!

Danger!

The frictional connection between the cone-shaped shaft of the rotor and EnDat measurement device is dimensioned for maximum rotor acceleration in accordance with the Heidenhain installation instructions. This acceleration value must not be exceeded in the worst case. The maximum acceleration is monitored on the SafeMC module and can be configured using the parameter "*Maximum acceleration*".

Danger!

False configuration of the unit system can cause 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

Parameters	Units	Description	Default value
Home Position or home Offset (units)	[units]	Reference position or homing 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	Selection of homing mode • Directly • Reference switch • Home Offset • Home Offset with Correction	Directly
Edge of reference switch	Positive/ Negative	Selection of switching edge for 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.	Positive
Trigger direction	Positive/ Negative	Selection of 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	Selection of whether or not to use a reference pulse for homing	Not Used
Blocking distance (% encoder reference system)	%	Distance within which evaluation of the reference pulse will be suppressed. It is calculated starting at the configured reference switch edge and indicated as a % of the encoder reference system. A single rotation is used as the encoder reference system for rotary encoders.	0

Table 124: SafeMC parameter group: Homing

Group: Safety deceleration ramp

Parameters	Units	Description	Default value
Deceleration Ramp [units/s²]	[units/s²]	Slope of the deceleration ramp to be monitored	1073676289

Table 125: SafeMC parameter group: Safety deceleration ramp

Group: General settings

<table>
<tr><th>Parameters</th><th>Units</th><th>Description</th><th>Default value</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 is activated</td></tr><tr><td>Unused</td><td>SMS is deactivated</td></tr></table></td><td>Used</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 changes to the state, "Operational" (start reset). The Reset input does not have to be actuated!</td></tr><tr><td>Unused</td><td>After startup, the module gets stuck in an Init state, until a positive edge is detected on the Reset input.</td></tr></table></td><td>Unused</td></tr>
<tr><td>Channel selection for One Channel STO (STO1)</td><td>HighSide/
LowSide</td><td>Selection of 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 high side IGBTs are actuated with the function STO1.</td></tr><tr><td>LowSide</td><td>The low side IGBTs are actuated with the function STO1.</td></tr></table></td><td>HighSide</td></tr>
<tr><td>Ramp monitoring for SS1</td><td>Activated/
Deactivated</td><td>Activates ramp monitoring (in addition to the time) when the SS1 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 SS1 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 SS1 function, only a configurable time is monitored</td></tr></table></td><td>Activated</td></tr>
<tr><td>Ramp monitoring for SS2</td><td>Activated/
Deactivated</td><td>Activates ramp monitoring (in addition to the time) when the SS2 function is activated<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></tr>
<tr><td>Ramp monitoring for SLS</td><td>Activated/
Deactivated</td><td>Activates ramp monitoring (in addition to the time) when the SLS function is activated<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></tr>
<tr><td>Early Limit Monitoring</td><td>Activated/
Deactivated</td><td>Deceleration ramp monitoring is terminated prematurely if the value drops 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></tr>
<tr><td>Safe Maximum Position</td><td>Used/
Unused</td><td>Activates the SMP safety function by 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></tr>
</table>

Table 126: SafeMC parameter group: General settings

Danger!

The parameter "Automatic Reset at Startup" activates/deactivates the restart inhibit during startup or when a network failure occurs.

If the parameter "Automatic Reset at Startup" is set to "Used", then the module automatically changes to "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. Additional measures must be implemented to ensure correct, safety-related functionality.

Group: Encoder Monitoring

<table>
<tr><th>Parameters</th><th>Units</th><th>Description</th><th>Default value</th></tr>
<tr><td>Encoder Position monitoring</td><td>Activated/
Deactivated</td><td>Activates/deactivates the monitoring of the position lag error generated on the SafeMC 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></tr>
</table>

Table 127: SafeMC parameter group: Encoder Monitoring

Parameters	Units	Description	Default value
Encoder Speed monitoring	Activated/ Deactivated	Activates/deactivates the monitoring of the speed error generated on the SafeMC module. **Value** – **Description** Activated – Monitoring active Deactivated – Monitoring not active	Activated
Set position alive testing	Activated/ Deactivated	Activates/deactivates the monitor that detects whether the set position generated on the ACOPOSmulti is frozen. **Value** – **Description** Activated – Monitoring active Deactivated – Monitoring not active	Deactivated

Table 127: SafeMC parameter group: Encoder Monitoring

Group: Behavior of Functional Fail Safe

Parameters	Units	Description	Default value
Behavior of Functional Fail Safe	STO/ STO1 and STO with time delay	In the Functional Fail Safe state, STO and SBC is activated immediately or STO1 and then STO after a delay **Value** – **Description** STO – In the Functional Fail Safe state, STO and SBC is activated immediately. STO1 and STO with time delay – In the Functional Fail Safe state, STO1 is activated first and then STO and SBC after a delay.	STO
Delay for STO in Functional Fail Safe [µs]	[µs]	Delay between STO1 and STO (and SBC) in the Functional Fail Safe state	0
Delay time until the brake engages [µs]	[µs]	**Activation delay before the brake engages** The second enable channel is activated after this delay if STO1 and delayed STO and SBC is configured for Functional Fail Safe.	0

Table 128: SafeMC parameter group: Safety deceleration ramp

Group: Safety Speed Limits

Parameters	Units	Description	Default value
Maximum speed	[units/s]	Speed limit of the maximum speed (SMS)	0
Safe Speed Limit 1 for SLS	[units/s]	Speed Limit 1 for SLS (SLS1)	0
Safe Speed Limit 2 for SLS	[units/s]	Speed Limit 2 for SLS (SLS2)	0
Safe Speed Limit 3 for SLS	[units/s]	Speed Limit 3 for SLS (SLS3)	0
Safe Speed Limit 4 for SLS	[units/s]	Speed Limit 4 for SLS (SLS4)	0

Table 129: SafeMC parameter group: Safety Speed Limits

Danger!

The respectively monitored speed limit must be set in such a manner so 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 SafeMC module.

If this rule is not adhered to, then the SafeMC module immediately changes to the Fail Safe state after startup. The application in SafeDESIGNER must be set accordingly!

Group: Safety Position Limits

Parameters	Units	Description	Default value
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 130: SafeMC parameter group: Safety Position Limits

Danger!

The position limits to monitor must be set in such a manner so 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 SafeMC module immediately changes to the Fail Safe state after startup. The application in SafeDESIGNER must be set accordingly!

Group: Safety Standstill and Direction Tolerances

Parameters	Units	Description	Default value
Speed Tolerance (units /s)	[units/s]	Speed tolerance for standstill monitoring (SOS)	0
Position Tolerance (units)	[units]	Position tolerance for standstill and direction monitoring	0

Table 131: SafeMC parameter group: Safety Standstill and Direction Tolerances

Danger!

The respectively monitored speed limit must be set in such a manner so 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

Parameters	Units	Description	Default value
Safe Increments (units)	[units]	Maximum moveable increments when SLI is active	0
SLI Off Delay (µs)	[µs]	Switch off delay of SLI	0

Table 132: SafeMC parameter group: Safely Limited Increment

Danger!

The maximum increment range must be set in such a manner so 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

Parameters	Units	Description	Default value
Ramp Monitoring Time for SS1	[µs]	Deceleration monitoring time for SS1	0
Ramp Monitoring Time for SS2	[µs]	Deceleration monitoring time for SS2	0
Ramp Monitoring Time for SLS1	[µs]	Deceleration monitoring time for SLS1	0
Ramp Monitoring Time for SLS2	[µs]	Deceleration monitoring time for SLS2	0
Ramp Monitoring Time for SLS3	[µs]	Deceleration monitoring time for SLS3	0
Ramp Monitoring Time for SLS4	[µs]	Deceleration monitoring time for SLS4	0

Table 133: SafeMC parameter group: Safety Ramp Monitoring Times

Group: Safety Additional Parameters

Parameters	Units	Description	Default value
Delay time to start ramp monitoring (µs)	[µs]	Delay time between request of ramp monitoring and start of monitoring	0
Delay time to start SDI (µs)	[µs]	Delay time between request of SDI and activation of the safety function	0
Delay time to start SBC (µs)	[µs]	Delay time between request of SBC and activation of the safety function	0

Table 134: SafeMC parameter group: Safety Additional Parameters

Parameters	Units	Description	Default value
Delay time to start SLP (µs)	[µs]	Delay time between request of SLP and start of monitoring	0
Early Limit Monitoring time (µs)	[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 134: SafeMC parameter group: Safety Additional Parameters

Danger!

The delay parameters cause a delay before the safety function is started. This delay must be accounted for when determining the increments and performing the risk analysis!

Group: Encoder Monitoring Tolerances

Parameters	Units	Description	Default value
Encoder Monitoring Position Tolerance (units)	[units]	Position lag error tolerance for encoder monitoring	0
Encoder Monitoring Speed Tolerance (units/s)	[units/s]	Speed error tolerance for encoder monitoring	0

Table 135: SafeMC parameter group: Encoder Monitoring Tolerances

6.3 Channel list

Channel Name	Starting in safety release	Access via Automation Studio	Access via SafeDESIGNER	Data type	Description
ModulIOK	R 13	Read	---	BOOL	Indicates if the module is OK
SerialNumber	R 13	Read [1)]	---	UDINT	Module serial number
ModuleID	R 13	Read [1)]	---	UINT	Module code
HardwareVariant	R 13	Read [1)]	---	UINT	Hardware variants
FirmwareVersion	R 13	Read [2)]	---	UINT	Module firmware version
UDID_low	R 13	(Read) [2)]	---	UDINT	UDID, lower 4 bytes
UDID_high	R 13	(Read) [2)]	---	UINT	UDID, upper 2 bytes
SafetyFWversion1	R 13	(Read) [2)]	---	UINT	Firmware version of safety processor 1
SafetyFWversion2	R 13	(Read) [2)]	---	UINT	Firmware version of safety processor 2
Diag1_Temp	R 13	(Read) [2)]	---	UINT	Module temperature in °C
SafeModuleOK	R 13	---	Read	SAFEBOOL	Indicates if the safe communication channel is OK
SafetyActiveSTO	R 13	Read	(Read) [3)]	SAFEBOOL	STO safety function status (TRUE = safe state)
SafetyActiveSBC	R 13	Read	(Read) [3)]	SAFEBOOL	SBC safety function status (TRUE = safe state)
SafetyActiveSOS	R 13	Read	(Read) [3)]	SAFEBOOL	SOS safety function status (TRUE = safe state)
SafetyActiveSS1	R 13	Read	(Read) [3)]	SAFEBOOL	SS1 safety function status (TRUE = safe state)
SafetyActiveSS2	R 13	Read	(Read) [3)]	SAFEBOOL	SS2 safety function status (TRUE = safe state)
SafetyActiveSLS1	R 13	Read	(Read) [3)]	SAFEBOOL	SLS1 safety function status (TRUE = safe state)
SafetyActiveSLS2	R 13	Read	(Read) [3)]	SAFEBOOL	SLS2 safety function status (TRUE = safe state)
SafetyActiveSLS3	R 13	Read	(Read) [3)]	SAFEBOOL	SLS3 safety function status (TRUE = safe state)
SafetyActiveSL4	R 13	Read	(Read) [3)]	SAFEBOOL	SLS4 safety function status (TRUE = safe state)
SafetyActiveSTO1	R 13	Read	(Read) [3)]	SAFEBOOL	STO1 safety function status (TRUE = safe state)
SafetyActiveSDIpos	R 13	Read	(Read) [3)]	SAFEBOOL	SDIpos safety function status (TRUE = safe state)
SafetyActiveSLI	R 13	Read	(Read) [3)]	SAFEBOOL	SLI safety function status (TRUE = safe state)
SafetyActiveSDIneg	R 13	Read	(Read) [3)]	SAFEBOOL	SDIneg safety function status (TRUE = safe state)
SafetyActiveSLP	R 14	Read	(Read) [3)]	SAFEBOOL	SLP safety function status (TRUE = safe state)
SafetyActiveSMP	R 14	Read	(Read) [3)]	SAFEBOOL	SMP safety function status (TRUE = safe state)
SafePositionValid	R 14	Read	(Read) [3)]	SAFEBOOL	Status of the safe position (TRUE = valid position referencing and no errors found)
StatusSetPosAlive	R 13	Read	---	SAFEBOOL	Status of set position "Alive Testing" (TRUE = valid)
AllReqFuncAct	R 13	Read	(Read) [3)]	SAFEBOOL	Status of the requested safety functions (TRUE = all requested safety functions are active)
SafetyActiveSDC	R 13	Read	(Read) [3)]	SAFEBOOL	Status of the delay monitor (TRUE = delay monitoring is active)

Table 136: SafeMC channel list

Channel Name	Starting in safety release	Access via Automation Studio	Access via SafeDESIGNER	Data type	Description
Operational	R 13	Read	---	SAFEBOOL	Status of the function block (TRUE = function block is in the state "Operational", "Safe", or "Wait for Confirmation")
NotErrENC	R 13	Read	(Read) 3)	SAFEBOOL	Status of the safe encoder (FALSE = pending encoder error)
NotErrFUNC	R 13	Read	(Read) 3)	SAFEBOOL	SafeMC module status (FALSE = SafeMC module is in the error state Functional Fail Safe)
ScaledSpeed	R 13	Read	(Read) 3)	SAFEINT	Safe scaled speed
SafePos	R 14	Read	(Read) 3)	SAFEDINT	Safe position
RequestSTO	R 13	(Read) 4)	(Write) 5)	SAFEBOOL	Select/deselect the safety function STO
RequestSBC	R 13	(Read) 4)	(Write) 5)	SAFEBOOL	Select/deselect the safety function SBC
RequestSOS	R 13	(Read) 4)	(Write) 5)	SAFEBOOL	Select/deselect the safety function SOS
RequestSS1	R 13	(Read) 4)	(Write) 5)	SAFEBOOL	Select/deselect the safety function SS1
RequestSS2	R 13	(Read) 4)	(Write) 5)	SAFEBOOL	Select/deselect the safety function SS2
RequestSLS1	R 13	(Read) 4)	(Write) 5)	SAFEBOOL	Select/deselect the safety function SLS1
RequestSLS2	R 13	(Read) 4)	(Write) 5)	SAFEBOOL	Select/deselect the safety function SLS2
RequestSLS3	R 13	(Read) 4)	(Write) 5)	SAFEBOOL	Select/deselect the safety function SLS3
RequestSLS4	R 13	(Read) 4)	(Write) 5)	SAFEBOOL	Select/deselect the safety function SLS4
RequestSTO1	R 13	(Read) 4)	(Write) 5)	SAFEBOOL	Select/deselect the safety function STO1
RequestSDIpos	R 13	(Read) 4)	(Write) 5)	SAFEBOOL	Select/deselect the safety function SDIpos
RequestSLI	R 13	(Read) 4)	(Write) 5)	SAFEBOOL	Select/deselect the safety function SLI
RequestSDIneg	R 13	(Read) 4)	(Write) 5)	SAFEBOOL	Select/deselect the safety function SDIneg
RequestSLP	R 14	(Read) 4)	(Write) 5)	SAFEBOOL	Select/deselect the safety function SLP
RequestHoming	R 14	(Read) 4)	(Write) 5)	SAFEBOOL	Request safe homing
ReferenceSwitch	R 14	(Read) 4)	(Write) 5)	SAFEBOOL	Safe input for using a reference switch
Activate	R 13	(Read) 4)	(Write) 5)	SAFEBOOL	Enabling the function block
Reset	R 13	(Read) 4)	(Write) 5)	SAFEBOOL	Reset input for confirming the "Functional Fail Safe" state.

Table 136: SafeMC channel list

1) Channel only visible if the parameter "*Module Information*" was 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 or SF_SafeMC_Position_BR
4) This data can be accessed via NC Action or Trace.
5) This data is accessed indirectly via the inputs of the function block SF_SafeMC_BR or SF_SafeMC_BR_V2.

7 Programming the safety application

The concept of integrated safety technology in the ACOPOSmulti with SafeMC is based on the function controller remaining fully in the inverter module (as before) and the SafeMC module monitoring configurable limits.

The only exception is that the SafeMC 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 safe application (and thereby ensuring maximum availability of the system), the different timing of the two applications must be accounted for.

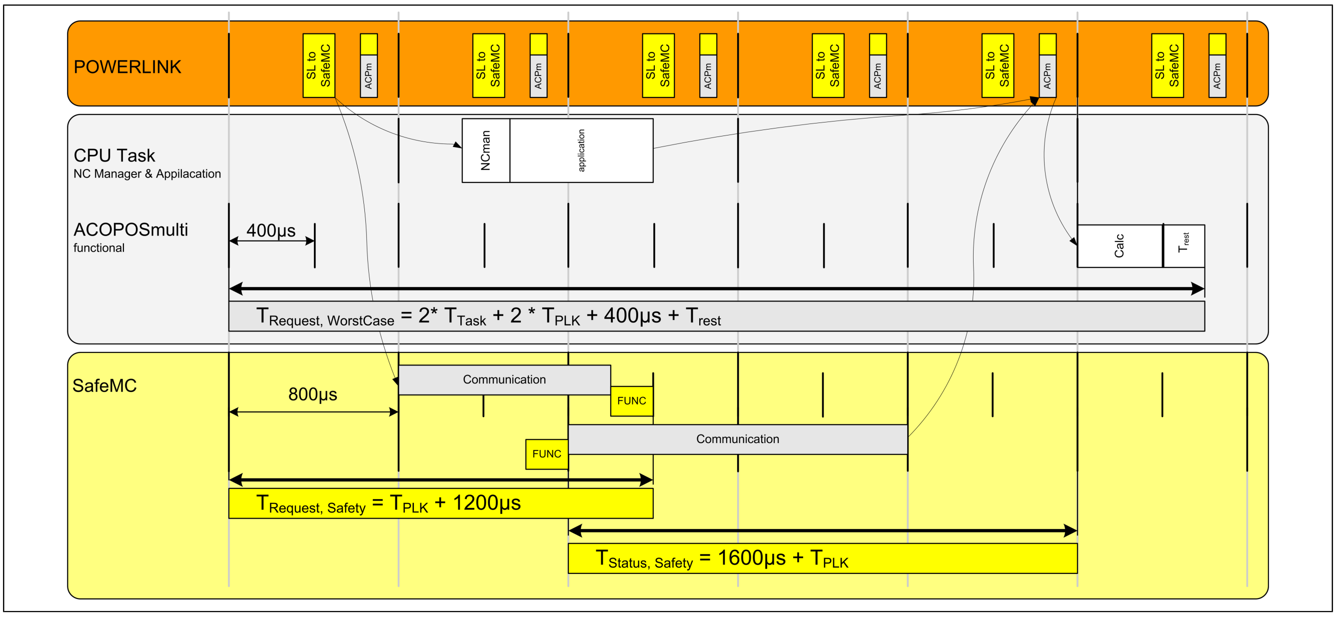


Figure 42: Inverter module timing - SafeMC module

The differing runtimes of the standard and the safe application can be accounted for using the "Delay times for requesting a safety function".

Parameters	Units	Description	Default value
Delay time to start ramp monitoring (µs)	[µs]	Delay time between request of ramp monitoring and start of monitoring	0
Delay time to start SDI(µs)	[µs]	Delay time between request of SDI and activation of the safety function	0
Delay time to start SBC(µs)	[µs]	Delay time between request of SBC and activation of the safety function	0
Delay time to start SLP (µs) [1]	[µs]	Delay time between request of SLP and start of monitoring	0

Table 137: Delay times for requesting a safety function

1) Only available in Safety Release 1.4 or higher!

7.1 SafeMC Help Tool

The SafeMC Help Tool assists in the development of SafeMC projects. This program can be used to make calculations that are required frequently.

Start the SafeMC Help Tool →

7.1.1 Status and Control Bits tab

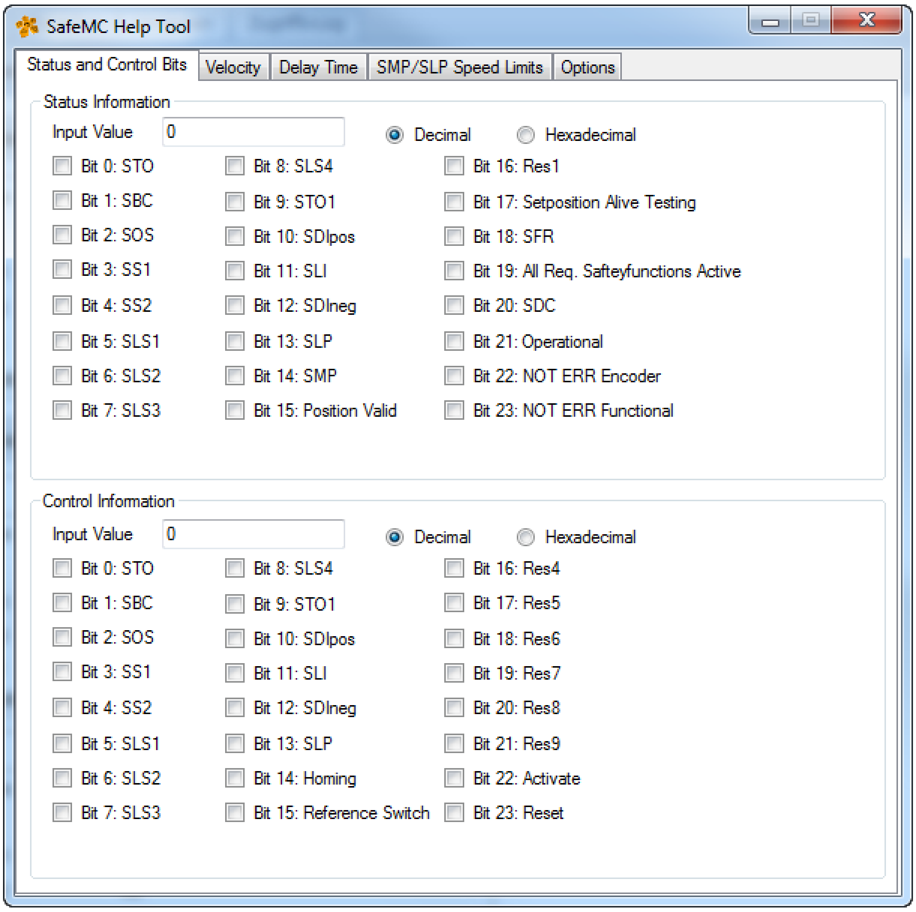


Figure 43: SafeMC Help Tool - Status and Control Bits tab

"Status Information" section

Information:

Status information can be determined by running a trace on the cyclic data (ParID 4).

Showing status bits for the status information that has been determined

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 check boxes now show the status bits for the determined status information.

Determining the input value for a combination of status bits

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 check boxes
   → The input value that corresponds with the combination of status bits is displayed.

"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 display the control bits for the control information that has been determined.

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

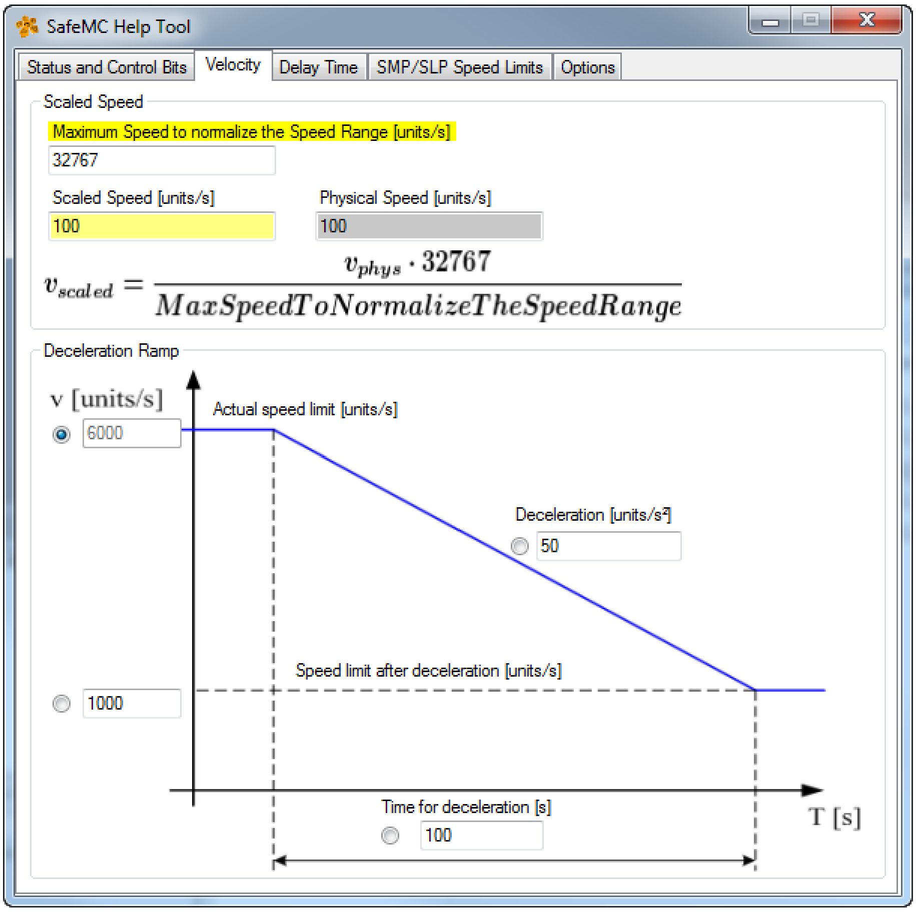


Figure 44: SafeMC Help Tool - Velocity tab

Scaled Speed section

In the *Scaled Speed* section, a scaled speed can be converted to a physical speed [units/s] and vice versa based on the value "Maximum speed to normalize the speed range [units/s]".

The parameter names marked in yellow correspond to the parameters in SafeDESIGNER.

Converting scaled → physical speed

1. Enter value for "Maximum speed to normalize the speed range [units/s]"
2. Enter value for scaled speed [units/s]
   → The respective value for the physical speed [units/s] is shown.

Converting physical → scaled speed

1. Enter value for "Maximum speed to normalize the speed range [units/s]"
2. Enter value for 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:
   - Actual speed limit [units/s]
   - Delay [units/s]
   - Speed limit after the delay [units/s]
   - Delay time [s]

2. Enter values for the three remaining parameters in the respective fields
   → The calculated value for the fourth parameter is shown.

7.1.3 Delay Time tab

This tab can be used to calculate the delay time for the SafeMC module (e.g.: Delay time to start ramp monitoring), see "Figure 42: Inverter module timing - SafeMC module" on page 182. The delay time is the difference between the times $T_{Request,\ Safety}$ and $T_{Request,\ WorstCase}$.

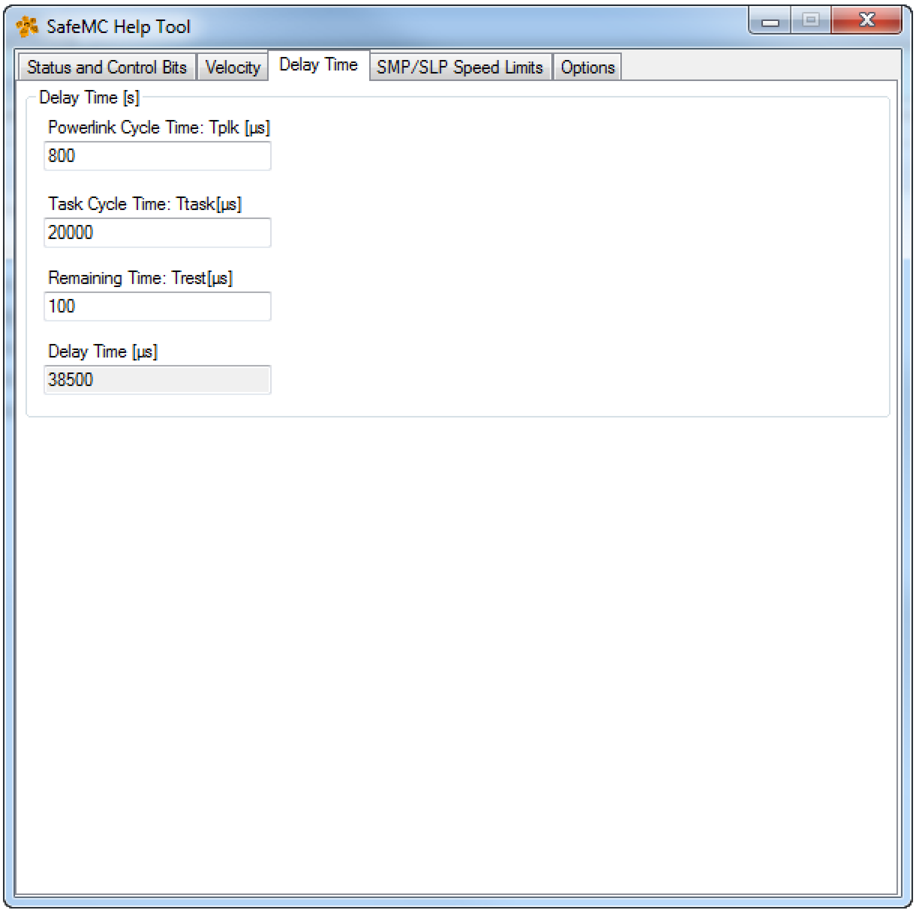


Figure 45: SafeMC Help Tool - Delay Time tab

Delay Time section

Procedure

1. Enter value for POWERLINK cycle time [µs]
2. Enter value for task cycle time [µs]
3. Enter value for remaining time [µs]
   → The value calculated for the delay time [µs] is shown.

7.1.4 SMP/SLP Speed Limits tab

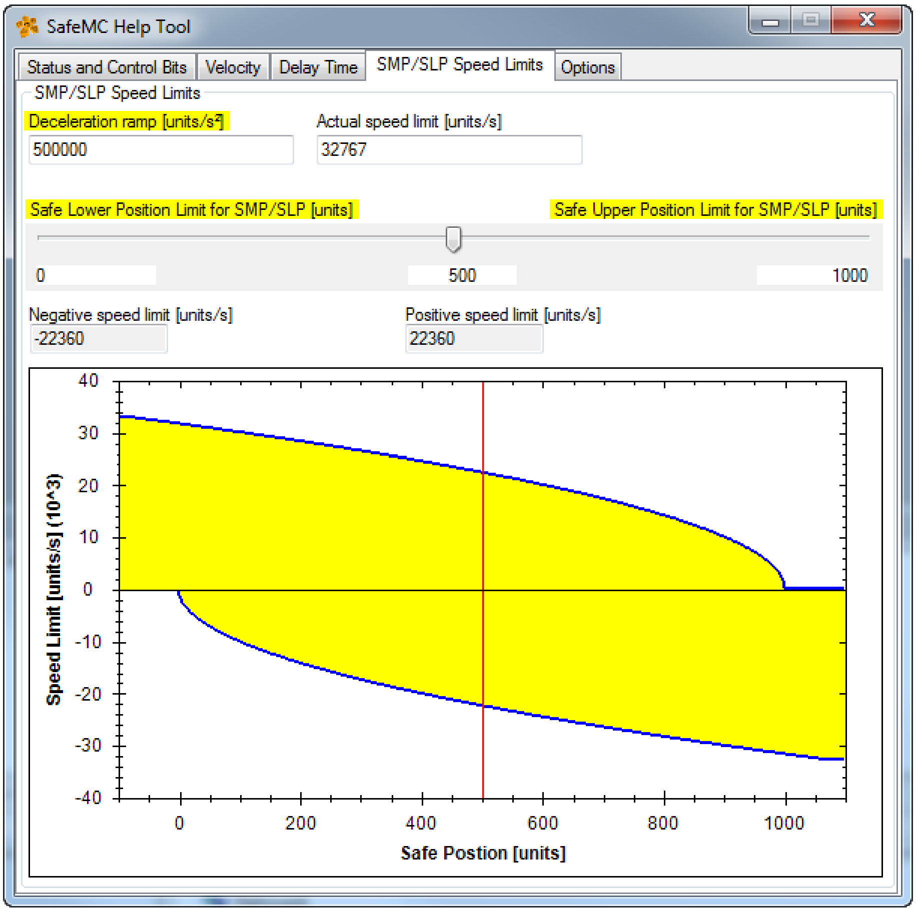


Figure 46: SafeMC Help Tool - SMP/SLP Speed Limits tab

SMP/SLP Speed Limits section

In the *SMP/SLP Speed Limits* section, the parameters "Deceleration ramp [units/s²]" and "Actual speed limit [units/s]" 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.

The parameter names marked in yellow correspond to the parameters in SafeDESIGNER.

Calculating the negative and positive speed limits

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 shown in the fields and in the diagram.

Diagram

In the diagram, the speed limit [units/s] is shown in relation to the safe position [units].

Displaying and using the diagram

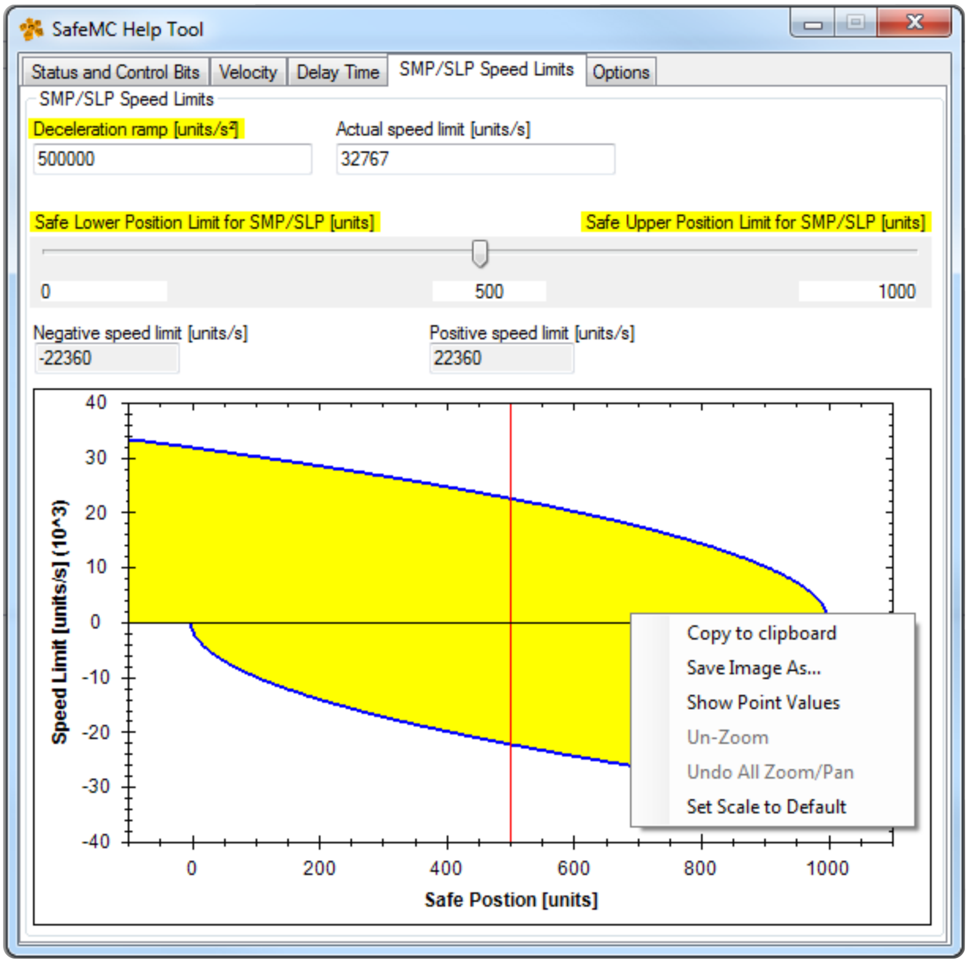


Figure 47: Displaying the diagram with the selection menu

Move the mouse pointer into the diagram

→ A cross-hair pointer is displayed
Holding the left mouse button and marking a section zooms in the diagram.
Scrolling with the mouse also zooms in the diagram.

Right-click with the mouse in an area of the diagram

→ A selection menu is displayed
Select a menu item with the left mouse button

Copy to the clipboard	Image is copied to the clipboard
Save image as...	Saves the image
Show point values	Moving the cross-hair pointer over the line in the diagram shows the values of the individual points.
Undo zoom	Resets the last zoom
Undo all zoom/pan actions	Resets all zoom/pan actions
Set scale to default value	Sets scaling to the default values

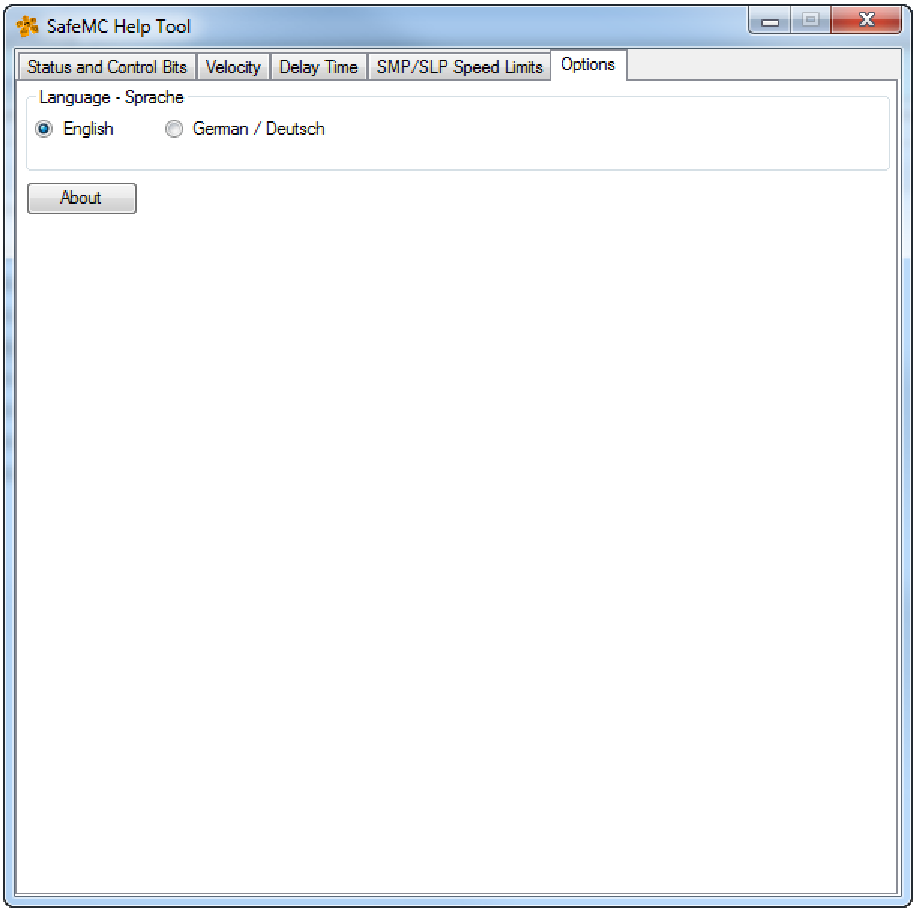
7.1.5 Options tab

Language section

Select English or German

About button

Clicking on "About" displays information about the manufacturer.



7.2 Application in SafeDESIGNER

The safety application is implemented in SafeDESIGNER.

The SafeMC modules are controlled using the function blocks **SF_SafeMC_BR** and **SF_SafeMC_Speed_BR** as well as the function blocks **SF_SafeMC_BR_V2** and **SF_SafeMC_Position_BR** in Safety Release 1.4 and higher.

The section PLCopen Safety contains detailed descriptions of how the function blocks and their underlying safety functions and safe parameters are used.

> **Danger!**
>
> **The safety application should only be created by qualified personnel.**
> **The respective processes specified in the standards must be followed!**

Furthermore, the specifications in chapter "SafeDESIGNER" of the Integrated Safety User's Manual MASAFETY1-ENG must also be taken into account.

> **Danger!**
>
> **All of the safety functions that are used must be tested.**
> **A function is considered to be used if the respective input variable is connected or the safety function has been configured!**

7.3 Access to the data of the SafeMC module in Automation Studio

There are three ways to access the safety-related data from a safe axis in Automation Studio.

7.3.1 I/O mapping

The states of the individual safety functions can be accessed via the I/O mapping of the respective SafeMC module. These are provided in the form of status bits.

To link PVs to the status bits, you must switch to the view "I/O configuration". As can be seen in the following image, the PV can then be selected in the "PV or Channel Name" column.

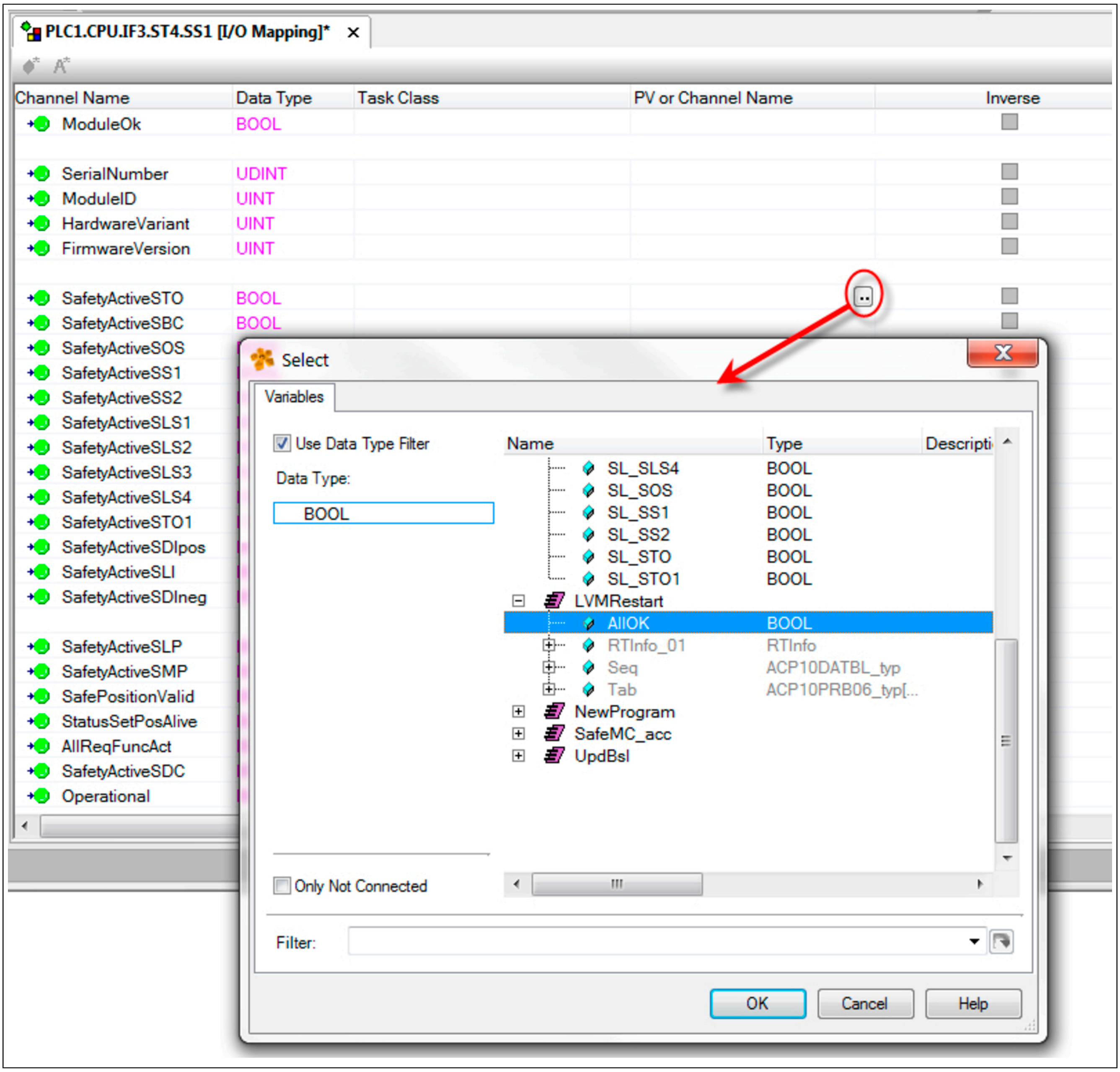


Figure 48: PV Mapping

7.3.2 ACOPOSmulti parameter IDs

The following parameter IDs are available to make the SafeMC data available to the non safety-related part of the ACOPOSmulti.

ParID	Data type	NC constant	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 138: ACOPOSmulti parameter IDs for SafeMC

Using these Par IDs, you can now use all the familiar features of ACOPOSmulti (e.g. ACOPOSmulti trace, read parameters via service channel, SPT-FBK connections, etc.).

The ACOPOSmulti trace can be used, e.g. to optimize how the functional 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.

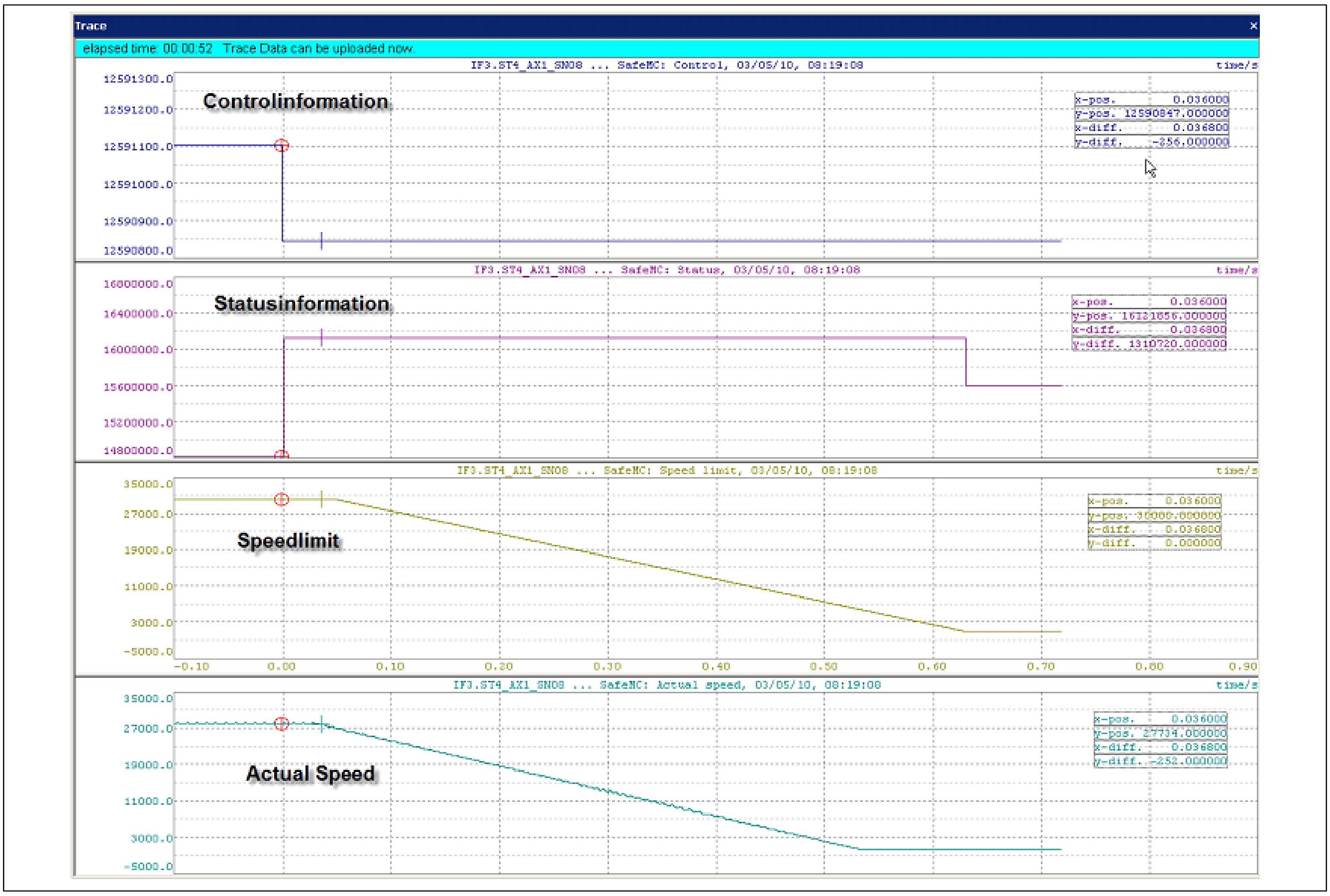


Figure 49: ACOPOSmulti Trace: Example SafeMC data

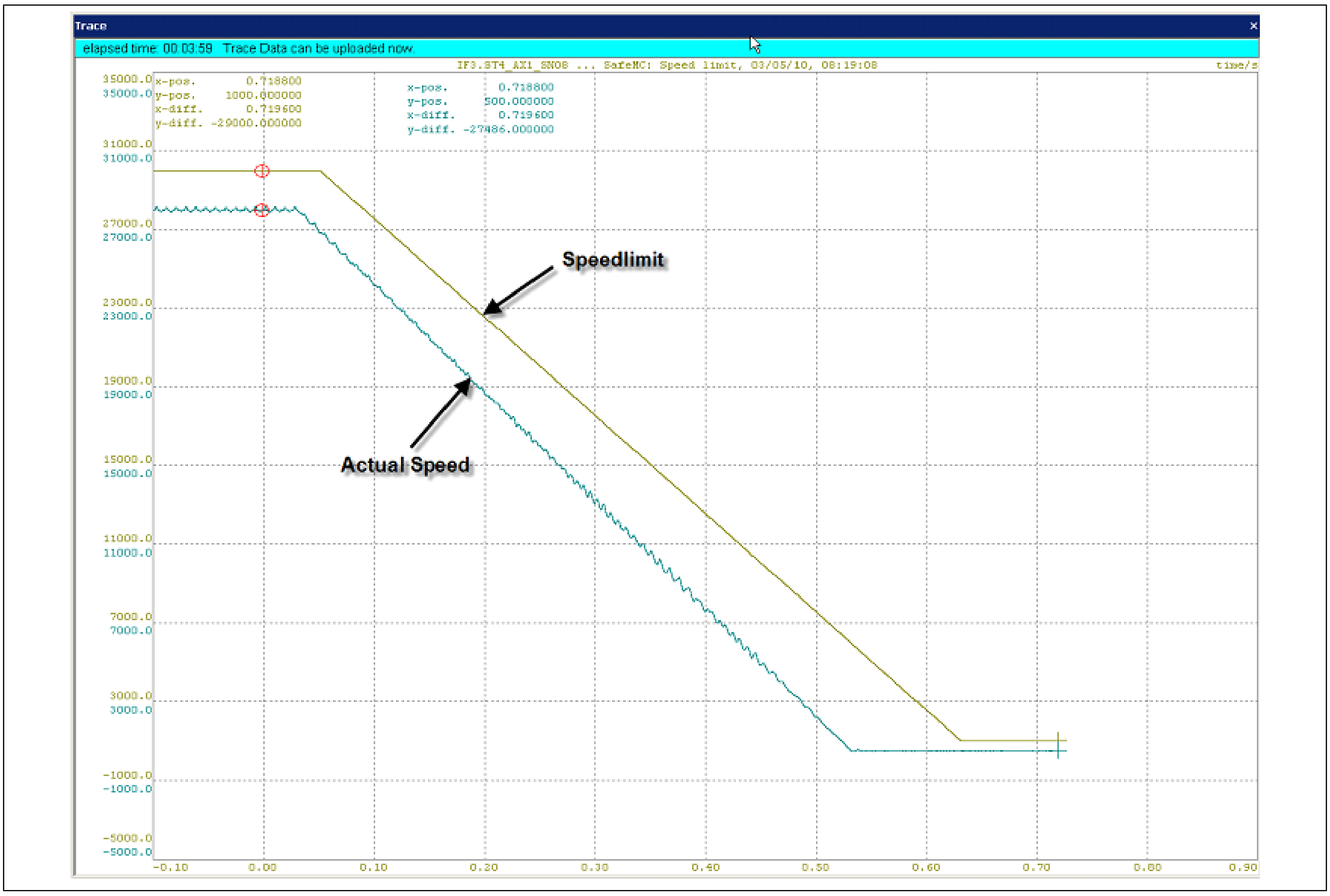


Figure 50: ACOPOSmulti Trace: Speed reserve

The parameter IDs "4 status bits" and "5 control bits" are bit-coded, whereby only the lower three bytes are 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 14**
SLS4	STO1	SDIpos	SLI	SDIneg	SLP [1]	SMP [1]	Position Valid [1]
Bit 16	**Bit 17**	**Bit 18**	**Bit 19**	**Bit 20**	**Bit 21**	**Bit 22**	**Bit 23**
Reserved	Set position Alive Testing	Safety Function Requested	All requested safety functions active	SDC	Operational	NOT ERR Encoder	NOT ERR Functional

Table 139: Status bits

1) Only available in Safety Release 1.4 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 14**
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**
Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Activate	Reset

Table 140: Control bits

1) Only available in Safety Release 1.4 or higher!

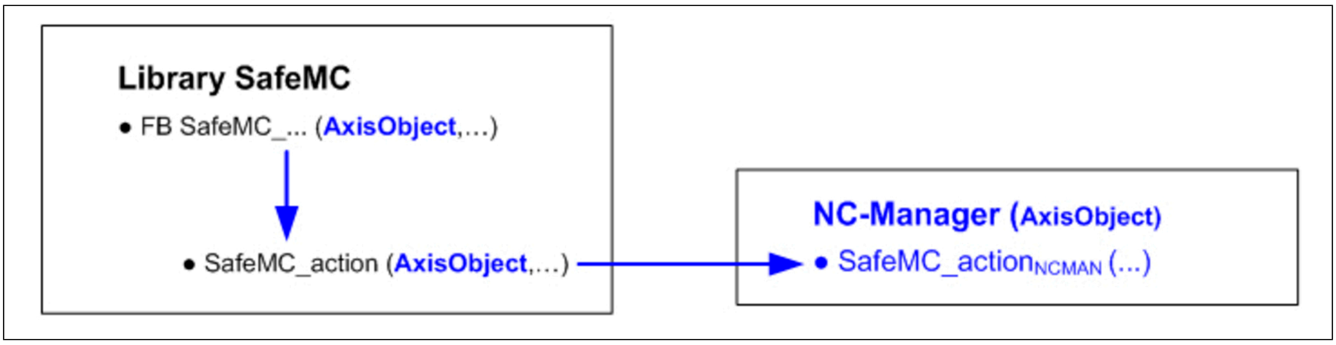
7.3.3 Library SafeMC

The function SafeMC_action() as well as the function blocks SafeMC_ReadSafeOutData and SafeMC_ReadSafeInData are implemented in the SafeMC library. This library can be used to access the SafeMC data of an ACOPOSmulti axis. This is particularly important because it is the only way to access the control bits of each individual SafeMC module.

Valid data definitions:

- **SafeOUT**: Data from the SafeLOGIC to the SafeMC module
- **SafeIN**: Data from the SafeMC module to the SafeLOGIC

The SafeMC function blocks call the global function **SafeMC_action()**. If this function is called, then it uses the specified NC object to call a function SafeMC_action$_{NCMAN}$(), which is contained in the NC Manager belonging to this NC object. The function SafeMC_Action() can also be used directly.



Information:

The function SafeMC_action() only contains a call frame. The actual functionality is contained in the corresponding NC manager function.

Therefore, the constants and data types for the functionalities implemented for the function SafeMC_action() are not contained in the SafeMC library, but rather...

- **the constants in the NCGLOBAL library**
- **the data types in the ACP10MAN library**

Function SafeMC_action(): Execute SafeMC 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 141: SafeMC_action()

Error codes

The following error codes are output by the NC manager function SafeMC_action$_{NCMAN}$() :

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 (parameter "action") is not defined or not allowed for this NC object
10724	Invalid NC object type
10726	This action is not allowed because the corresponding initializations are not yet complete.
10729	The parameter "par_ptr" is zero
10731	Invalid NC object data (is a PV being used as NC object, for which an INIT value is defined in the variable declaration?)
10732	The parameter "par_size" is not valid for this action
10733	Network status 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

Moreover, the following error codes are output for some actions, which suggests an initialization error in the SafeMC data:

10712	NC object not enabled (channel number too high or no PDO data defined)
20918	The "data_len" provided by plAction(plACTION_GET_DP_INFO) is too large
20953	The "direction_id" provided by plAction(plACTION_GET_DP_INFO) is invalid

All other error codes are provided by the POWERLINK library. Only the following is mentioned:

20923	Data point not available (not entered in the PDO Mapping)

Access to the SafeMC data with the function SafeMC_action()

READ_SAFEOUT_DATA: Read SafeOUT data

Parameter:

```
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
```

Data type ACP10SAFEOUTDAT_typ

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)]
reserved_ctrl_b16	*USINT*	*Reserved*
reserved_ctrl_b17	*USINT*	*Reserved*
reserved_ctrl_b18	*USINT*	*Reserved*
reserved_ctrl_b19	*USINT*	*Reserved*
reserved_ctrl_b20	*USINT*	*Reserved*
reserved_ctrl_b21	*USINT*	*Reserved*
Activate	USINT	SafeMC module activation
Reset	USINT	Reset bit

1) V2.250 of higher for Safety Release 1.4

READ_SAFEIN_DATA: Read SafeIN data

Parameter:

```
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
```

Data type ACP10SAFEINDAT_typ

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)]
reserved_stat_b16	*USINT*	*Reserved*
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 operational
NotErrENC	USINT	Encoder error status bit
NotErrFUNC	USINT	Functional fail safe status bit
reserved_stat_b24	*USINT*	*Reserved*
reserved_stat_b25	*USINT*	*Reserved*
reserved_stat_b26	*USINT*	*Reserved*
reserved_stat_b27	*USINT*	*Reserved*
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) V2.250 of higher for Safety Release 1.4

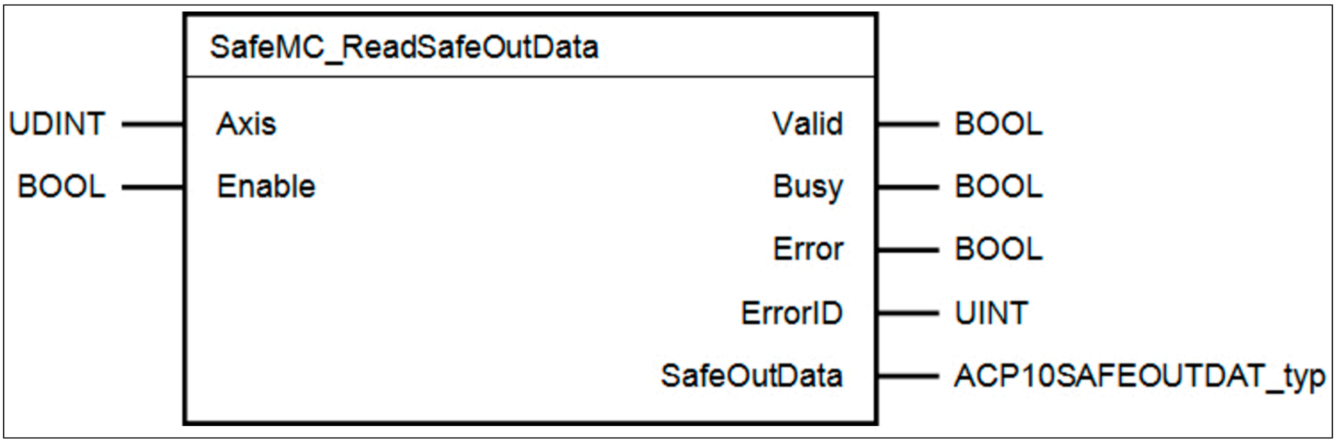
Example: Access to the SafeOUT and SafeIN data

```
#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));
}
}
```

Access to the SafeMC data with SafeMC function blocks

Function block SafeMC_ReadSafeOutData: Read SafeOUT data

Function block



Parameters

I/O	Parameters	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	Data in output data structure is valid
OUT	Busy	BOOL	Function block is not yet finished
OUT	Error	BOOL	An error has occurred in the function block
OUT	ErrorID	UINT	FB error code
OUT	SafeOutData	ACP10SAFEOUTDAT_typ	Output data structure

Error codes

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 (parameter "action") is not defined or not allowed for this NC object
10724	Invalid NC object type
10726	This action is not allowed because the corresponding initializations are not yet complete.
10729	The parameter "par_ptr" is zero
10731	Invalid NC object data (is a PV being used as NC object, for which an INIT value is defined in the variable declaration?)
10732	The parameter "par_size" is not valid for this action
10733	Network status 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

Moreover, the following error codes are output for some actions, which suggests an initialization error in the SafeMC data:

10712	NC object not enabled (channel number too high or no PDO data defined)
20918	The "data_len" provided by plAction(plACTION_GET_DP_INFO) is too large
20953	The "direction_id" provided by plAction(plACTION_GET_DP_INFO) is invalid

All other error codes are provided by the POWERLINK library. Only the following is mentioned:

20923	Data point not available (not entered in the PDO Mapping)

Data type ACP10SAFEOUTDAT_typ

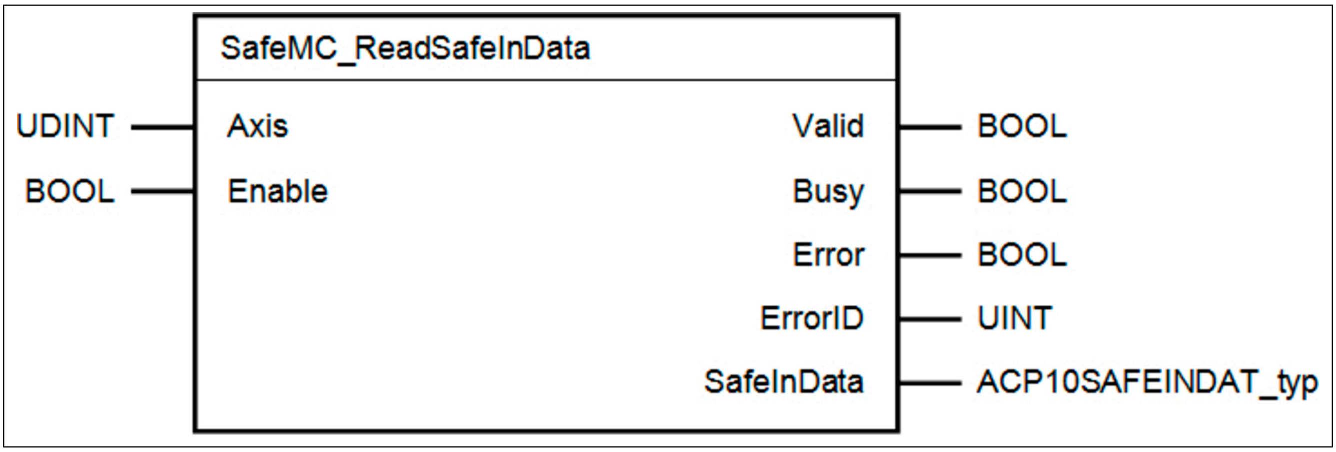
RequestSTO	USINT	STO control bit
RequestSBC	USINT	SBC control bit
RequestSOS	USINT	SOS control bit
RequestSS1	USINT	SS1 control bit
RequestSS2	USINT	SS2 control bit
RequestSLS1	USINT	SLS1 control bit
RequestSLS2	USINT	SLS2 control bit
RequestSLS3	USINT	SLS3 control bit
RequestSLS4	USINT	SLS4 control 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)]
reserved_ctrl_b16	*USINT*	*Reserved*
reserved_ctrl_b17	*USINT*	*Reserved*
reserved_ctrl_b18	*USINT*	*Reserved*
reserved_ctrl_b19	*USINT*	*Reserved*
reserved_ctrl_b20	*USINT*	*Reserved*
reserved_ctrl_b21	*USINT*	*Reserved*
Activate	USINT	SafeMC module activation
Reset	USINT	Reset bit

1) V2.250 of higher for Safety Release 1.4

Function block SafeMC_ReadSafeInData: Read SafeIN data

Function block



Parameters

I/O	Parameters	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	Data in output data structure is valid
OUT	Busy	BOOL	Function block is not yet finished
OUT	Error	BOOL	An error has occurred in the function block
OUT	ErrorID	UINT	FB error code
OUT	SafeInData	ACP10SAFEINDAT_typ	Output data structure

Error codes

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 (parameter "action") is not defined or not allowed for this NC object
10724	Invalid NC object type
10726	This action is not allowed because the corresponding initializations are not yet complete.
10729	The parameter "par_ptr" is zero
10731	Invalid NC object data (is a PV being used as NC object, for which an INIT value is defined in the variable declaration?)
10732	The parameter "par_size" is not valid for this action
10733	Network status 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

Moreover, the following error codes are output for some actions, which suggests an initialization error in the SafeMC data:

10712	NC object not enabled (channel number too high or no PDO data defined)
20918	The "data_len" provided by plAction(plACTION_GET_DP_INFO) is too large
20953	The "direction_id" provided by plAction(plACTION_GET_DP_INFO) is invalid

All other error codes are provided by the POWERLINK library. Only the following is mentioned:

20923	Data point not available (not entered in the PDO Mapping)

Data type ACP10SAFEINDAT_typ

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)]
reserved_stat_b16	*USINT*	*Reserved*
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 operational
NotErrENC	USINT	Encoder error status bit
NotErrFUNC	USINT	Functional fail safe status bit
reserved_stat_b24	*USINT*	*Reserved*
reserved_stat_b25	*USINT*	*Reserved*
reserved_stat_b26	*USINT*	*Reserved*
reserved_stat_b27	*USINT*	*Reserved*
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) V2.250 of higher for Safety Release 1.4

Example: Access to the 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 Validate the safety functions

Danger!

The user is responsible for performing safeguard function tests. You must therefore validate the safe-guards.

Information:

The 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 should only be created by qualified personnel. Acceptance of the final product, in particular the validation and verification must also be performed by qualified personnel.

When commissioning the machine, the complete safety application must be tested as well as validated and verified in accordance with the SRS (Safety Requirements Specification).

When performing the comprehensive safety function test, all of the specified limits and timing values must be tested in accordance with the SRS. All of the monitored limits must be violated and the respective error reactions must then be 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 as being used if the respective function block input is used in the safe 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 limits	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)	✓

Table 142: Test matrix for the safety functions

1) Speed limit is calculated dynamically according to the current position

Danger!

Check the parameter settings for the unit system! An incorrectly configured unit system can cause dangerous situations because the monitored limits may not correspond with the physical limits under certain circumstances!

7.5 Maintenance scenarios

7.5.1 Commissioning

Bei der Inbetriebnahme ist immer ein vollständiger Test der Sicherheitsfunktionen, wie in Validate the safety functions beschrieben, durchzuführen.

Danger!

All of the safety functions that are used must be tested.
A function is considered to be used if the respective input variable is connected or the safety function has been configured!

7.5.2 Replacing ACOPOSmulti with SafeMC safe inverter modules

The SafeLOGIC controller recognizes, on its own, when safe modules have been replaced. Following a module replacement, the entire system (SafeLOGIC, openSAFETY) automatically ensures that the module is operated again with the correct parameters and that incompatible modules are rejected.

Replacing a safe inverter module, such as ACOPOSmulti with SafeMC, can present the following potential errors, which must be detected and prevented through testing:

- Wiring errors in the motor connection
- Wiring errors in the motor holding brake connection
- Wrong encoder connected

Danger!

All of the safety functions that are used on the exchanged module must be tested!
You must always validate the overall safety function.

7.5.3 Replacing a safe encoder/motor

SafeLOGIC recognizes, on its own, when safe modules have been exchanged.
A safe encoder that is replaced on a safe inverter module will be detected as a replacement on the SafeLOGIC controller and must be acknowledged as such.

After the replacement, the safety functions configured on the affected axis must be tested.

Danger!

All of the safety functions that are used on the exchanged module must be tested!
You must always validate the overall safety function.

7.5.4 Firmware update/Acknowledging a firmware exchange

Changes to safety-related parts of the firmware are distributed by B&R as firmware updates.
Upgrades to safety-related firmware can only be performed by qualified personnel.
A firmware upgrade is indicated on the SafeLOGIC controller and must be acknowledged accordingly.

Danger!

A firmware exchange must always be concluded with a full function test.

7.5.5 Decommissioning a system

SafeMC modules have a mission time of maximum 20 years.
This means that all SafeMC modules must be taken out of service one week (at the latest) before the expiration of this 20 year time span (starting from B&R's delivery date).

Danger!

Operating SafeMC modules beyond the specified mission time is not permitted!

The user must ensure that all SafeMC modules are removed from operation i.e. replaced by new SafeMC modules, before their mission time expires.

Chapter 5 • PLCopen Safety

Special function blocks that are compliant with PLCopen Safety were implemented to ensure effective use of the SafeMC module. These function blocks revolutionize the development of safety applications. They are certified and therefore reduce time and cost in all phases of the safety application's life cycle. From the specification and implementation to testing and checking functions, the procedure used is more similar to virtual wiring than it is to programming.

Unlike "real wiring", downloading the program to the SafeLOGIC guarantees that an identical copy will be stored. This completely eliminates wiring errors during series production. Naturally, all options for a safe programmable controller are available to handle even more complex problems that can't be solved with "real wiring".

1 Definition of terms

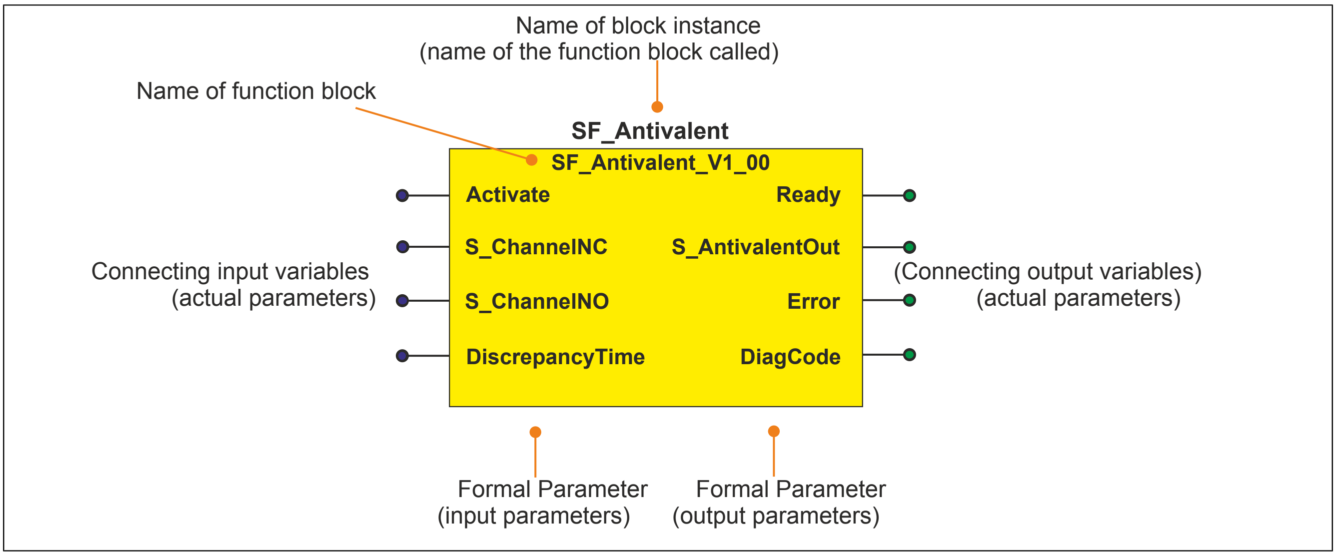


Figure 51: Function block label

When calling the function block, the actual parameters supply the formal parameters with the current values of the variables or constants.

Actual parameters do not need to share the same name as the corresponding formal parameters, but must be the same type. A difference in the data type of formal and actual parameters is reported as an error following compilation.

A function block's name is created from the function (e.g. SF_Antivalent, SF = safety function). The representation for version Vx_yz used in the document is universal. Please take the actual version from the function block in use.

2 SF_SafeMC_BR

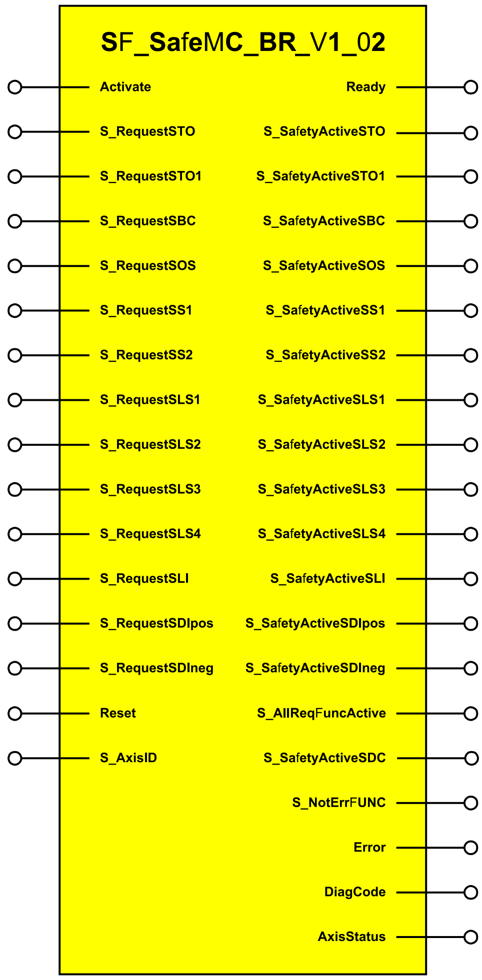


Figure 52: Function block SF_SafeMC_BR

2.1 Formal Parameters of the Function Block

In the following, a "variable" may designate either a variable or a graphic connection.

Name	Type	Connection	Signal type [1]	Initial Value	Description/General Function
Activate	BOOL	Variable/ Constant	State	FALSE	Function block activation (= TRUE)
S_RequestSTO	SAFEBOOL	Variable / Constant	State	SAFEFALSE	STO safety function request: SAFEFALSE: Safety function requested
S_RequestSTO1	SAFEBOOL	Variable/ Constant	State	SAFEFALSE	STO1 safety function request: SAFEFALSE: Safety function requested
S_RequestSBC	SAFEBOOL	Variable/ Constant	State	SAFEFALSE	SBC safety function request: SAFEFALSE: Safety function requested
S_RequestSOS	SAFEBOOL	Variable/ Constant	State	SAFEFALSE	SOS safety function request: SAFEFALSE: Safety function requested
S_RequestSS1	SAFEBOOL	Variable/ Constant	State	SAFEFALSE	SS1 safety function request: SAFEFALSE: Safety function requested
S_RequestSS2	SAFEBOOL	Variable/ Constant	State	SAFEFALSE	SS2 safety function request: SAFEFALSE: Safety function requested
S_RequestSLS1	SAFEBOOL	Variable/ Constant	State	SAFEFALSE	SLS1 safety function request: SAFEFALSE: Safety function requested
S_RequestSLS2	SAFEBOOL	Variable/ Constant	State	SAFEFALSE	SLS2 safety function request: SAFEFALSE: Safety function requested
S_RequestSLS3	SAFEBOOL	Variable/ Constant	State	SAFEFALSE	SLS3 safety function request: SAFEFALSE: Safety function requested
S_RequestSLS4	SAFEBOOL	Variable/ Constant	State	SAFEFALSE	SLS4 safety function request: SAFEFALSE: Safety function requested
S_RequestSLI	SAFEBOOL	Variable/ Constant	State	SAFEFALSE	SLI safety function request: SAFEFALSE: Safety function requested
S_RequestSDIpos	SAFEBOOL	Variable/ Constant	State	SAFEFALSE	SDIpos safety function request: SAFEFALSE: Safety function requested
S_RequestSDIneg	SAFEBOOL	Variable/ Constant	State	SAFEFALSE	SDIneg safety function request: SAFEFALSE: Safety function requested
Reset	BOOL	Variable	Edge	FALSE	Resets error messages and the SafeMC module once the cause of the error has been removed.
S_AxisID	SAFEINT	Constant	State	-1	Assigns an axis to the function block

Table 143: SF_SafeMC_BR: Brief overview of the input parameters

1) Evaluation of 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	State	FALSE	Indication of function block activation
S_SafetyActiveSTO	SAFEBOOL	Variable	State	SAFEFALSE	Safety function STO is active (= SAFETRUE)
S_SafetyActiveSTO1	SAFEBOOL	Variable	State	SAFEFALSE	Safety function STO1 is active (= SAFETRUE)
S_SafetyActiveSBC	SAFEBOOL	Variable	State	SAFEFALSE	Safety function SBC is active (= SAFETRUE)
S_SafetyActiveSOS	SAFEBOOL	Variable	State	SAFEFALSE	Safety function SOS is active, no violation of a monitored limit (= SAFETRUE)
S_SafetyActiveSS1	SAFEBOOL	Variable	State	SAFEFALSE	Safety function SS1 is active, deceleration monitor is finished, no violation of a monitored limit detected (= SAFETRUE)
S_SafetyActiveSS2	SAFEBOOL	Variable	State	SAFEFALSE	Safety function SS2 is active, deceleration monitor is finished, no violation of a monitored limit detected (= SAFETRUE)
S_SafetyActiveSLS1	SAFEBOOL	Variable	State	SAFEFALSE	Safety function SLS1 is active, deceleration monitor is finished, no violation of a monitored limit detected (= SAFETRUE)
S_SafetyActiveSLS2	SAFEBOOL	Variable	State	SAFEFALSE	Safety function SLS2 is active, deceleration monitor is finished, no violation of a monitored limit detected (= SAFETRUE)
S_SafetyActiveSLS3	SAFEBOOL	Variable	State	SAFEFALSE	Safety function SLS3 is active, deceleration monitor is finished, no violation of a monitored limit detected (= SAFETRUE)
S_SafetyActiveSLS4	SAFEBOOL	Variable	State	SAFEFALSE	Safety function SLS4 is active, deceleration monitor is finished, no violation of a monitored limit detected (= SAFETRUE)
S_SafetyActiveSLI	SAFEBOOL	Variable	State	SAFEFALSE	Safety function SLI is active, no violation of a monitored limit (= SAFETRUE)
S_SafetyActiveSDIpos	SAFEBOOL	Variable	State	SAFEFALSE	Safety function SDIpos is active (= SAFETRUE)
S_SafetyActiveSDIneg	SAFEBOOL	Variable	State	SAFEFALSE	Safety function SDIneg is active (= SAFETRUE)
S_AllReqFuncActive	SAFEBOOL	Variable	State	SAFEFALSE	All requested safety functions have achieved their safety state (= SAFETRUE)
S_SafetyActiveSDC	SAFEBOOL	Variable	State	SAFEFALSE	Deceleration monitor is active (= SAFETRUE)

Table 144: SF_SafeMC_BR: Brief overview of the output parameters

Name	Type	Connection	Signal type [1]	Initial Value	Description/General Function
S_NotErrFUNC	SAFEBOOL	Variable	State	SAFEFALSE	SafeMC is not in the Functional Fail Safe state (= SAFETRUE)
Error	BOOL	Variable	State	FALSE	Function block error message
DiagCode	WORD	Variable	State	16#0000	Function block diagnostic message
AxisStatus	DWORD	Variable	State	32#00000000	Status information from axis

Table 144: SF_SafeMC_BR: Brief overview of the output parameters

1) Output of 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	Bool
WORD	Word	16	Binary number, hexadecimal number, unsigned decimal number
SAFEBOOL	Bit	1	Bool (signal source: safe device)
SAFEINT	Integer	16	Binary number, hexadecimal number, unsigned decimal number (signal source: safe device)

Table 145: SF_SafeMC_BR: Formats of the data types used

You can link a safe signal with a standard input parameter. To do this, you need to use a function block for type conversion.

2.2 SafeMC module parameters

Parameter	Units	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). To do this, the relationship between a whole number 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). To do this, the relationship between a whole number 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	Default/ Inverse	Counting direction of the position and speed 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	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 by 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 One Channel STO function	STO1/configuration Functional Fail Safe
Ramp monitoring for SS1	Activated/ Deactivated	Activates ramp monitoring (in addition to the time) when the SS1 function is activated	SS1
Ramp monitoring for SS2	Activated/ Deactivated	Activates ramp monitoring (in addition to the time) when the SS2 function is activated	SS2
Ramp monitoring for SLS	Activated/ Deactivated	Activates ramp monitoring (in addition to the time) when the SLS function is activated	SLS
Early Limit Monitoring	Activated/ Deactivated	Monitoring of the deceleration ramp is prematurely terminated if the target limit is exceeded	SS1, SS2, SLS
Encoder Monitoring			
Encoder Position Monitoring	Activated/ Deactivated	Activates/deactivates the monitoring of the position lag error generated on the SafeMC module.	Monitors the encoder shaft breakage
Encoder Speed Monitoring	Activated/ Deactivated	Activates/deactivates the monitoring of the speed error generated on the SafeMC module.	Monitors the encoder shaft breakage
Set position alive testing	Activated/ Deactivated	Activates/deactivates the monitor that detects whether the set position generated on the ACOPOSmulti is frozen.	Monitors the 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 between STO1 and STO (and SBC) in the Functional Fail Safe state	Configuration
Delay time until the brake engages	[µs]	Delay time until the brake engages Switching of the second enable channel is delayed if STO1 and delayed STO and SBC are configured for Functional Fail Safe.	Configuration
Speed Limits			
Maximum speed limit for SMS	[units/s]	Speed limit of the maximum speed	SMS
Safe Speed Limit 1 for SLS	[units/s]	Speed Limit 1 for SLS	SLS
Safe Speed Limit 2 for SLS	[units/s]	Speed Limit 2 for SLS	SLS
Safe Speed Limit 3 for SLS	[units/s]	Speed Limit 3 for SLS	SLS
Safe Speed Limit 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 moveable 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	[µs]	Deceleration monitoring time for SS1	SS1
Ramp Monitoring Time for SS2	[µs]	Deceleration monitoring time for SS2	SS2
Ramp Monitoring Time for SLS1	[µs]	Deceleration monitoring time for SLS1	SLS1

Table 146: SF_SafeMC_BR: Module parameter

Parameter	Units	Description	Safety function
Ramp Monitoring Time for SLS2	[µs]	Deceleration monitoring time for SLS2	SLS2
Ramp Monitoring Time for SLS3	[µs]	Deceleration monitoring time for SLS3	SLS3
Ramp Monitoring Time for SLS4	[µs]	Deceleration monitoring time for SLS4	SLS4
Safety Additional Parameters			
Delay time to start ramp monitoring	[µs]	Delay time between request of ramp monitoring and start of monitoring	SS1, SS2, SLS
Delay time to start SDI	[µs]	Delay time between request of SDI and activation of the safety function	SDI
Delay time to start SBC	[µs]	Delay time between request of SBC and activation of the safety function	SBC
Early Limit Monitoring time	[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	SS1, SS2, SLS
Encoder Monitoring Tolerances			
Encoder Monitoring Position Tolerance	[units]	Position lag error tolerance for encoder monitoring	Monitors the encoder shaft breakage
Encoder Monitoring Speed Tolerance	[units/s]	Speed error tolerance for encoder monitoring	Monitors the encoder shaft breakage

Table 146: SF_SafeMC_BR: Module parameter

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 SafeMC module.

If multiple functions are active, then the lowest value for speed will always be monitored.

Information:

The following application rules must be followed in order to enable prioritization of the safety functions:

$LIM_{SOS} \leq LIM_{SLS4} \leq LIM_{SLS3} \leq LIM_{SLS2} \leq LIM_{SLS1} \leq LIM_{SMS} <$ *NormSpeed*

If the application guideline rule is violated, then the SafeMC module changes to the Fail Safe state.

2.3 Integrated safety functions

The function block makes it easy to use the safety functions implemented on the SafeMC module.
Furthermore, the respective safety function is assigned to to a real axis by using the function block.

Information:

If a safety function is not used in the application, then the respective input variables should remain open.

Danger!

All of the safety functions that are used must be tested.
A function is considered to be used if the respective input variable is connected!

At least the activated input and the S_AxisID must be connected. Otherwise, the SafeMC module will not be operated by the SafeLOGIC. As a result, the pulse disabling and the motor holding brake output will be permanently set to 0 V, which means that the controller cannot be turned on.

The following functions are supported by the SafeMC module, safety release R1.4:

Safety function	Starting in safety release	EN ISO 13849-1	EN 61508/EN 62061	Safe encoder evaluation required
Safe Torque Off (STO)	R 1.3	Pl e	SIL 3	No
Safe Torque Off One Channel (STO1)	R 1.3	Pl d	SIL 2	No
Safe Operation Stop (SOS)	R 1.3	Pl d	SIL 2	Yes
Safe Stop 1 (SS1)	R 1.3	PL e (time monitored) Pl d	SIL 3 (time monitored) SIL 2	no (time monitored) Yes
Safe Stop 2 (SS2)	R 1.3	Pl d	SIL 2	Yes
Safely Limited Speed (SLS)	R 1.3	Pl d	SIL 2	Yes
Safe Maximum Speed (SMS)	R 1.3	Pl d	SIL 2	Yes
Safe Direction (SDI)	R 1.3	Pl d	SIL 2	Yes
Safely Limited Increment (SLI)	R 1.3	Pl d	SIL 2	Yes
Safe Brake Control (SBC)	R 1.3	Pl d	SIL 2	No
Safely Limited Position (SLP)	R 1.4	Pl d	SIL 2	Yes
Safe Maximum Position (SMP)	R 1.4	Pl d	SIL 2	Yes
Safe referencing	R 1.4	Pl d	SIL 2	Yes

Table 147: Safety functions and corresponding safety levels

2.3.1 Safe Torque Off, STO

STO is the fundamental safety function of the ACOPOSmulti with SafeMC, since it represents the "fail-safe" principle.
A request from the STO safety function activates safe pulse disabling and switches off the torque and power to the drive. The SafeMC module actively triggers safe pulse disabling.

Danger!

The STO request causes synchronized axes lose their synchronicity.

Danger!

In cases involving external forces (e.g. hanging loads), this can cause dangerous movement!
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!

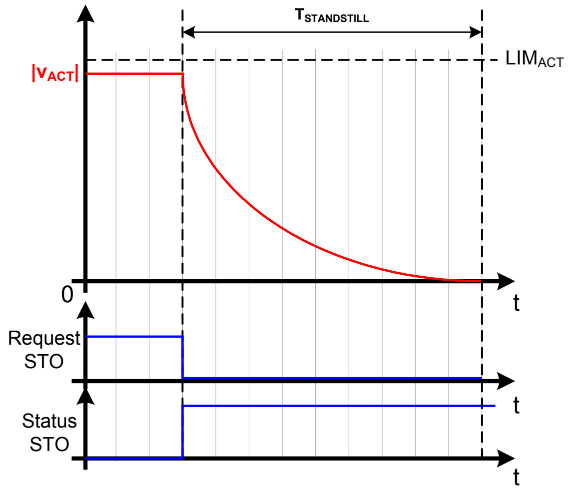


Figure 53: Safe Torque Off, STO

Information:

The functional safe state of the STO function has been achieved when the pulse disabling outputs are switched to 0 V. The respective bit is set once the functional safe state has been achieved.

Danger!

The drive will spin out if it is in motion at the time of the STO request. The resulting remnant movement and time $T_{STANDSTILL}$ 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 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 remnant movement and time $T_{STANDSTILL}$ determines the intervals between the safety features that must be maintained and therefore the size of the machine as well.

Information:

The safety function Safe Torque Off does not require safe encoder evaluation and can therefore also be used without a safe encoder.

Danger!

If the safety function STO is used in the safe application, then the ability to enable/disable it must be tested when commissioning the machine!

2.3.2 Single-channel Safe Torque Off, STO1

The safety function STO1 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 function has been achieved when the configured pulse disabling output is switched to 0 V.
The respective bit is set once the functional safe state has been achieved.

Parameter	Unit	Description	Default value
General settings			
Channel selection for One Channel STO (STO1)	HighSide/ LowSide	Selection of HighSide or LowSide IGBT in the One-ChannelSTO function	HighSide

Table 148: STO1 safety function parameters

Information:

The two-channel aspect is lost because either only the low side or only the high side of the pulse disabling is activated with STO1.
This results in a lower SIL and Performance Level!

Information:

The safety function Safe Torque Off, single-channel, does not require safe encoder evaluation and can therefore also be used without a safe encoder.

Danger!

If the safety function STO1 is used in the safe application, then the ability to enable/disable it must be tested when commissioning the machine!

2.3.3 Safe Brake Control, SBC

The SBC function is a safe (time delayed) output whose purpose is to safety-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.

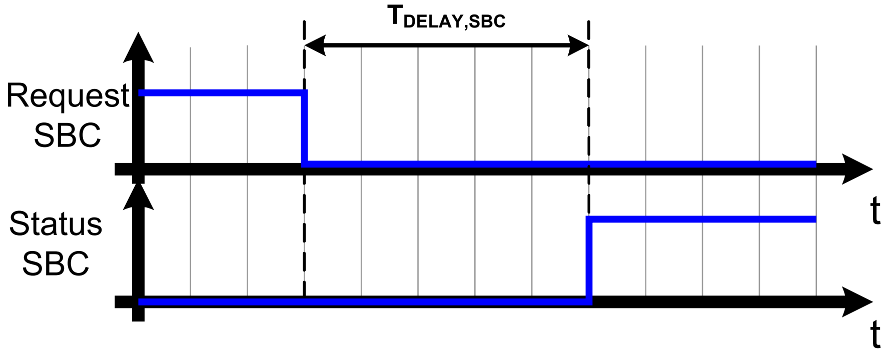


Figure 54: Safe Brake Control, SBC

Only the actuation of the motor holding brake output through the SafeMC module is safely evaluated with SIL 2.

The braking procedure will not be monitored for safety by the SafeMC module.

Information:

The functional safe state of the SBC function has been achieved when the safe motor holding brake ouptput has been switched to 0 V.
The respective bit is set once the functional safe state has been achieved.

The purpose of the delay time $T_{DELAY,SBC}$ is to compensate for the different runtimes of functional and safe applications.

Parameter	Unit	Description	Default value
Safety Additional Parameters			
Delay time to start SBC (us)	[µs]	Delay time between request of SBC and activation of the safety function	0

Table 149: SBC safety function parameters

Information:

The safety function Safe Brake Control does not require safe encoder evaluation and can therefore also be used without a safe encoder.

Danger!

If the safety function SBC is used in the safe application, then the ability to enable/disable it must be tested when commissioning the machine!

Information:

Functional errors will occur (e.g. 6029: Holding brake: Control signal on and output status off), if the holding is released by the standard application but the motor holding brake output is switched to 0 V by the SafeMC module.

2.3.4 Safe Operating Stop, SOS

When the SOS safety function is active, the safe stop of the drive is monitored. Pulse disabling is not controlled by the SafeMC module.
The drive can remain active and must be kept in standstill by the functional application.

Information:

The safety function Safe Operating Stop requires safe encoder evaluation of the speed and position. If the function is programmed in the safe application and if no safe encoder is detected or an encoder error is detected, then the SafeMC module immediately changes to the Functional Fail Safe state after the function block is activated!

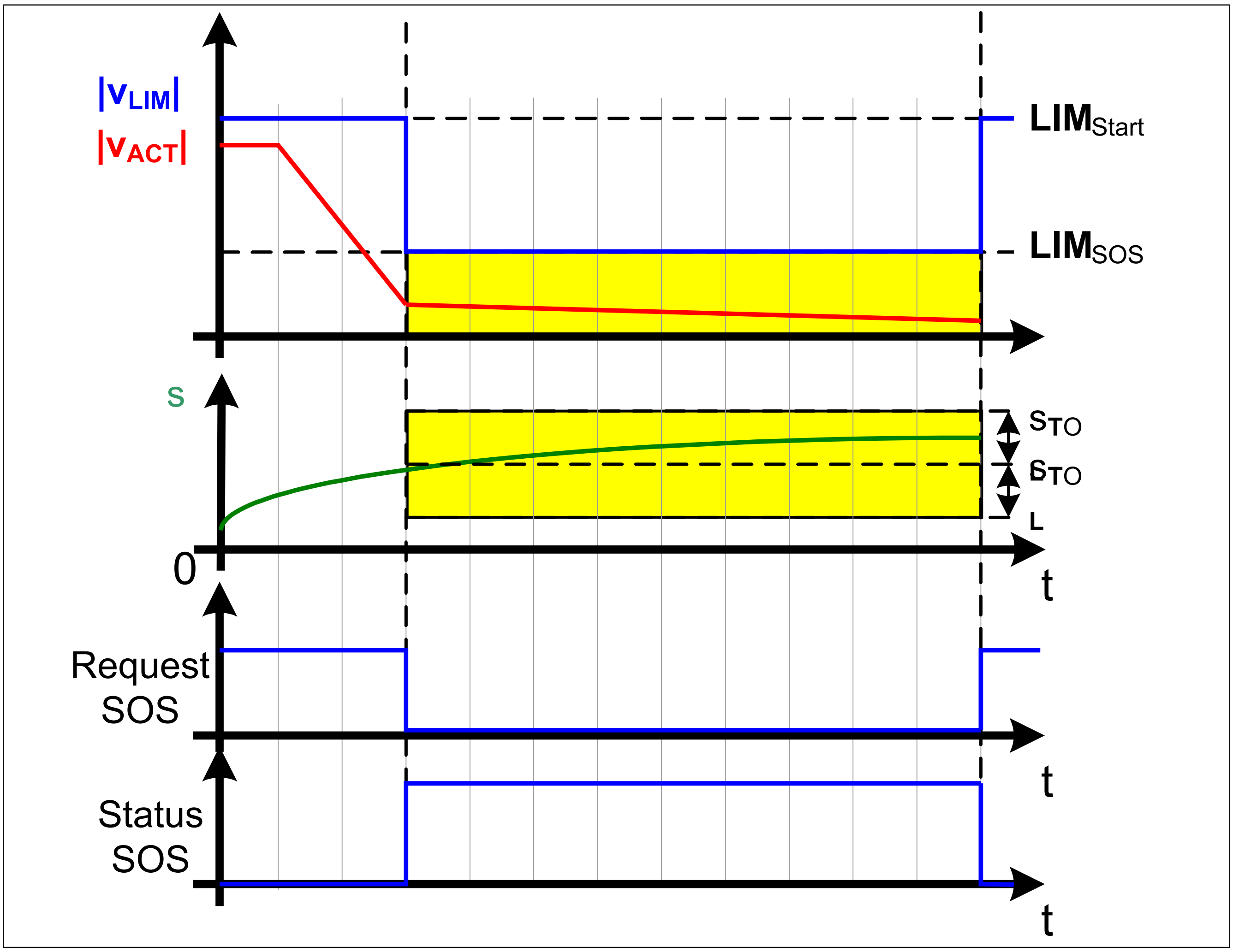


Figure 55: Safe Operating Stop, SOS

To prevent the axis from drifting, both the speed and position are monitored with standstill tolerance limits. The position window is established 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 the request is made, the standstill tolerance position window will be re-established, based on the current position.

Information:

The functional safe state of the SOS function has been achieved when the drive is stopped and the standstill is being monitored for safety.
The respective bit is set once the functional safe state has been achieved.

The standstill tolerances can be configured for each axis in SafeDESIGNER with the following 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 150: SOS safety function parameters

Danger!

In the event of an error, forward movement can occur during the error response time when monitoring the standstill tolerance window. Within this amount of time, the drive could accelerate to its maximum before spinning out.
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 a Functional Fail Safe error state which must be acknowledged. When an error occurs, a synchronous axis loses its synchronicity.

Danger!

If a standstill limit (position or speed) is violated, then the module changes to the error state "Functional Fail Safe", which must be confirmed. Torque and power to the drive are switched off, causing the drive to spin out! An error will cause a synchronous axis to lose its synchronicity. This will reset the output on the function block S_NotErrFUNC!

Danger!

If the safety function SOS is used in the safe application, then the ability to enable/disable it must be tested when commissioning the machine!
The configured limits must be violated with the function enabled and the error reaction must be tested accordingly!

Danger!

In cases involving external forces (e.g. hanging loads), this can cause dangerous movement!
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!

2.3.5 Safe Stop 1, SS1

When there is a request from the SS1 safety function, after the ramp delay, the deceleration process is monitored until standstill. After decelerating, safe pulse disabling is activated and switches off the torque and power to the drive.

Danger!

Synchronous axes lose their synchronicity when SS1 is in its safe state.

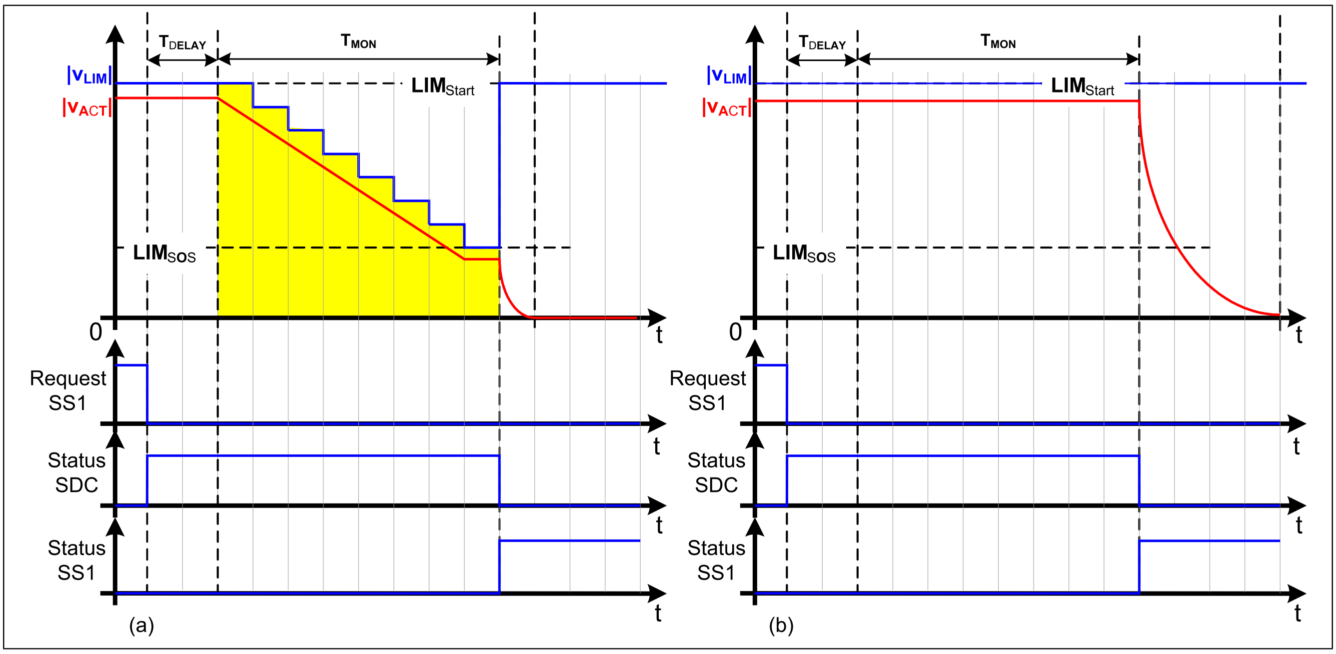


Figure 56: Safe Stop 1, SS1

The deceleration itself is controlled by the functional application, which is not safety-oriented.

The purpose of the ramp delay time T_{DELAY} (parameter "*Delay time to start ramp monitoring (µs)*") is to compensate for the different runtimes of functional and safe applications.

Information:

The functional safe state of the SS1 function has been achieved when the pulse disabling outputs are switched to 0 V. The respective bit is set once the functional safe state has been achieved.

Danger!

In cases involving external forces (e.g. hanging loads), this can cause dangerous movement!
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 following parameters in SafeDESIGNER affect the behavior of the safety function:

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 SS1	Activated/ Deactivated	Activates ramp monitoring (in addition to the time) when the SS1 function is requested	Activated
Early Limit Monitoring	Activated/ Deactivated	Monitoring of the deceleration ramp is prematurely terminated if the value drops below the lower limit for a defined amount of time	Deactivated
Safety Ramp Monitoring Times			
Ramp Monitoring Time for SS1 (us)	[µs]	Deceleration monitoring time for SS1	0
Safety Additional Parameters			
Delay time to start ramp monitoring (us)	[µs]	Delay time between request of ramp monitoring and 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 151: SS1 safety function parameters

Depending on the request for the safety function and its configuration, either only the deceleration time T_{MON} - see figure (b) - or also the deceleration ramp - see figure (a) - can be monitored.
If the monitoring limits are violated during deceleration, then an error state that must be confirmed is entered.

The parameter "*Ramp monitoring for SS1*" configures the behavior of the delay monitor.

2.3.6 Safe Stop 2, SS2

With SS2, after the ramp delay, the deceleration process is monitored until standstill. Then the drive must be kept at standstill by the functional application. Like with SOS, this standstill is monitored by the SafeMC module according to the configured tolerance window LIM_{SOS} and s_{TOL}.

The delay itself must be generated by the non-safety-oriented, functional application by halting the drive in response to the dangerous situation.

Information:

The safety function Safe Stop 2 requires safe encoder evaluation of the speed and position.
If the function is programmed in the safe application and if no safe encoder is detected or an encoder error is detected, then the SafeMC module immediately changes to the Functional Fail Safe state after the function block is activated!

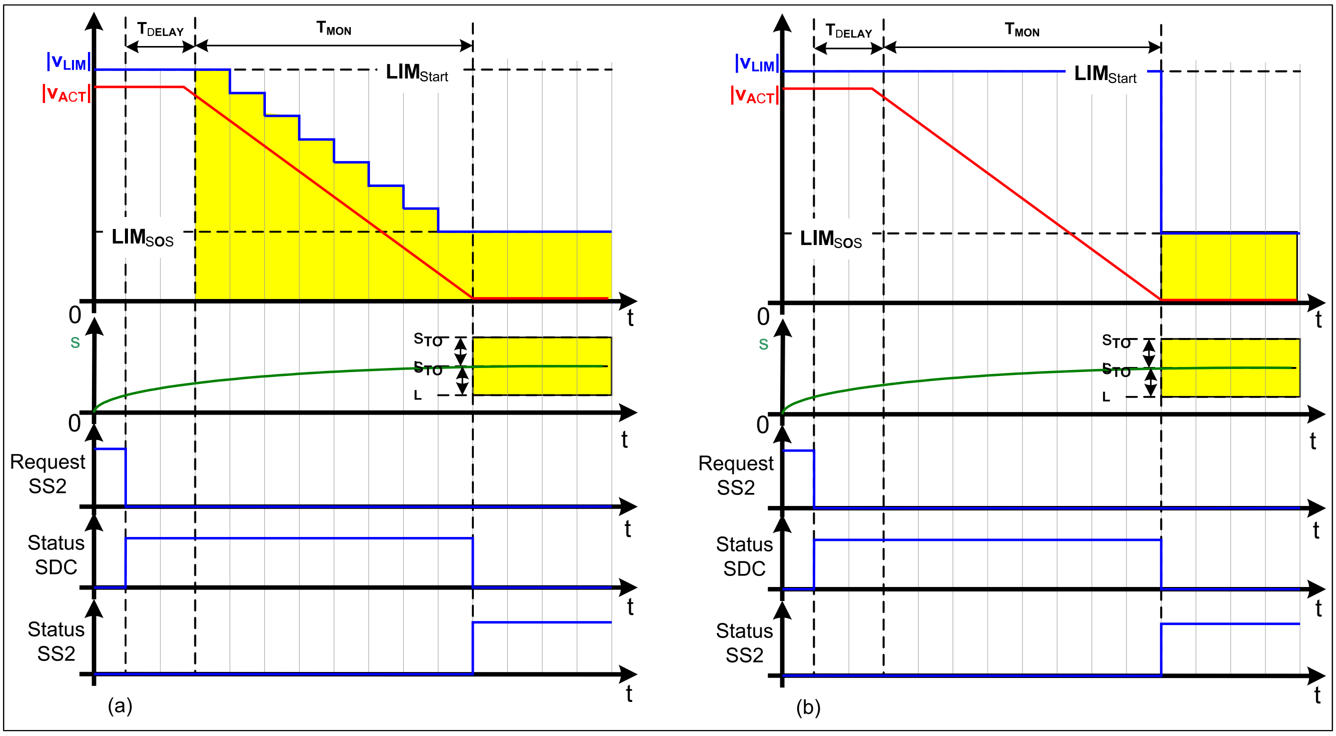


Figure 57: Safe Stop 2, SS2

Danger!

If a standstill limit (position or speed) is violated, then the module changes to the error state "Functional Fail Safe", which must be confirmed. Torque and power to the drive are switched off, causing the drive to spin out! An error will cause a synchronous axis to lose its synchronicity.
This will reset the output on the function block S_NotErrFUNC!

Danger!

In cases involving external forces (e.g. hanging loads), this can cause dangerous movement!
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 T_{DELAY} (parameter "*Delay time to start ramp monitoring (µs)*") is to compensate for the different runtimes of functional and safe applications.

Information:

The functional safe state of the SS2 function has been achieved when the drive is stopped and the standstill is being monitored for safety.
The respective bit is set once the functional safe state has been achieved.

The following parameters in SafeDESIGNER affect the behavior of the safety function:

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 SS2	Activated/ Deactivated	Activates ramp monitoring (in addition to the time) when the SS2 function is activated	Activated
Early Limit Monitoring	Activated/ Deactivated	Monitoring of the deceleration ramp is prematurely terminated if the value drops 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 monitoring time for SS2	0
Safety Additional Parameters			
Delay time to start ramp monitoring (us)	[μs]	Delay time between request of ramp monitoring and 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 152: SS2 safety function parameters

Similar to SS1, either only the deceleration time T_{MON} - see figure 6 (b) - or also the deceleration ramp - see figure 6 (a) - can be monitored depending on the requirements for the safety function.

The parameter "*Ramp monitoring for SS2*" configures the behavior of the delay monitor.

2.3.7 Safely Limited Speed, SLS

The safety function SLS is used to monitor a specified speed limit LIM_{SLSx} (parameter "*Safe Speedlimit 1, 2, 3, 4 for SLS (units/s)*"). Depending on the application, deceleration can also be monitored until the limit is reached.

Four different speed limits can be monitored on the SafeMC 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 contains the four different inputs "S_RequestSLSx", [x = 1..4].

The standard (non safety-oriented) application must use a closed-loop control appropriate for the level of danger to decelerate the movement and then maintain the respective speed limit.

Information:

The safety function SLS requires safe encoder evaluation of the speed. If the function is programmed in the safe application and if no safe encoder is detected or an encoder error is detected, then the SafeMC module immediately changes to the Functional Fail Safe state after the function block is activated!

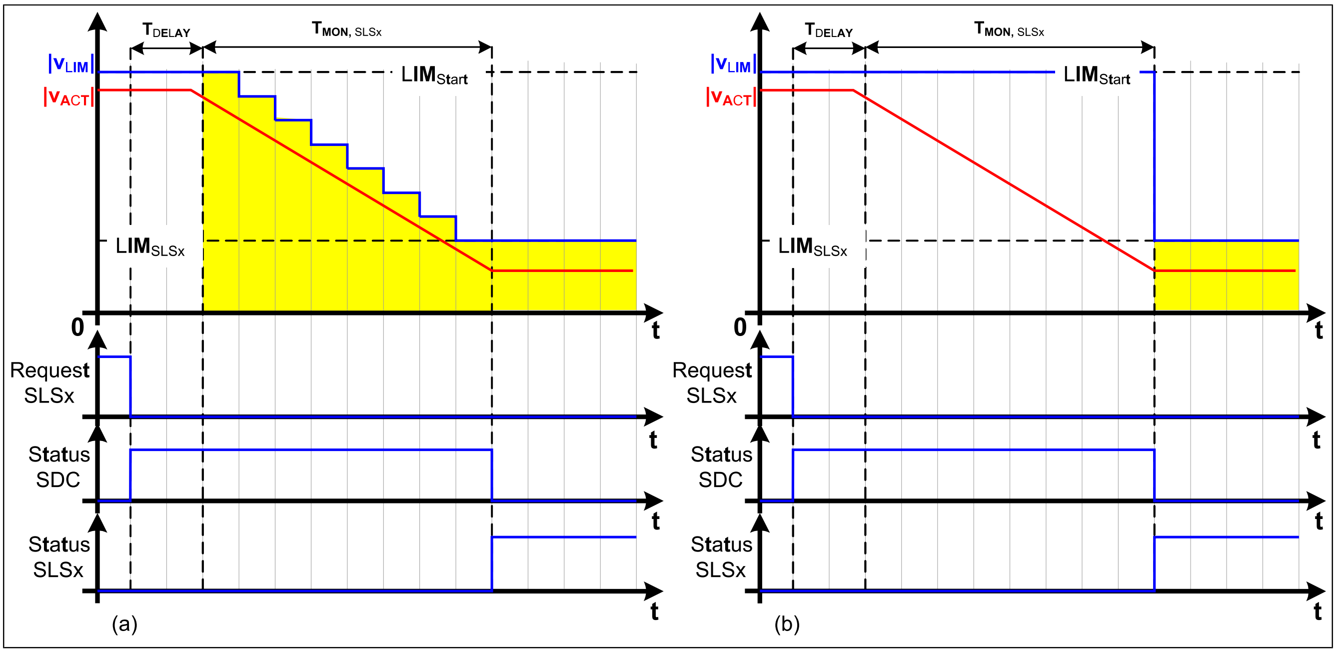


Figure 58: Safely Limited Speed, SLS

Danger!

In cases involving external forces (e.g. hanging loads), this can cause dangerous movement!
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 changes to the error state "Functional Fail Safe", which must be confirmed.
Torque and power to the drive are switched off, causing the drive to spin out!
An error will cause a synchronous axis to lose its synchronicity! This will reset the output on the function block S_NotErrFUNC!

The purpose of the ramp delay time T_{DELAY} is to compensate for the different runtimes of functional and safe applications.

If the delay time $T_{mon,\ SLS}$ is set to 0, then the speed limit will be monitored right after the request is made for the safety function.

Information:

The functional safe state of the SLS function has been achieved if the drive has not exceeded a defined speed limit and this limit is being monitored for safety. The respective bit is set once the functional safe state has been achieved.

The following parameters in SafeDESIGNER affect the behavior of the safety function:

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 monitoring (in addition to the time) when the SLS function is activated	Activated
Early Limit Monitoring	Activated/ Deactivated	Monitoring of the deceleration ramp is prematurely terminated if the value drops below the lower limit for a defined amount of time	Deactivated
Speed Limits			
Safe Speed-limit 1 for SLS	[units/s]	Speed Limit 1 for SLS	0
Safe Speed-limit 2 for SLS	[units/s]	Speed Limit 2 for SLS	0
Safe Speed-limit 3 for SLS	[units/s]	Speed Limit 3 for SLS	0
Safe Speed-limit 4 for SLS	[units/s]	Speed Limit 4 for SLS	0
Safety Ramp Monitoring Times			
Ramp Monitoring Time for SLS1 (us)	[µs]	Deceleration monitoring time for SLS1	0
Ramp Monitoring Time for SLS2 (us)	[µs]	Deceleration monitoring time for SLS2	0
Ramp Monitoring Time for SLS3 (us)	[µs]	Deceleration monitoring time for SLS3	0
Ramp Monitoring Time for SLS4 (us)	[µs]	Deceleration monitoring time for SLS4	0
Safety Additional Parameters			
Delay time to start ramp monitoring (us)	[µs]	Delay time between request of ramp monitoring and 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 153: SLS safety function parameters

Like with SS1 and SS2, the deceleration ramp monitoring can be adjusted according to the requirements, so that either only the deceleration time $T_{MON,\ SLSx}$ - see figure 7 (b) - or both the deceleration time and the deceleration ramp - see figure 7 (a) - are monitored.
The parameter "*Ramp monitoring for SLS*" configures the behavior of the delay monitor.

2.3.8 Safe Maximum Speed, SMS

The difference between SMS and SLS is that SMS cannot be actively initiated. It is either activated (parameter "*Safe Maximum Speed*" = Used) or deactivated (parameter "*Safe Maximum Speed*" = Unused) in the configuration.

When activated, the current speed is constantly monitored according to a defined limit (parameter "*Safe Maximum Speed (units/s)*").

Information:

The safety function SMS requires safe encoder evaluation of the speed.
If the function is programmed in the safe application and if no safe encoder is detected or an encoder error is detected, then the SafeMC module immediately changes to the Functional Fail Safe state after the function block is activated!

The following parameters in SafeDESIGNER affect the behavior of the safety function:

Parameter	Unit	Description	Default value
General settings			
Safe Maximum Speed	Used / Unused	SMS safety function activated or deactivated	Used
Speed Limits			
Maximum speed limit for SMS	[units/s]	Speed limit of the maximum speed	0

Table 154: SMS safety function parameters

Danger!

If the monitored speed limit is exceeded, the remaining distance must be calculated based on the error response time.
It must be ensured that the spin-out movement and remaining 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.
Within this amount of time, the drive could accelerate to its maximum before spinning out. 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 SMS is used in the safe application, then it must be tested when commissioning the machine!
The configured limit must be exceeded! The error response must be tested accordingly!

Danger!

In cases involving external forces (e.g. hanging loads), this can cause dangerous movement!
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!

2.3.9 Safely Limited Increment, SLI

With the SLI safety function, the movement is monitored for a defined number of increments (parameter "*Safe Increments (units)*").

Information:

The safety function SLI requires safe encoder evaluation of the speed and position.
If the function is programmed in the safe application and if no safe encoder is detected or an encoder error is detected, then the SafeMC module immediately changes to the Functional Fail Safe state after the function block is activated!

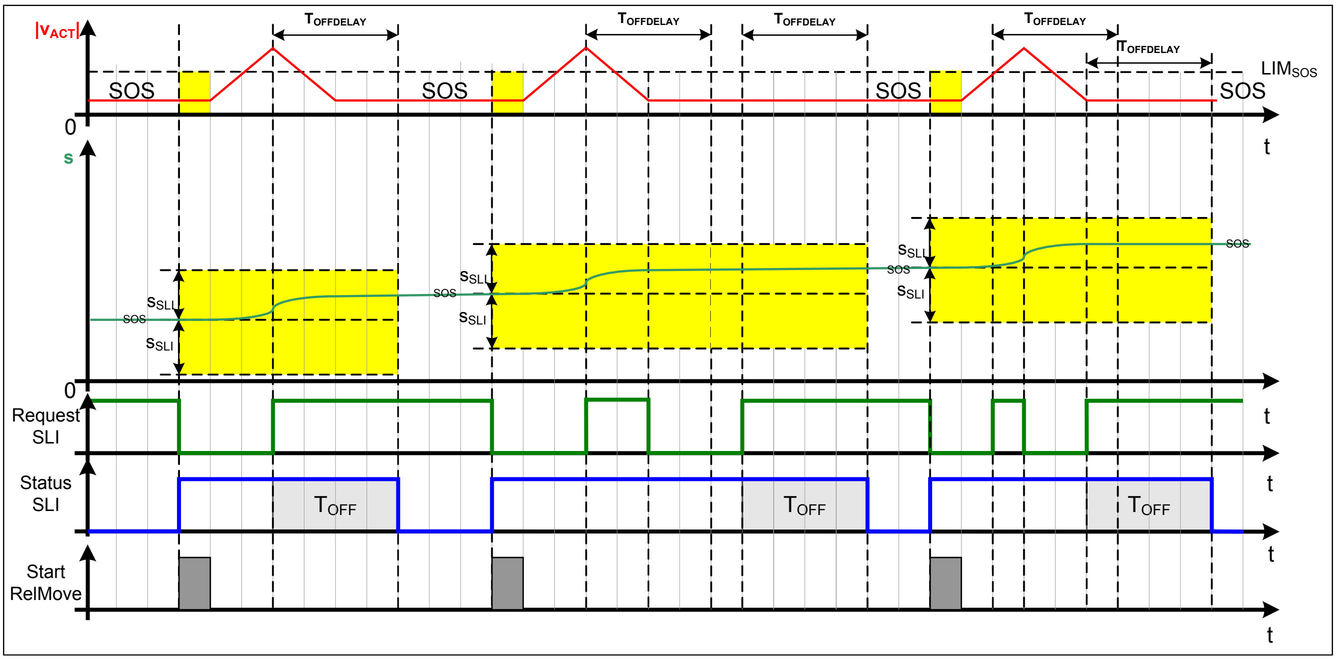


Figure 59: Safely Limited Increment, SLI

Information:

The SLI safety function is only effective when used in combination with at least a second safety function. This could be one of the safety functions such as SOS, SS2, or SLS.

Information:

The functional safe state of the SLI function has been achieved if the drive has not exceeded a defined increment size and this limit is being monitored for safety.
The respective bit is set once the functional safe state has been achieved.

The following parameters in SafeDESIGNER affect the behavior of the safety function:

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 moveable increments when SLI is active	0
SLI OFF Delay	[µs]	Switch off delay of SLI	0

Table 155: SLI safety function parameters

The safe axis must be stopped when the function is activated. To do this, the speed is monitored for adhering to the speed standstill tolerance (parameter "*Speed Tolerance (units /s)*").

A position window is established, which is monitored safely. This position window depends on the configured safe increment size (parameter "*Safe Increments (units)*"). The functional application must guarantee that this position window is not exceeded.

After the safety function is deactivated, the monitor remains active only for the configured time T_{OFF} (parameter "*SLI Off Delay (µs)*". This prevents continuous movement caused by constant inching!

Danger!

If a speed limit for requesting the function or if the position window is violated, then the module changes to the error state "Functional Fail Safe", which must be confirmed.
Torque and power to the drive are switched off, causing the drive to spin out! An error will cause a synchronous axis to lose its synchronicity.
This will reset the output on the function block S_NotErrFUNC!

Danger!

In cases involving external forces (e.g. hanging loads), this can cause dangerous movement!
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.
Within this amount of time, the drive could accelerate to its maximum before spinning out.
The resulting remaining distance must be accounted for when configuring the permissible increments and must not present any danger.
The dangerous movement must be determined by a risk analysis.

Danger!

If the safety function SLI is used in the safe application, then the ability to enable/disable it must be tested when commissioning the machine!
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!

2.3.10 Safe Direction, SDI

The SDI safety function monitors the defined direction of movement.

Either the positive or the negative direction can be monitored. The two inputs *"S_RequestSDIpos"* and *"S_RequestSDIneg"* provided on the function block can be used for this purpose.

Information:

The safety function SDI requires safe encoder evaluation of the position.
If the function is programmed in the safe application and if no safe encoder is detected or an encoder error is detected, then the SafeMC module immediately changes to the Functional Fail Safe state after the function block is activated!

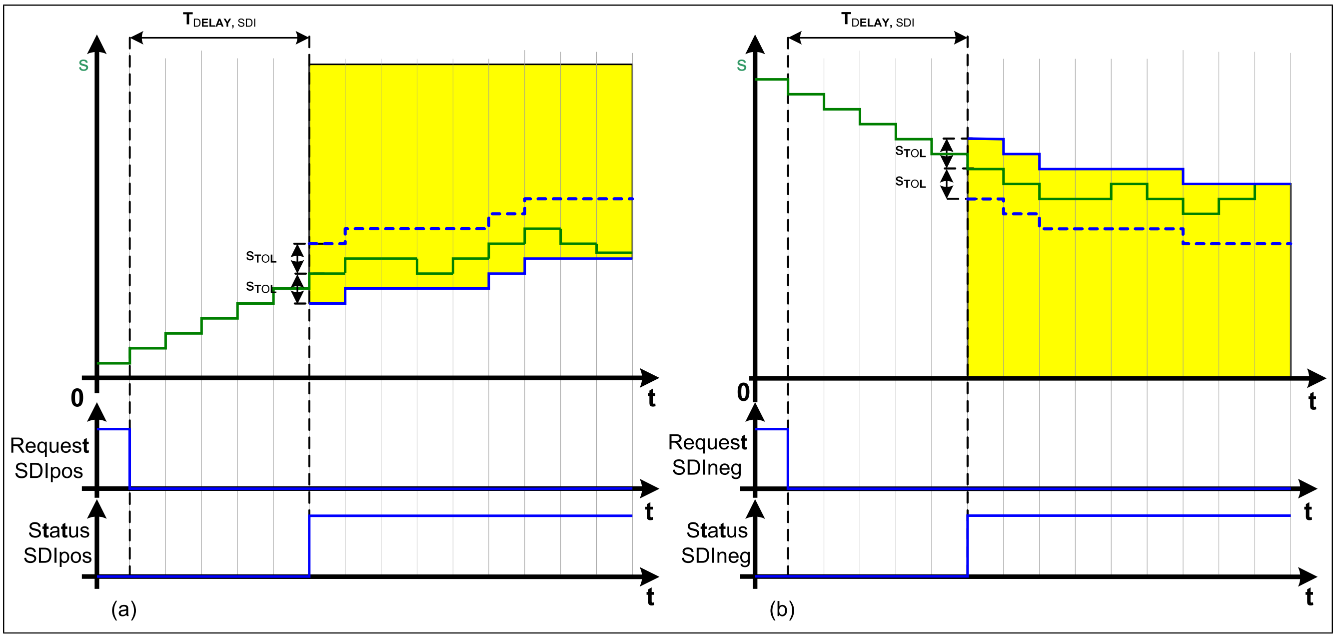


Figure 60: Safe Direction, SDI

Information:

The safe direction 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 function has been achieved if the drive has not violated a defined direction of movement and this direction of movement is being monitored for safety.
The respective bit is set once the functional safe state has been achieved.

The following parameters in SafeDESIGNER affect the behavior of the safety function:

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 request of SDI and activation of the safety function	0

Table 156: SDI safety function parameters

The purpose of the delay time $T_{DELAY,SDI}$ (parameter "*Delay time to start SDI (µs)*") is to compensate for the different runtimes of functional and safe applications.

When monitoring the direction of movement, then standstill tolerance s_{TOL} (parameter "*Position Tolerance (units)*") is not permitted to be exceeded in the forbidden direction of movement. When moving in the permitted direction of movement, the position pointer moves along like a slave pointer.

Danger!

If the safe direction of movement is violated, then the module changes to the error state "Functional Fail Safe", which must be confirmed. Torque and power to the drive are switched off, causing the drive to spin out!
An error will cause a synchronous axis to lose its synchronicity!
This will reset the output on the function block S_NotErrFUNC!

Danger!

In cases involving external forces (e.g. hanging loads), this can cause dangerous movement!
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.
Within this amount of time, the drive could accelerate to its maximum before spinning out. The resulting remaining distance must be accounted for 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 safety function SDI is used in the safe application, then the ability to enable/disable each of the directions of movement that are being used must be tested 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!

2.4 Error prevention

> ## Danger!
> **Validation**
>
> **Each of the safety functions that are used must be validated separately.**
> **Furthermore, the entire safety application (and therefore also the interaction of the individual functions) must be tested.**

2.4.1 Exceeding monitored limits

The SafeMC module monitors limits that can be configured. The drive itself however is controlled by the functional application on the standard PLC.

The following points must be considered in order to prevent the violation of a monitored limit:

- 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 the movement limitations. Make sure that the different configurations of the unit system match in the safe application and in the functional application!

> ## Danger!
> **Any violation of a monitored limit will cause the module to change to the error state "Functional Fail Safe", which must be confirmed.**
>
> **The function block output *S_NotErrFUNC* is reset and the drive becomes torque-free and force-free, causing it to spin out!**
>
> **Depending on the configuration, the motor holding brake will also be switched to 0 V.**
>
> **An error will cause a synchronous axis to lose its synchronicity.**
>
> **Check the Safety Logger in Automation Studio for detailed information about monitoring!**

2.4.2 Plausibility errors

Plausibility errors (limit values, data types, variable/constant), which occur when the function block is used, are detected and reported by the function block or compiler.

However, this is not always possible in the event of connection errors.

The function block cannot check whether:

- Actual parameter values or constants within the validity range are in fact incorrect for the safety function executed. However, a static TRUE signal at the Reset input is detected by the function block and reported as an error.
- Actual parameters have been connected incorrectly.
- I/O formal parameters have not been connected by mistake.

Please note, therefore:

Danger!

The connection of the safety function (sub-application) is your responsibility.

Check the connection when validating the sub-application.

2.4.3 Signal level changing or toggling sporadically or impermissible signals

Signal level changes or toggles sporadically at:

- Edge-controlled input formal parameters, if error avoidance measures are not taken this signal will be interpreted by the function block as an edge and an undesired action will be initiated accordingly in the function block.
- State-controlled input formal parameters, if error avoidance measures are not taken an undesired action will be initiated accordingly by the signal.

Impermissible signals at input formal parameters can lead to unexpected startup or result in the non-execution of a requested action or in an error message.

Possible causes of these signals:

- Programming error in the application program (user error)
- Cross circuit, short circuit or cable break (user error, wiring error)
- Error in the standard control system

To prevent this, the following measures can be taken depending on the safety function:

- Use of safe device signals.
- Additional measures to prevent a hazard if a signal from a standard control system is used (e.g. execution of an additional function start following reset of a triggered safety function or once an error has been removed).
- Line control in the safe control system.
- Suitable cabling when using standard signals from the standard control system.
- Checking the source code in the application program with final validation of the safety function.

The measures listed above can also be taken in combination in order to safely avoid errors.

Take note that a signal change detected at a state-controlled formal parameter will be output as diagnostic code.

2.4.4 Simultaneous edge change

To reduce the risk of unexpected startup, make sure that the Reset formal parameter is only connected with the signal of a manual reset device. This signal is based on your risk analysis.

2.4.5 Machine/system startup without safeguard function test

A faulty safeguard is only detected following a function test. A function test is not supported by the function block. Without additional measures, a faulty safeguard can result in errors.

> ## Danger!
>
> **You are responsible for performing safeguard function tests.**
> **You must therefore validate the safeguard.**

Possible causes of a faulty safeguard:

- faulty devices (hardware errors)
- Cross circuit, short circuit, and cable break (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 safe application, then the respective input should not be connected.

> **Information:**
>
> **If a safety function should not be used in the application, then the respective input variables should 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 least the activate input and the S_AxisID must be connected. Otherwise, the SafeMC module will not be operated by the SafeLOGIC. As a result, the pulse disabling and the 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

- Enabling the function block

Data type

- BOOL

Connection

- Constant or variable

Function description

This input parameter is used to activate the function block.

- If you activate or deactivate safe devices, link Activate to a variable, which indicates the status (deactivated or activated) of the relevant safe devices. This ensures that the function block does not output a triggered safety function as diagnostic information in the event that a device is deactivated.
- Furthermore, Activate can be connected to a constant (TRUE) in order to activate the function block.

TRUE

The function block is active.

FALSE

The function block is not active.

All binary output parameters are set to FALSE.
The DiagCode diagnostic parameter is set to WORD#16#0000.

If you want to control the function block diagnostics accordingly in your diagnostic concept in the event of error messages from safe devices and/or in the event of deactivated safe devices, connect Activate to a signal that indicates the status of the safe devices, which are involved in the safety function supported by the function block. Create this signal only from safe devices, whose I/O signals are connected to the function block via actual parameters. This prevents triggered safety functions from being reported by deactivated safe devices. This measure is only used to control the diagnostics in the event of deactivated safe devices.

2.5.3 S_RequestSTO

General function

- Selects/deselects the safety function "Safe Torque Off", STO

Data type

- SAFEBOOL

Connection

- Constant or variable

Function description

This input parameter is used to select or deselect the safety function STO.

TRUE

Safety function is deselected; the safe pulse disabling is not active!

FALSE

Safety function is selected; the safe pulse disabling is active! Torque and power are switched off on the drive.

Not connected

The safety function is disabled.

Relevant configuration parameters

- None

2.5.4 S_RequestSTO1

General function

- Selects/deselects the safety function "Safe Torque Off, One Channel", STO1

Data type

- SAFEBOOL

Connection

- Constant or variable

Function description

This input parameter is used to select or deselect the safety function STO1.

TRUE

Safety function is deselected; the safe pulse disabling is not active!

FALSE

Safety function is selected; depending on the configuration, the HighSide or LowSide of the safe pulse disabling is active! Torque and power are switched off on the drive.

Not connected

The safety function is disabled.

Relevant configuration parameters

Parameter	Units	Description
Channel selection for One Channel STO (STO1)	HighSide/LowSide	Selection of HighSide or LowSide IGBT in the One Channel STO function

Table 157: SF_SafeMC_BR: Parameter STO1

2.5.5 S_RequestSBC

General function

- Selects/deselects the safety function "Safe Brake Control", SBC

Data type

- SAFEBOOL

Connection

- Constant or variable

Function description

This input parameter is used to select or deselect the safety function SBC.

TRUE

Safety function is deselected. The motor holding brake is active and can be used by the functional application.

FALSE

Safety function is selected. The motor holding brake is switched to 0 V!

Not connected

The safety function is disabled.

Relevant configuration parameters

Parameter	Units	Description
Delay time to start SBC	[µs]	Delay time between request of SBC and activation of the safety function

Table 158: SF_SafeMC_BR: Parameter SBC

2.5.6 S_RequestSOS

General function

- Selects/deselects the safety function "Safe Operating Stop", SOS

Data type

- SAFEBOOL

Connection

- Constant or variable

Function description

This input parameter is used to select or deselect the safety function SOS.

TRUE

Safety function is deselected. Standstill tolerances are not being monitored.

FALSE

Safety function is selected. Standstill tolerances are being monitored.

Not connected

The safety function is disabled.

Relevant configuration parameters

Parameter	Units	Description
Speed Tolerance	[units/s]	Speed tolerance for standstill monitoring
Position Tolerance	[units]	Position tolerance for standstill and direction monitoring

Table 159: SF_SafeMC_BR: Parameter SOS

Information:

This safety function requires an EnDat 2.2 Safety encoder!

If multiple safety functions are selected at the same time, then the lowest limit value will always be monitored.

The following application rule must be observed:

$\mathbf{LIM_{SOS} \leq LIM_{SLS4} \leq LIM_{SLS3} \leq LIM_{SLS2} \leq LIM_{SLS1} \leq LIM_{SMS}} < \boldsymbol{NormSpeed}$

2.5.7 S_RequestSS1

General function

- Selects/deselects the safety function "Safe Stop 1", SS1

Data type

- SAFEBOOL

Connection

- Constant or variable

Function description

This input parameter is used to select or deselect the safety function SS1.

TRUE

Safety function is deselected; Safe Stop 1 is not active!

FALSE

Safety function is selected. Safe pulse disabling is activated after the end of ramp monitoring.

Not connected

The safety function is disabled.

Relevant configuration parameters

Parameter	Units	Description
Deceleration ramp	[units/s²]	Slope of the deceleration ramp to be monitored
Ramp monitoring for SS1	Activated/ Deactivated	Activates ramp monitoring (in addition to the time) when the SS1 function is activated
Early Limit Monitoring	Activated/ Deactivated	Monitoring of the deceleration ramp is prematurely terminated if the target limit is exceeded
Ramp Monitoring Time for SS1	[μs]	Deceleration monitoring time for SS1
Delay time to start ramp monitoring	[μs]	Delay time between request of ramp monitoring and start of monitoring
Early Limit Monitoring time	[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

Table 160: SF_SafeMC_BR: Parameter SS1

Information:

This safety function requires an EnDat 2.2 Safety encoder!
If an EnDat2.2 Safety encoder is not available, then "Ramp Monitoring for SS1" and "Early Limit Monitoring" must be deactivated.

2.5.8 S_RequestSS2

General function

- Selects/deselects the safety function "Safe Stop 2", SS2

Data type

- SAFEBOOL

Connection

- Constant or variable

Function description

This input parameter is used to select or deselect the safety function SS2.

TRUE

Safety function is deselected; Safe Stop 2 is not active!

FALSE

Safety function is selected. Standstill monitoring is activated after the end of ramp monitoring.

Not connected

The safety function is disabled.

Relevant configuration parameters

Parameter	Units	Description
Deceleration ramp	[units/s²]	Slope of the deceleration ramp to be monitored
Ramp monitoring for SS2	Activated/ Deactivated	Activates ramp monitoring (in addition to the time) when the SS2 function is activated
Early Limit Monitoring	Activated/ Deactivated	Monitoring of the deceleration ramp is prematurely terminated if the target limit is exceeded
Speed Tolerance	[units/s]	Speed tolerance for standstill monitoring
Position Tolerance	[units]	Position tolerance for standstill and direction monitoring
Ramp Monitoring Time for SS2	[μs]	Deceleration monitoring time for SS2
Delay time to start ramp monitoring	[μs]	Delay time between request of ramp monitoring and start of monitoring

Table 161: SF_SafeMC_BR: Parameter SS2

Information:

This safety function requires an EnDat 2.2 Safety encoder!

If multiple safety functions are selected at the same time, then the lowest limit value will always be monitored.

The following application rule must be observed:

$\mathbf{LIM_{SOS} \leq LIM_{SLS4} \leq LIM_{SLS3} \leq LIM_{SLS2} \leq LIM_{SLS1} \leq LIM_{SMS}} < \boldsymbol{NormSpeed}$

2.5.9 S_RequestSLS1

General function

- Selects/deselects the safety function "Safely Limited Speed", Speed Limit 1

Data type

- SAFEBOOL

Connection

- Constant or variable

Function description

This input parameter is used to select or deselect the safety function SLS1.

TRUE

Safety function is deselected; SLS1 is not active!

FALSE

Safety function is selected. Speed Limit 1 is monitored after the end of ramp monitoring.

Not connected

The safety function is disabled.

Relevant configuration parameters

Parameter	Units	Description
Deceleration ramp	[units/s²]	Slope of the deceleration ramp to be monitored
Ramp monitoring for SLS	Activated/ Deactivated	Activates ramp monitoring (in addition to the time) when the SLS function is activated
Early Limit Monitoring	Activated/ Deactivated	Monitoring of the deceleration ramp is prematurely terminated if the target limit is exceeded
Safe Speed Limit 1 for SLS	[units/s]	Speed Limit 1 for SLS
Ramp Monitoring Time for SLS1	[µs]	Deceleration monitoring time for SLS1
Delay time to start ramp monitoring	[µs]	Delay time between request of ramp monitoring and start of monitoring
Early Limit Monitoring time	[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

Table 162: SF_SafeMC_BR: Parameter SLS1

Information:

This safety function requires an EnDat 2.2 Safety encoder!

If multiple safety functions are selected at the same time, then the lowest limit value will always be monitored.

The following application rule must be observed:

$\mathbf{LIM_{SOS} \le LIM_{SLS4} \le LIM_{SLS3} \le LIM_{SLS2} \le LIM_{SLS1} \le LIM_{SMS}} < \textbf{\textit{NormSpeed}}$

2.5.10 S_RequestSLS2

General function

- Selects/deselects the safety function "Safely Limited Speed", Speed Limit 2

Data type

- SAFEBOOL

Connection

- Constant or variable

Function description

This input parameter is used to select or deselect the safety function SLS2.

TRUE

Safety function is deselected; SLS2 is not active!

FALSE

Safety function is selected. Speed Limit 2 is monitored after the end of ramp monitoring.

Not connected

The safety function is disabled.

Relevant configuration parameters

Parameter	Units	Description
Deceleration ramp	[units/s²]	Slope of the deceleration ramp to be monitored
Ramp monitoring for SLS	Activated/ Deactivated	Activates ramp monitoring (in addition to the time) when the SLS function is activated
Early Limit Monitoring	Activated/ Deactivated	Monitoring of the deceleration ramp is prematurely terminated if the target limit is exceeded
Safe Speed Limit 2 for SLS	[units/s]	Speed Limit 2 for SLS
Ramp Monitoring Time for SLS2	[µs]	Deceleration monitoring time for SLS2
Delay time to start ramp monitoring	[µs]	Delay time between request of ramp monitoring and start of monitoring
Early Limit Monitoring time	[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

Table 163: SF_SafeMC_BR: Parameter SLS2

Information:

This safety function requires an EnDat 2.2 Safety encoder!

If multiple safety functions are selected at the same time, then the lowest limit value will always be monitored.

The following application rule must be observed:

$\mathbf{LIM_{SOS} \leq LIM_{SLS4} \leq LIM_{SLS3} \leq LIM_{SLS2} \leq LIM_{SLS1} \leq LIM_{SMS}} < \boldsymbol{NormSpeed}$

2.5.11 S_RequestSLS3

General function

- Selects/deselects the safety function "Safely Limited Speed", Speed Limit 3

Data type

- SAFEBOOL

Connection

- Constant or variable

Function description

This input parameter is used to select or deselect the safety function SLS3.

TRUE

Safety function is deselected; SLS3 is not active!

FALSE

Safety function is selected. Speed Limit 3 is monitored after the end of ramp monitoring.

Not connected

The safety function is disabled.

Relevant configuration parameters

Parameter	Units	Description
Deceleration ramp	[units/s²]	Slope of the deceleration ramp to be monitored
Ramp monitoring for SLS	Activated/ Deactivated	Activates ramp monitoring (in addition to the time) when the SLS function is activated
Early Limit Monitoring	Activated/ Deactivated	Monitoring of the deceleration ramp is prematurely terminated if the target limit is exceeded
Safe Speed Limit 3 for SLS	[units/s]	Speed Limit 3 for SLS
Ramp Monitoring Time for SLS3	[µs]	Deceleration monitoring time for SLS3
Delay time to start ramp monitoring	[µs]	Delay time between request of ramp monitoring and start of monitoring
Early Limit Monitoring time	[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

Table 164: SF_SafeMC_BR: Parameter SLS3

Information:

This safety function requires an EnDat 2.2 Safety encoder!

If multiple safety functions are selected at the same time, then the lowest limit value will always be monitored.

The following application rule must be observed:

$\mathbf{LIM_{SOS} \leq LIM_{SLS4} \leq LIM_{SLS3} \leq LIM_{SLS2} \leq LIM_{SLS1} \leq LIM_{SMS}} < \boldsymbol{NormSpeed}$

2.5.12 S_RequestSLS4

General function

- Selects/deselects the safety function "Safely Limited Speed", Speed Limit 4

Data type

- SAFEBOOL

Connection

- Constant or variable

Function description

This input parameter is used to select or deselect the safety function SLS4.

TRUE

Safety function is deselected; SLS4 is not active!

FALSE

Safety function is selected. Speed Limit 4 is monitored after the end of ramp monitoring.

Not connected

The safety function is disabled.

Relevant configuration parameters

Parameter	Units	Description
Deceleration ramp	[units/s²]	Slope of the deceleration ramp to be monitored
Ramp monitoring for SLS	Activated/ Deactivated	Activates ramp monitoring (in addition to the time) when the SLS function is activated
Early Limit Monitoring	Activated/ Deactivated	Monitoring of the deceleration ramp is prematurely terminated if the target limit is exceeded
Safe Speed Limit 4 for SLS	[units/s]	Speed Limit 4 for SLS
Ramp Monitoring Time for SLS4	[µs]	Deceleration monitoring time for SLS4
Delay time to start ramp monitoring	[µs]	Delay time between request of ramp monitoring and start of monitoring
Early Limit Monitoring time	[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

Table 165: SF_SafeMC_BR: Parameter SLS4

Information:

This safety function requires an EnDat 2.2 Safety encoder!

If multiple safety functions are selected at the same time, then the lowest limit value will always be monitored.

The following application rule must be observed:

$\mathbf{LIM_{SOS} \leq LIM_{SLS4} \leq LIM_{SLS3} \leq LIM_{SLS2} \leq LIM_{SLS1} \leq LIM_{SMS}} < \textbf{\textit{NormSpeed}}$

2.5.13 S_RequestSLI

General function

- Selects/deselects the safety function "Safely Limited Increment", SLI

Data type

- SAFEBOOL

Connection

- Constant or variable

Function description

This input parameter is used to select or deselect the safety function SLI.

TRUE

Safety function is deselected; SLI is not active!

FALSE

Safety function is selected. A safe range of increments is monitored.

Not connected

The safety function is disabled.

Relevant configuration parameters

Parameter	Units	Description
Speed Tolerance	[units/s]	Speed tolerance for standstill monitoring
Safe Increments	[units]	Maximum moveable increments when SLI is active
SLI OFF Delay	[µs]	Switch off delay of SLI

Table 166: SF_SafeMC_BR: Parameter SLI

Information:

This safety function requires an EnDat 2.2 Safety encoder!

2.5.14 S_RequestSDIpos

General function

- Selects/deselects the safety function "Safe Direction", movement is allowed in the positive direction

Data type

- SAFEBOOL

Connection

- Constant or variable

Function description

This input parameter is used to select or deselect the safety function SDI, movement is allowed in the positive direction of movement.

TRUE

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 disabled.

Relevant configuration parameters

Parameter	Units	Description
Position Tolerance	[units]	Position tolerance for standstill and direction monitoring
Delay time to start SDI	[µs]	Delay time between request of SDI and activation of the safety function

Table 167: SF_SafeMC_BR: Parameter SDIpos

Information:

This safety function requires an EnDat 2.2 Safety encoder!

2.5.15 S_RequestSDIneg

General function

- Selects/deselects the safety function "Safe Direction", movement is allowed in the negative direction

Data type

- SAFEBOOL

Connection

- Constant or variable

Function description

This input parameter is used to select or deselect the safety function SDI, movement is allowed in the negative direction of movement.

TRUE

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 disabled.

Relevant configuration parameters

Parameter	Units	Description
Position Tolerance	[units]	Position tolerance for standstill and direction monitoring
Delay time to start SDI	[µs]	Delay time between request of SDI and activation of the safety function

Table 168: SF_SafeMC_BR: Parameter SDIneg

Information:

This safety function requires an EnDat 2.2 Safety encoder!

2.5.16 Reset

General function

- Reset input for confirming the "Functional Fail Safe" state

Data type

- BOOL

Connection

- Variable

Function description

Reset input for confirming the "Functional Fail Safe" state

A positive switching edge triggers the reset function.

Depending on the configuration of the parameter "Automatic Reset at Startup", a positive switching edge might be needed to get the SafeMC module from the "Init" state to the "Operational" state after starting up.

Relevant configuration parameters

Parameter	Units	Description
Automatic Reset at Startup (StartReset)	Used/Unused	Activates automatic reset of the function block at startup

Table 169: SF_SafeMC_BR: Parameter Reset

2.5.17 S_AxisID

General function

- This input parameter assigns a real axis to the function block.

Data type

- SAFEINT

Connection

- Constant

Function description

You can assign the axis by dragging and dropping it onto the respective parameter in the SafeDESIGNER.

> ## Information:
> **There can only be one combination of AxisID and the SF_SafeMC_BR function block in the safe application. Otherwise, it will not be possible to compile the safe application.**

2.6 Output parameters

The output parameters provide information about the state of the SafeMC module and the individual safety functions.

2.6.1 Ready

General function

- Message: Function block active/not active.

Data type

- BOOL

Connection

- Variable

Function description

This output parameter indicates whether or not the function block is active.

TRUE

The function block is active (Activate = TRUE) and the output parameters indicate the current state of the safety function.

FALSE

The function block is not active (Activate = FALSE) and the function block outputs are set to FALSE.

2.6.2 S_SafetyActiveSTO

General function

- Status information about the safety function "Safe Torque Off", STO

Data type

- SAFEBOOL

Connection

- Variable

Function description

Returns the functional safe state of the safety function STO.

TRUE

Safety function STO is active and currently in its safe state.

FALSE

Safety function STO is not requested, the function or the SafeMC module is currently in an error state or the function block has not been activated.

2.6.3 S_SafetyActiveSTO1

General function

- Status information for the safety function "Safe Torque Off, One Channel", STO1

Data type

- SAFEBOOL

Connection

- Variable

Function description

Returns the functional safe state of the safety function STO1.

TRUE

Safety function STO1 is active and currently in its safe state.

FALSE

Safety function STO1 is not requested, the function or the SafeMC module is currently in an error state or the function block has not been activated.

2.6.4 S_SafetyActiveSBC

General function

- Status information for the safety function "Safe Brake Control", SBC

Data type

- SAFEBOOL

Connection

- Variable

Function description

Returns the functional safe state of the safety function SBC.

TRUE

Safety function SBC is active and currently in its safe state.

FALSE

Safety function SBC is not requested, the function or the SafeMC module is currently in an error state or the function block has not been activated.

2.6.5 S_SafetyActiveSOS

General function

- Status information for the safety function "Safe Operating Stop", SOS.

Data type

- SAFEBOOL

Connection

- Variable

Function description

Returns the functional safe state of the safety function SOS.

TRUE

Safety function SOS is active and currently in its safe state.

FALSE

Safety function SOS is not requested, the function or the SafeMC module is currently in an error state or the function block has not been activated.

2.6.6 S_SafetyActiveSS1

General function

- Status information for the safety function "Safe Stop 1", SS1.

Data type

- SAFEBOOL

Connection

- Variable

Function description

Returns the functional safe state of the safety function SS1.

TRUE

Safety function SS1 is active and currently in its safe state.

FALSE

Safety function SS1 is not requested, has not yet achieved its safe state, the function or the SafeMC module is currently in an error state or the function block has not been activated.

2.6.7 S_SafetyActiveSS2

General function

- Status information for the safety function "Safe Stop 2", SS2.

Data type

- SAFEBOOL

Connection

- Variable

Function description

Returns the functional safe state of the safety function SS2.

TRUE

Safety function SS2 is active and currently in its safe state.

FALSE

Safety function SS2 is not requested, has not yet achieved its safe state, the function or the SafeMC module is currently in an error state or the function block has not been activated.

2.6.8 S_SafetyActiveSLS1

General function

- Status information the safety function "Safely Limited Speed" Speed Limit 1

Data type

- SAFEBOOL

Connection

- Variable

Function description

Returns the functional safe state of the safety function SLS1.

TRUE

Safety function SLS1 is active and currently in its safe state.

FALSE

Safety function SLS1 is not requested, has not yet achieved its safe state, the function or the SafeMC module is currently in an error state or the function block has not been activated.

2.6.9 S_SafetyActiveSLS2

General function

- Status information the safety function "Safely Limited Speed" Speed Limit 2

Data type

- SAFEBOOL

Connection

- Variable

Function description

Returns the functional safe state of the safety function SLS2.

TRUE

Safety function SLS2 is active and currently in its safe state.

FALSE

Safety function SLS2 is not requested, has not yet achieved its safe state, the function or the SafeMC module is currently in an error state or the function block has not been activated.

2.6.10 S_SafetyActiveSLS3

General function

- Status information the safety function "Safely Limited Speed" Speed Limit 3

Data type

- SAFEBOOL

Connection

- Variable

Function description

Returns the functional safe state of the safety function SLS3.

TRUE

Safety function SLS3 is active and currently in its safe state.

FALSE

Safety function SLS3 is not requested, has not yet achieved its safe state, the function or the SafeMC module is currently in an error state or the function block has not been activated.

2.6.11 S_SafetyActiveSLS4

General function

- Status information the safety function "Safely Limited Speed" Speed Limit 4

Data type

- SAFEBOOL

Connection

- Variable

Function description

Returns the functional safe state of the safety function SLS4.

TRUE

Safety function SLS4 is active and currently in its safe state.

FALSE

Safety function SLS4 is not requested, has not yet achieved its safe state, the function or the SafeMC module is currently in an error state or the function block has not been activated.

2.6.12 S_SafetyActiveSLI

General function

- Status information the safety function "Safely Limited Increment"

Data type

- SAFEBOOL

Connection

- Variable

Function description

Returns the functional safe state of the safety function SLI.

TRUE

Safety function SLI is active and currently in its safe state.

FALSE

Safety function SLI is not requested, the function or the SafeMC module is currently in an error state or the function block has not been activated.

2.6.13 S_SafetyActiveSDIpos

General function

- Status information for the safety function "Safe Direction", movement is allowed in the positive direction

Data type

- SAFEBOOL

Connection

- Variable

Function description

Returns the functional safe state of the safety function SDIpos.

TRUE

Safety function SDIpos is active and currently in its safe state.

FALSE

Safety function SDIpos is not requested, the function or the SafeMC module is currently in an error state or the function block has not been activated.

2.6.14 S_SafetyActiveSDIneg

General function

- Status information for the safety function "Safe Direction", movement is allowed in the negative direction

Data type

- SAFEBOOL

Connection

- Variable

Function description

Returns the functional safe state of the safety function SDIneg.

TRUE

Safety function SDIneg is active and currently in its safe state.

FALSE

Safety function SDIneg is not requested, the function or the SafeMC module is currently in an error state or the function block has not been activated.

2.6.15 S_SafetyActiveSDC

General function

- Information about the status of the ramp monitor

Data type

- SAFEBOOL

Connection

- Variable

Function description

This output parameter specifies the status of ramp monitoring.

TRUE

Ramp monitoring is active.

FALSE

Ramp monitoring is not active, the module is currently in an error state or the function block has not been activated.

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

Function description

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 module is in an error state or the function block has not yet been activated.

2.6.17 S_NotErrFUNC

General function

- Information about the error state of the SafeMC module

Data type

- SAFEBOOL

Connection

- Variable

Function description

This output parameter specifies the error status of the SafeMC module.

TRUE

No error was found on the SafeMC module.

FALSE

Am SafeMC Modul wurde ein Fehler (z. B. die Überschreitung eines überwachten Limits) festgestellt oder der Funktionsblock wurde nicht aktiviert.
Im Fehlerfall kann die Zusatzinformation zum Fehler im Safety Logger des Automation Studios entnommen werden!
Handelt es sich hierbei um einen funktionalen Fehler, kann dieser quittiert werden, indem das Signal am Eingang Reset von FALSE auf TRUE wechselt (positive Flanke)!

Danger!

This signal should only be used for status information. This only applies in relation to the requested safety functions.
S_NotErrFUNC does not represent the functional safe state of the SafeMC module!

Danger!

It is your responsibility to ensure that all necessary repairs are made if an error occurs because subsequent errors could create a dangerous situation!

2.6.18 Error

General function

- Function block error message

Data type

- BOOL

Connection

- Variable

Function description

This formal parameter indicates a pending block error message.

TRUE

The activated function block has detected an error. DiagCode indicates the error code.

FALSE

The function block is not activated or the activated function block has not detected any errors. DiagCode indicates the state.

> **Danger!**
>
> **It is your responsibility to ensure that all necessary repairs are made if an error occurs because subsequent errors could create a dangerous situation!**

In order to exit an error state (Error= TRUE), the signal on the Reset input must change from FALSE to TRUE (positive edge).

2.6.19 DiagCode

General function

- Function block diagnostic message

Data type

- WORD

Connection

- Variable

Function description

Block-specific diagnostic and status messages are output and automatically made available to the higher-level diagnostic tools via this output parameter.

Higher-level diagnostic tools cannot confirm block diagnostic messages. This is done exclusively in the **safe** application program.

The function block indicates the presence of an error message at the DiagCode output via the Error output parameter.

Diagnostic code

The diagnostic code is indicated in the WORD data type. The values of the diagnostics codes and their meaning are described below.

For status messages ($0xxx_{hex}$, $8xxx_{hex}$) the function block sets Error to FALSE.

For 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 active.	Activate the function block by setting Activate to TRUE.
8001	Init	The function block has been activated and the SafeMC module is in the Init state. The SafeMC module startup inhibit is active.	Configure the parameter "Startreset" accordingly or change to a positive edge on the Reset input.
8002	Operational	The SafeMC module is in the Operational state. No safety function is selected. The speed limit SMS is monitored according to the configuration.	No action required.
8003	Wait for Confirmation	The SafeMC 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. This will provide you with detailed information about the currently pending error. Depending on the type of error, check the functional and safe application. When functional errors occur, check the module configuration or replace the faulty module!

Table 170: SF_SafeMC_BR: Diagnostic codes

2.6.21 AxisStatus

General function

- Diagnostics message from the function block, representation of the axis status bits in a DWORD

Data type

- DWORD

Connection

- Variable

Function description

The AxisStatus output returns bit-coded information about the status of the 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	-	-	-
Bit 16	**Bit 17**	**Bit 18**	**Bit 19**	**Bit 20**	**Bit 21**	**Bit 22**	**Bit 23**
-	Status Set Position Alive Test	Status SFR	Status "All requested safety functions active"	Status SDC	Status operational	Status Not Encoder Error	Status Not Functional Error

Table 171: SF_SafeMC_BR: SafeMC module status bits

2.7 State machine

The state machine shown is implemented on the SafeMC module.

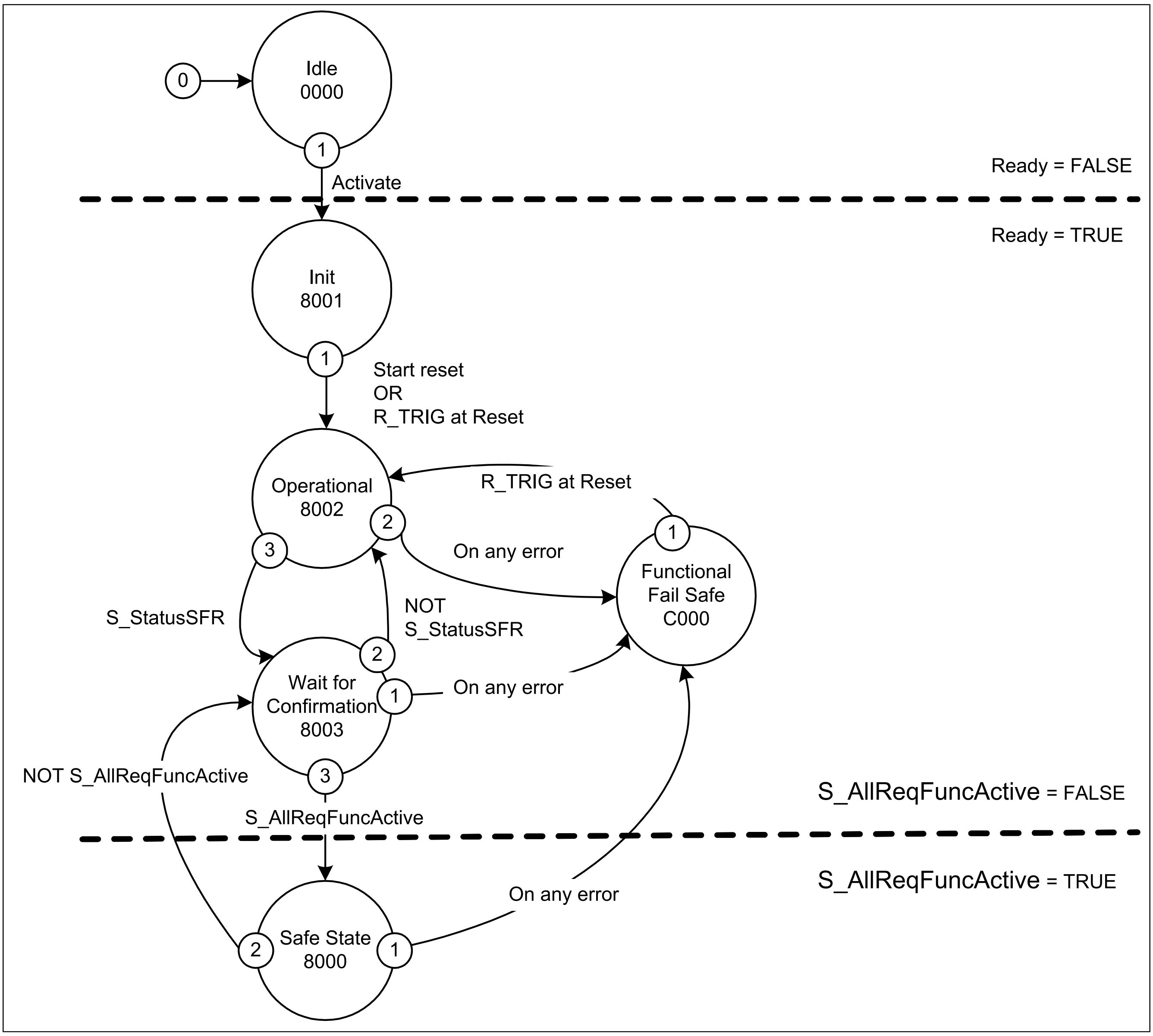


Figure 61: SF_SafeMC_BR_V2: State machine

The individual states are provided on the DiagCode output parameter. In this sense, the function block provides a representation of the SafeMC module's state machine.

2.8 Signal sequence diagram for the function block

A general signal sequence diagram of the function block cannot be specified because it depends on the safety functions that are selected or deselected.
The signal sequence diagrams for the individual safety functions are illustrated in section "Safety functions"!

3 SF_SafeMC_BR_V2

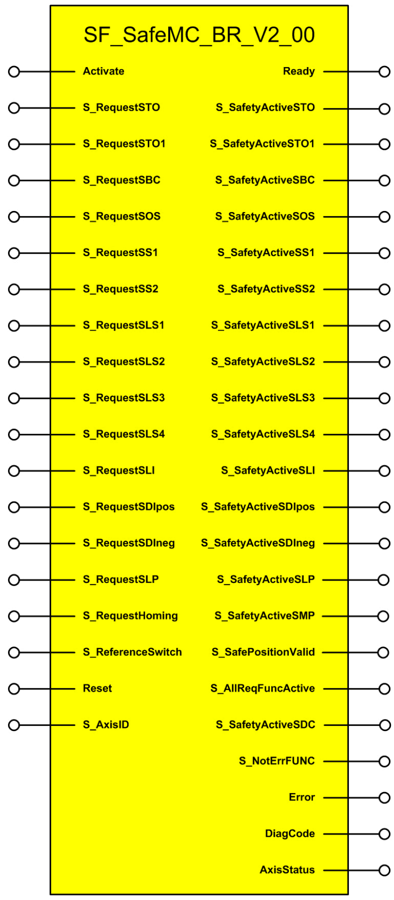


Figure 62: Function block SF_SafeMC_BR_V2

Information:

The function block SF_SafeMC_BR_V2_00 cannot be used without safety release 1.4.

If safety release 1.3 is being used, then SafeDESIGNER returns an error when compiling the safety application!

3.1 Formal Parameters of the Function Block

In the following, a "variable" may designate either a variable or a graphic connection.

Name	Type	Connection	Signal type [1)]	Initial value	Description/General Function
Activate	BOOL	Variable/ Constant	Status	FALSE	Function block activation (= 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 occurs at positive edge!
S_ReferenceSwitch	SAFEBOOL	Variable/ Constant	Status	SAFEFALSE	Safe input for a reference switch
Reset	BOOL	Variable	Edge	FALSE	Resets error messages and the SafeMC module once the cause of the error has been removed.
S_AxisID	SAFEINT	Constant	Status	-1	Assigns an axis to the function block

Table 172: SF_SafeMC_BR_V2: Brief overview of the input parameters

1) Evaluation of 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	Indication of function block activation
S_SafetyActiveSTO	SAFEBOOL	Variable	Status	SAFEFALSE	Safety function STO is active (= SAFETRUE)
S_SafetyActiveSTO1	SAFEBOOL	Variable	Status	SAFEFALSE	Safety function STO1 is active (= SAFETRUE)
S_SafetyActiveSBC	SAFEBOOL	Variable	Status	SAFEFALSE	Safety function SBC is active (= SAFETRUE)
S_SafetyActiveSOS	SAFEBOOL	Variable	Status	SAFEFALSE	Safety function SOS is active, no violation of a monitored limit (= SAFETRUE)
S_SafetyActiveSS1	SAFEBOOL	Variable	Status	SAFEFALSE	Safety function SS1 is active, deceleration monitor is finished, no violation of a monitored limit detected (= SAFETRUE)
S_SafetyActiveSS2	SAFEBOOL	Variable	Status	SAFEFALSE	Safety function SS2 is active, deceleration monitor is finished, no violation of a monitored limit detected (= SAFETRUE)
S_SafetyActiveSLS1	SAFEBOOL	Variable	Status	SAFEFALSE	Safety function SLS1 is active, deceleration monitor is finished, no violation of a monitored limit detected (= SAFETRUE)
S_SafetyActiveSLS2	SAFEBOOL	Variable	Status	SAFEFALSE	Safety function SLS2 is active, deceleration monitor is finished, no violation of a monitored limit detected (= SAFETRUE)
S_SafetyActiveSLS3	SAFEBOOL	Variable	Status	SAFEFALSE	Safety function SLS3 is active, deceleration monitor is finished, no violation of a monitored limit detected (= SAFETRUE)
S_SafetyActiveSLS4	SAFEBOOL	Variable	Status	SAFEFALSE	Safety function SLS4 is active, deceleration monitor is finished, no violation of a monitored limit detected (= SAFETRUE)
S_SafetyActiveSLI	SAFEBOOL	Variable	Status	SAFEFALSE	Safety function SLI is active, no violation of a monitored limit (= SAFETRUE)
S_SafetyActiveSDIpos	SAFEBOOL	Variable	Status	SAFEFALSE	Safety function SDIpos is active (= SAFETRUE)
S_SafetyActiveSDIneg	SAFEBOOL	Variable	Status	SAFEFALSE	Safety function SDIneg is active (= SAFETRUE)
S_SafetyActiveSLP	SAFEBOOL	Variable	Status	SAFEFALSE	Safety function SLP is active (= SAFETRUE)
S_SafetyActiveSMP	SAFEBOOL	Variable	Status	SAFEFALSE	Safety function SMP is 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 safety state (= SAFETRUE)
S_SafetyActiveSDC	SAFEBOOL	Variable	Status	SAFEFALSE	Deceleration monitor is active (= SAFETRUE)
S_NotErrFUNC	SAFEBOOL	Variable	Status	SAFEFALSE	SafeMC is 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 173: SF_SafeMC_BR_V2: Brief overview of the output parameters

1) Output of 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	Bool
WORD	Word	16	Binary number, hexadecimal number, unsigned decimal number
SAFEBOOL	Bit	1	Bool (signal source: safe device)
SAFEINT	Integer	16	Binary number, hexadecimal number, unsigned decimal number (signal source: safe device)

Table 174: SF_SafeMC_BR_V2: Formats of the data types used

You can link a safe signal with a standard input parameter. To do this, you need to use a function block for type conversion.

3.2 SafeMC 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 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). To do this, the relationship between a whole number 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 units-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). To do this, the relationship between a whole number 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	Default/ Inverse	Counting direction of the position and speed 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	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 rotation.	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	Selection of homing mode	Homing
Edge of reference switch	Positve/ Negative	Selection of switching edge for 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	Positve/ Negative	Selection of 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	Selection of 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. It is calculated starting at the configured reference switch edge and indicated as a % of the encoder reference system. A single rotation 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 by 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 One Channel STO function	STO1/configuration Functional Fail Safe
Ramp monitoring for SS1	Activated/ Deactivated	Activates ramp monitoring (in addition to the time) when the SS1 function is requested	SS1
Ramp monitoring for SS2	Activated/ Deactivated	Activates ramp monitoring (in addition to the time) when the SS2 function is activated	SS2
Ramp monitoring for SLS	Activated/ Deactivated	Activates ramp monitoring (in addition to the time) when the SLS function is activated	SLS
Early Limit Monitoring	Activated/ Deactivated	Monitoring of the deceleration ramp is prematurely terminated if the target limit is exceeded	SS1, SS2, SLS
Safe Maximum Position	Used/Unused	Activates the SMP safety function by configuration	SMP
Encoder Monitoring			
Encoder Position Monitoring	Activated/ Deactivated	Activates/deactivates the monitoring of the position lag error generated on the SafeMC module.	Monitors the encoder shaft breakage
Encoder Speed Monitoring	Activated/ Deactivated	Activates/deactivates the monitoring of the speed error generated on the SafeMC module.	Monitors the encoder shaft breakage

Table 175: SF_SafeMC_BR_V2: Module parameter

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 is frozen.	Monitors the 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 between STO1 and STO (and SBC) in the Functional Fail Safe state	Configuration
Delay time until the brake engages	[µs]	Delay time until the brake engages Switching of the second enable channel is delayed if STO1 and delayed STO and SBC are configured for Functional Fail Safe.	Configuration
Speed Limits			
Maximum speed limit for SMS	[units/s]	Speed limit of the maximum speed	SMS
Safe Speed Limit 1 for SLS	[units/s]	Speed Limit 1 for SLS	SLS
Safe Speed Limit 2 for SLS	[units/s]	Speed Limit 2 for SLS	SLS
Safe Speed Limit 3 for SLS	[units/s]	Speed Limit 3 for SLS	SLS
Safe Speed Limit 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 moveable 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	[µs]	Deceleration monitoring time for SS1	SS1
Ramp Monitoring Time for SS2	[µs]	Deceleration monitoring time for SS2	SS2
Ramp Monitoring Time for SLS1	[µs]	Deceleration monitoring time for SLS1	SLS1
Ramp Monitoring Time for SLS2	[µs]	Deceleration monitoring time for SLS2	SLS2
Ramp Monitoring Time for SLS3	[µs]	Deceleration monitoring time for SLS3	SLS3
Ramp Monitoring Time for SLS4	[µs]	Deceleration monitoring time for SLS4	SLS4
Safety Additional Parameters			
Delay time to start ramp monitoring (us)	[µs]	Delay time between request of ramp monitoring and start of monitoring	SS1, SS2, SLS
Delay time to start SDI (us)	[µs]	Delay time between request of SDI and activation of the safety function	SDI
Delay time to start SBC (us)	[µs]	Delay time between request of SBC and activation of the safety function	SBC
Delay time to start SLP (us)	[µs]	Delay time between request of SLP and start of monitoring	SLP
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	SS1, SS2, SLS
Encoder Monitoring Tolerances			
Encoder Monitoring Position Tolerance	[units]	Position lag error tolerance for encoder monitoring	Monitors the encoder shaft breakage
Encoder Monitoring Speed Tolerance	[units/s]	Speed error tolerance for encoder monitoring	Monitors the encoder shaft breakage

Table 175: SF_SafeMC_BR_V2: Module parameter

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 SafeMC module.

If multiple functions are active, then the lowest value for speed will always be monitored.

Information:

The following application rules must be followed in order to enable prioritization of the safety functions:

$\mathbf{LIM_{SOS} \leq LIM_{SLS4} \leq LIM_{SLS3} \leq LIM_{SLS2} \leq LIM_{SLS1} \leq LIM_{SMS} < NormSpeed}$

or

$\mathbf{LIM_{SMP,NEG} \leq LIM_{SLP,NEG} \leq LIM_{SLP,POS} \leq LIM_{SMP,POS}}$

If the application guideline is violated, then the SafeMC module changes to the Fail Safe state.

3.3 Integrated safety functions

The function block makes it easy to use the safety functions implemented on the SafeMC module.
Furthermore, the respective safety function is assigned to to a real axis by using the function block.

Information:

If a safety function is not used in the application, then the respective input variables should remain open.

Danger!

All of the safety functions that are used must be tested.
A function is considered to be used if the respective input variable is connected!

At least the activated input and the S_AxisID must be connected. Otherwise, the SafeMC module will not be operated by the SafeLOGIC. As a result, the pulse disabling and the motor holding brake output will be permanently set to 0 V, which means that the controller cannot be turned on.

The following functions are supported by the SafeMC module, safety release R1.4:

Safety function	Starting in safety release	EN ISO 13849-1	EN 61508/EN 62061	Safe encoder evaluation required
Safe Torque Off (STO)	R 1.3	Pl e	SIL 3	No
Safe Torque Off One Channel (STO1)	R 1.3	Pl d	SIL 2	No
Safe Operation Stop (SOS)	R 1.3	Pl d	SIL 2	Yes
Safe Stop 1 (SS1)	R 1.3	PL e (time monitored) Pl d	SIL 3 (time monitored) SIL 2	no (time monitored) Yes
Safe Stop 2 (SS2)	R 1.3	Pl d	SIL 2	Yes
Safely Limited Speed (SLS)	R 1.3	Pl d	SIL 2	Yes
Safe Maximum Speed (SMS)	R 1.3	Pl d	SIL 2	Yes
Safe Direction (SDI)	R 1.3	Pl d	SIL 2	Yes
Safely Limited Increment (SLI)	R 1.3	Pl d	SIL 2	Yes
Safe Brake Control (SBC)	R 1.3	Pl d	SIL 2	No
Safely Limited Position (SLP)	R 1.4	Pl d	SIL 2	Yes
Safe Maximum Position (SMP)	R 1.4	Pl d	SIL 2	Yes
Safe referencing	R 1.4	Pl d	SIL 2	Yes

Table 176: Safety functions and corresponding safety levels

3.3.1 Fail Safe state

If an error in the hardware or firmware occurs, then the safe inverter module changes to a non-acknowledgeable error state; the Fail Safe state. The log book entry in Automation Studio provides more detailed information about the pending error. This log book can also be evaluated in the standard application.
If there is a hardware defect, then the module must be replaced.

> **Note:**
>
> **The SafeMC modules cannot be exchanged! The SafeMC modules together with the inverter module form a single unit. In the event of an error, the entire inverter module must be replaced.**

However, the error can also have been caused by a configuration mistake. If this is the case, then the safe configuration must be checked and reloaded to the SafeLOGIC. This must then be followed by a PowerOff/PowerOn cycle to get the module back to the "Operational" state.

> **Danger!**
>
> **Safe pulse disabling is always active in Fail Safe state (i.e. torque and power are switched off on the motor). The motor holding brake output is always switched to 0 V in this state!**

> **Danger!**
>
> **Constantly lit LEDs "SE" indicate a fail safe state that cannot be acknowledged. 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 measures for repair are initiated after an error occurs as successive errors can result in dangerous situations.**

> **Danger!**
>
> **The motor holding brake is engaged in Fail Safe state. The motor holding brake will suffer mechanical wear if the drive is in motion just before the safe state. This must be considered when selecting and sizing the motor holding brake (E-stop capability).**

3.3.2 Functional Fail Safe state

If a monitored limit is exceeded or an encoder error occurs during operation, then the SafeMC module (as long as the safe encoder is required for the safety functions being used) changes to an acknowledgeable error state; the Functional Fail Safe state.
Information about the error can be found in the logbook entry in Automation Studio. This log book can also be evaluated in the functional application.

Danger!

The motor holding brake is engaged in Functional Fail Safe state. The motor holding brake will suffer mechanical wear if the drive is in motion just before the safe state. This must be considered when selecting and sizing the motor holding brake (E-stop capability).

Danger!

The error response time described in the manual affects the remnant movement in the event of error! This must be accounted for when planning the safety equipment (e.g. distances, monitored limits, etc.)

The following parameters are provided in SafeDESIGNER for configuring the Functional Fail Safe state:

Parameter	Unit	Description	Default value
General settings			
Channel selection for One Channel STO (STO1)	HighSide/LowSide	Selection of 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 between STO1 and STO (and SBC) in the Functional Fail Safe state	0
Delay time until the brake engages	[µs]	Delay time until the brake engages Switching of the second enable channel is delayed if STO1 and delayed STO and SBC are configured for Functional Fail Safe.	0

Table 177: Functional Fail Safe state configuration parameters

"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.

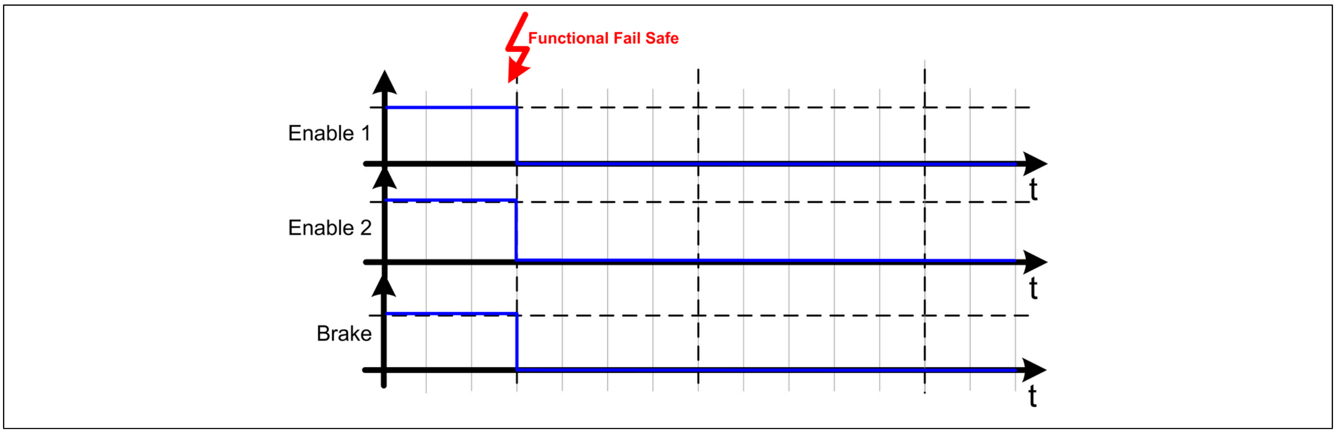


Figure 63: Functional Fail Safe - Configuration of STO

"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 configured time "Delay time for STO in Functional Fail Safe" ($T_{STO\ Delay}$) 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" ($T_{Brake\ engage}$) has expired.

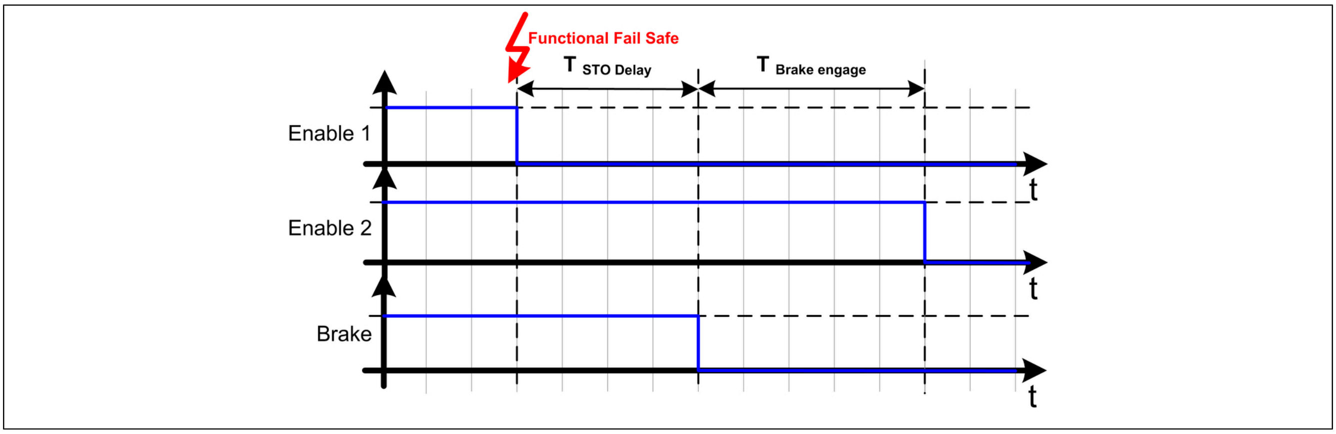


Figure 64: Functional Fail Safe - Configuration of STO1 and STO with time delay

This makes it possible for the drive to be decelerated via the short-circuit braking integrated in the ACOPOSmulti for the amount of time in which just one pulse disabling channel is active.
In this case, the time $T_{Brake\ engage}$ serves 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!

The short-circuit braking in the ACOPOSmulti is not suitable for safety purposes and can therefore only be used to protect the machine. If release of the motor energy could result in dangerous situations (e.g. with hanging loads), then a mechanical safeguard must also be installed.

3.3.3 Safe Torque Off, STO

STO is the fundamental safety function of the ACOPOSmulti with SafeMC, since it represents the "fail-safe" principle.
A request from the STO safety function activates safe pulse disabling and switches off the torque and power to the drive. The SafeMC module actively triggers safe pulse disabling.

Danger!

The STO request causes synchronized axes lose their synchronicity.

Danger!

In cases involving external forces (e.g. hanging loads), this can cause dangerous movement!
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!

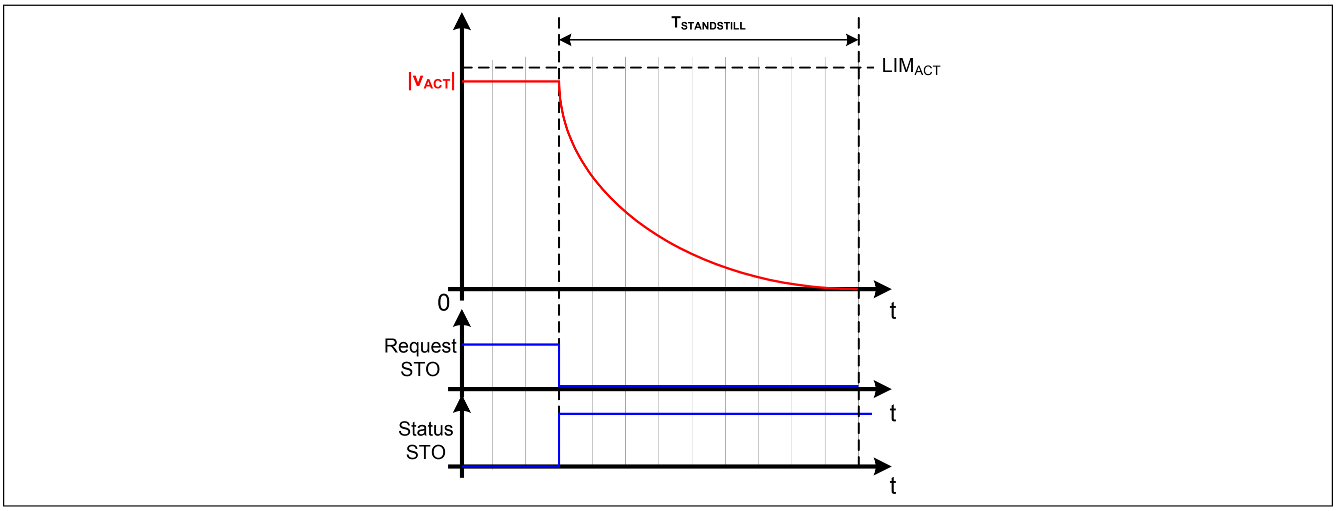


Figure 65: Safe Torque Off, STO

Information:

The functional safe state of the STO function has been achieved when the pulse disabling outputs are switched to 0 V. The respective bit is set once the functional safe state has been achieved.

Danger!

The drive will spin out if it is in motion at the time of the STO request. The resulting remnant movement and time $T_{STANDSTILL}$ 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 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 remnant movement and time $T_{STANDSTILL}$ determines the intervals between the safety features that must be maintained and therefore the size of the machine as well.

Information:

The safety function Safe Torque Off does not require safe encoder evaluation and can therefore also be used without a safe encoder.

Danger!

If the safety function STO is used in the safe application, then the ability to enable/disable it must be tested when commissioning the machine!

3.3.4 Single-channel Safe Torque Off, STO1

The safety function STO1 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 function has been achieved when the configured pulse disabling output is switched to 0 V.
The respective bit is set once the functional safe state has been achieved.

Parameter	Unit	Description	Default value
General settings			
Channel selection for One Channel STO (STO1)	HighSide/ LowSide	Selection of HighSide or LowSide IGBT in the One-ChannelSTO function	HighSide

Table 178: STO1 safety function parameters

Information:

The two-channel aspect is lost because either only the low side or only the high side of the pulse disabling is activated with STO1.
This results in a lower SIL and Performance Level!

Information:

The safety function Safe Torque Off, single-channel, does not require safe encoder evaluation and can therefore also be used without a safe encoder.

Danger!

If the safety function STO1 is used in the safe application, then the ability to enable/disable it must be tested when commissioning the machine!

3.3.5 Safe Brake Control, SBC

The SBC function is a safe (time delayed) output whose purpose is to safety-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.

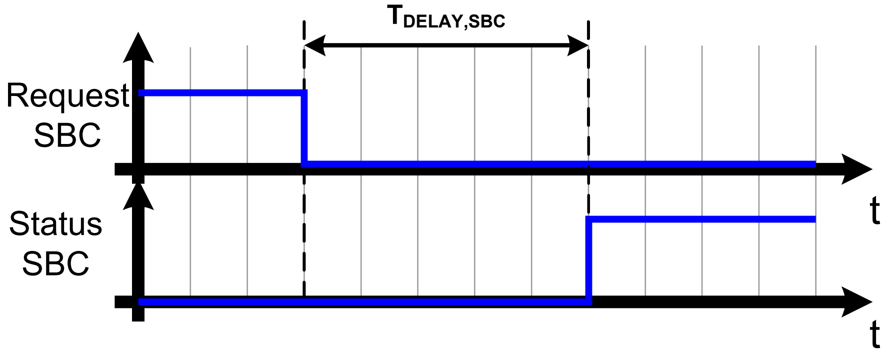


Figure 66: Safe Brake Control, SBC

Only the actuation of the motor holding brake output through the SafeMC module is safely evaluated with SIL 2.

The braking procedure will not be monitored for safety by the SafeMC module.

Information:

The functional safe state of the SBC function has been achieved when the safe motor holding brake ouptput has been switched to 0 V.
The respective bit is set once the functional safe state has been achieved.

The purpose of the delay time $T_{DELAY,SBC}$ is to compensate for the different runtimes of functional and safe applications.

Parameter	Unit	Description	Default value
Safety Additional Parameters			
Delay time to start SBC (us)	[µs]	Delay time between request of SBC and activation of the safety function	0

Table 179: SBC safety function parameters

Information:

The safety function Safe Brake Control does not require safe encoder evaluation and can therefore also be used without a safe encoder.

Danger!

If the safety function SBC is used in the safe application, then the ability to enable/disable it must be tested when commissioning the machine!

Information:

Functional errors will occur (e.g. 6029: Holding brake: Control signal on and output status off), if the holding is released by the standard application but the motor holding brake output is switched to 0 V by the SafeMC module.

3.3.6 Safe Operating Stop, SOS

When the SOS safety function is active, the safe stop of the drive is monitored. Pulse disabling is not controlled by the SafeMC module.
The drive can remain active and must be kept in standstill by the functional application.

Information:

The safety function Safe Operating Stop requires safe encoder evaluation of the speed and position. If the function is programmed in the safe application and if no safe encoder is detected or an encoder error is detected, then the SafeMC module immediately changes to the Functional Fail Safe state after the function block is activated!

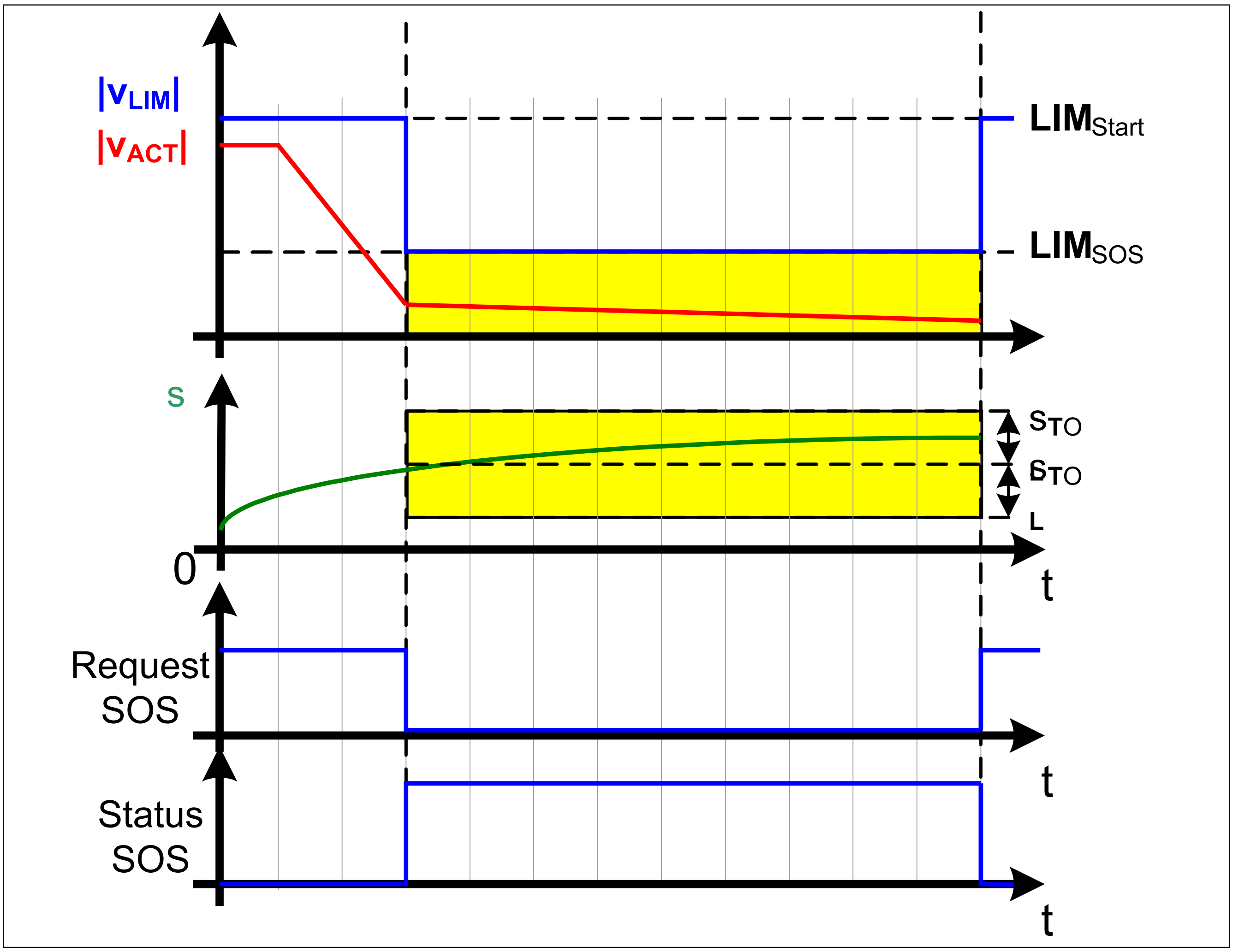


Figure 67: Safe Operating Stop, SOS

To prevent the axis from drifting, both the speed and position are monitored with standstill tolerance limits. The position window is established 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 the request is made, the standstill tolerance position window will be re-established, based on the current position.

Information:

The functional safe state of the SOS function has been achieved when the drive is stopped and the standstill is being monitored for safety.
The respective bit is set once the functional safe state has been achieved.

The standstill tolerances can be configured for each axis in SafeDESIGNER with the following 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 180: SOS safety function parameters

Danger!

In the event of an error, forward movement can occur during the error response time when monitoring the standstill tolerance window. Within this amount of time, the drive could accelerate to its maximum before spinning out.
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 a Functional Fail Safe error state which must be acknowledged. When an error occurs, a synchronous axis loses its synchronicity.

Danger!

If a standstill limit (position or speed) is violated, then the module changes to the error state "Functional Fail Safe", which must be confirmed. Torque and power to the drive are switched off, causing the drive to spin out! An error will cause a synchronous axis to lose its synchronicity. This will reset the output on the function block S_NotErrFUNC!

Danger!

If the safety function SOS is used in the safe application, then the ability to enable/disable it must be tested when commissioning the machine!
The configured limits must be violated with the function enabled and the error reaction must be tested accordingly!

Danger!

In cases involving external forces (e.g. hanging loads), this can cause dangerous movement!
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!

3.3.7 Safe Stop 1, SS1

When there is a request from the SS1 safety function, after the ramp delay, the deceleration process is monitored until standstill. After decelerating, safe pulse disabling is activated and switches off the torque and power to the drive.

Danger!

Synchronous axes lose their synchronicity when SS1 is in its safe state.

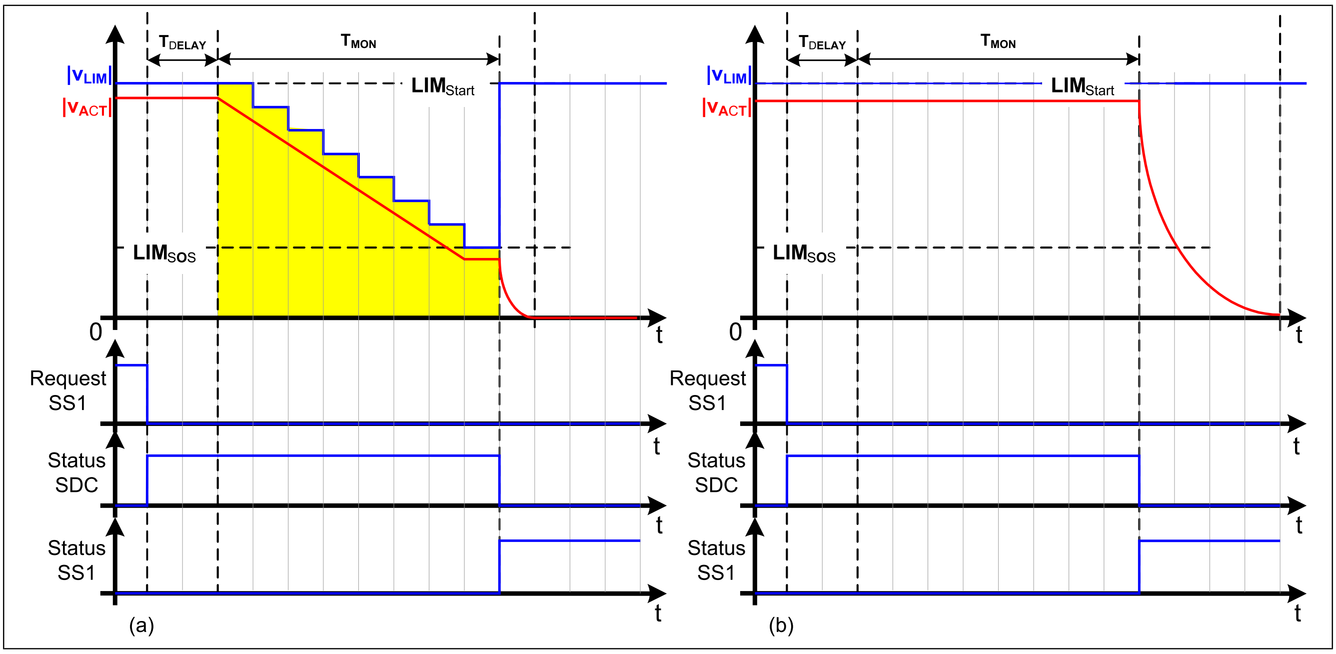


Figure 68: Safe Stop 1, SS1

The deceleration itself is controlled by the functional application, which is not safety-oriented.

The purpose of the ramp delay time T_{DELAY} (parameter "*Delay time to start ramp monitoring (µs)*") is to compensate for the different runtimes of functional and safe applications.

Information:

The functional safe state of the SS1 function has been achieved when the pulse disabling outputs are switched to 0 V. The respective bit is set once the functional safe state has been achieved.

Danger!

In cases involving external forces (e.g. hanging loads), this can cause dangerous movement!
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 following parameters in SafeDESIGNER affect the behavior of the safety function:

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 SS1	Activated/ Deactivated	Activates ramp monitoring (in addition to the time) when the SS1 function is requested	Activated
Early Limit Monitoring	Activated/ Deactivated	Monitoring of the deceleration ramp is prematurely terminated if the value drops below the lower limit for a defined amount of time	Deactivated
Safety Ramp Monitoring Times			
Ramp Monitoring Time for SS1 (us)	[µs]	Deceleration monitoring time for SS1	0
Safety Additional Parameters			
Delay time to start ramp monitoring (us)	[µs]	Delay time between request of ramp monitoring and 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 181: SS1 safety function parameters

Depending on the request for the safety function and its configuration, either only the deceleration time T_{MON} - see figure (b) - or also the deceleration ramp - see figure (a) - can be monitored.
If the monitoring limits are violated during deceleration, then an error state that must be confirmed is entered.

The parameter "*Ramp monitoring for SS1*" configures the behavior of the delay monitor.

SS1 - Stopping procedure with ramp-based monitoring

"Ramp monitoring for SS1" = Activated

With this configuration, the configurable deceleration ramp is monitored in addition to time 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 stopping procedure must be adjusted to the dangerous situation by the functional application.

The slope of the monitoring ramp can be set using the parameter, "*Deceleration Ramp*".

A timer is started when the safety function is requested. Monitoring of the deceleration ramp begins after the delay time for the request "*Delay time to start ramp monitoring (µs)*". 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 if 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.

Early activation of the safety state can be configured using the parameter "*Early Limit Monitoring*" = Activated. 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 is violated during monitoring of the deceleration procedure, then the drive will immediately switch to the acknowledgeable error state Functional Fail Safe.

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 safe application and if no safe encoder is detected or an encoder error is detected, then the SafeMC module immediately changes to the Functional Fail Safe state after the function block is activated!

Danger!

**If safe pulse disabling is on (spin-out) and the safety function is in a functionally safe state, the maximum speed at the end of the deceleration ramp must be used to calculate the remaining 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 remaining distance do not present any danger!**

Danger!

**If the monitored ramp is exceeded, the remaining 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 remaining distance do not present any danger!**

Danger!

**If the safety function SS1 with ramp monitoring is used in the safe application, then the ability to enable/disable it must be tested when commissioning the machine!
The test should include at least one violation of the monitored ramp and the error reaction must be tested accordingly!**

SS1 - Stopping procedure with time-monitoring

"Ramp monitoring for SS1" = Deactivated

This configuration provides true time-monitoring of the delay.
A timer is started when the safety function is requested. Within this time frame, the drive must implement a stopping procedure that is appropriate for the respective dangerous situation using the standard application.
After the delay time for the request, "*Delay time to start ramp monitoring (µs)*" and the monitoring time, "*Ramp Monitoring Time for SS1 (µs)*" have expired, safe pulse disabling is activated and torque is shutoff on the drive.

Information:

With this configuration of the Safe Stop 1 safety function, only the time frame is monitored.
No speed or position window is monitored.
This is why the function can also be used in this configuration without safe encoder!

Danger!

If safe pulse disabling is on (spin-out), the maximum speed after the time frame has expired must be used to calculate the remaining distance!
The drive can move at its physically maximum 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 remaining distance do not present any danger!

Danger!

If the safety function SS1 with true time-monitoring is used in the safe application, then the ability to enable/disable it must be tested when commissioning the machine!
The drive should be accelerated to its maximum during the monitored time frame and the error response tested accordingly!

3.3.8 Safe Stop 2, SS2

With SS2, after the ramp delay, the deceleration process is monitored until standstill. Then the drive must be kept at standstill by the functional application. Like with SOS, this standstill is monitored by the SafeMC module according to the configured tolerance window LIM_{SOS} and s_{TOL}.

The delay itself must be generated by the non-safety-oriented, functional application by halting the drive in response to the dangerous situation.

Information:

The safety function Safe Stop 2 requires safe encoder evaluation of the speed and position.
If the function is programmed in the safe application and if no safe encoder is detected or an encoder error is detected, then the SafeMC module immediately changes to the Functional Fail Safe state after the function block is activated!

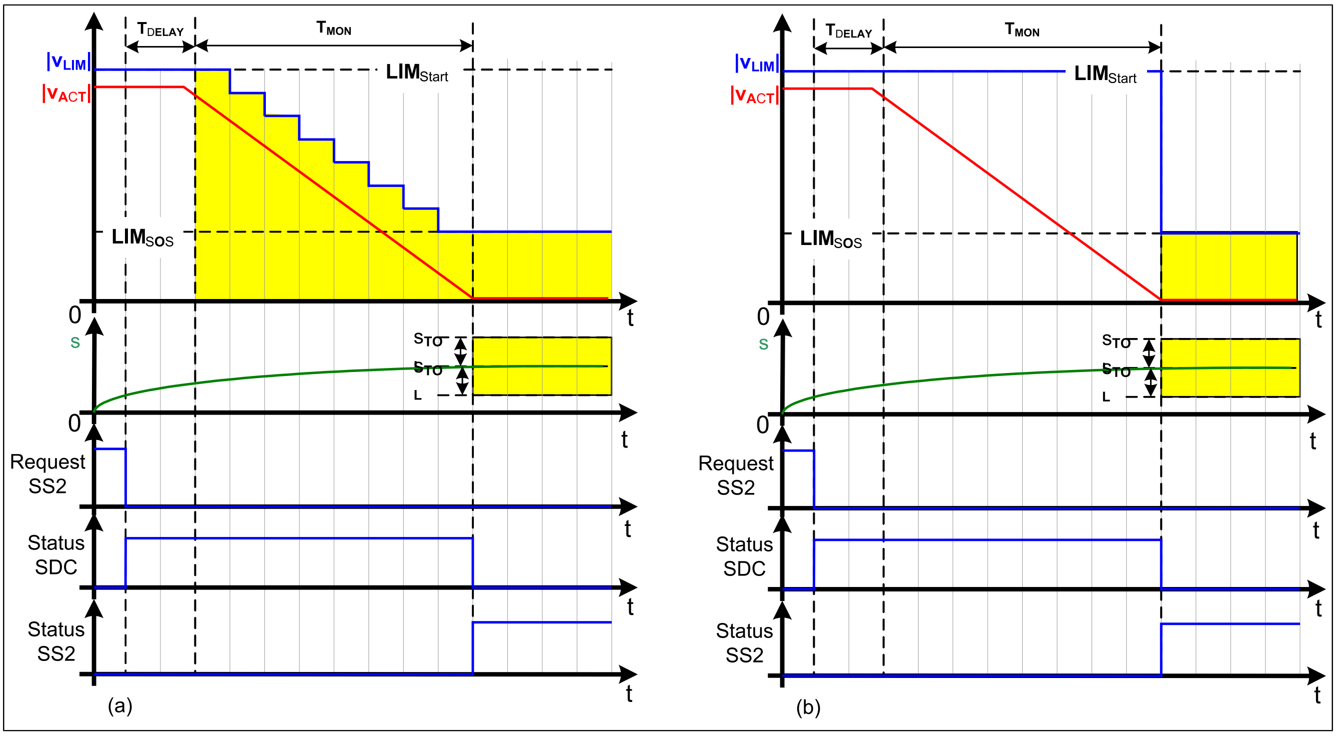


Figure 69: Safe Stop 2, SS2

Danger!

If a standstill limit (position or speed) is violated, then the module changes to the error state "Functional Fail Safe", which must be confirmed. Torque and power to the drive are switched off, causing the drive to spin out! An error will cause a synchronous axis to lose its synchronicity.
This will reset the output on the function block S_NotErrFUNC!

Danger!

In cases involving external forces (e.g. hanging loads), this can cause dangerous movement!
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 T_{DELAY} (parameter "*Delay time to start ramp monitoring (µs)*") is to compensate for the different runtimes of functional and safe applications.

Information:

The functional safe state of the SS2 function has been achieved when the drive is stopped and the standstill is being monitored for safety.
The respective bit is set once the functional safe state has been achieved.

The following parameters in SafeDESIGNER affect the behavior of the safety function:

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 SS2	Activated/ Deactivated	Activates ramp monitoring (in addition to the time) when the SS2 function is activated	Activated
Early Limit Monitoring	Activated/ Deactivated	Monitoring of the deceleration ramp is prematurely terminated if the value drops 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 monitoring time for SS2	0
Safety Additional Parameters			
Delay time to start ramp monitoring (us)	[µs]	Delay time between request of ramp monitoring and 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 182: SS2 safety function parameters

Similar to SS1, either only the deceleration time T_{MON} - see figure 6 (b) - or also the deceleration ramp - see figure 6 (a) - can be monitored depending on the requirements for the safety function.

The parameter "*Ramp monitoring for SS2*" configures the behavior of the delay monitor.

SS2 - Stopping procedure with ramp-based monitoring

"Ramp monitoring for SS2" = Activated

With this configuration, the configurable deceleration ramp is monitored in addition to time 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 stopping procedure must be adjusted to the dangerous situation by the functional application.

The slope of the monitoring ramp can be set using the parameter, "*Deceleration Ramp*".

A timer is started when the safety function is requested. Monitoring of the deceleration ramp begins after the delay time for the request "*Delay time to start ramp monitoring (µs)*". 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 if 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.

Early activation of the safety state can be configured using the parameter "*Early Limit Monitoring*" = Activated. 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 error state Functional Fail Safe.

Danger!

If the monitored ramp or standstill tolerance window is exceeded, the remaining 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 remaining 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. Within this amount of time, the drive could accelerate to its maximum before spinning out.
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 safety function SS2 with ramp monitoring is used in the safe application, then the ability to enable/disable it must be tested when commissioning the machine!
The test should contain at least one violation of the monitored ramp and standstill tolerance window. The error response must be tested accordingly!

SS2 - Stopping procedure with time-monitoring

"Ramp monitoring for SS2" = Deactivated

This configuration provides true time-monitoring of the delay.
A timer is started when the safety function is requested. Within this time frame, the drive must implement a stopping procedure that is appropriate for the respective dangerous situation using the functional application.

After the delay time for the request, "*Delay time to start ramp monitoring (µs)*" and the monitoring time, "*Ramp Monitoring Time for SS2 (µs)*" have expired, the standstill tolerance window will be monitored safely.

Danger!

If the standstill tolerance window is exceeded, the remaining 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 remaining 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. Within this amount of time, the drive could accelerate to its maximum before spinning out.
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 safety function SS2 with time-monitored stopping procedure is used in the safe application, then the ability to enable/disable it must be tested when commissioning the machine!
The test should contain at least one violation of the standstill tolerance window. The error response must be tested accordingly!

3.3.9 Safely Limited Speed, SLS

The safety function SLS is used to monitor a specified speed limit LIM_{SLSx} (parameter "*Safe Speedlimit 1, 2, 3, 4 for SLS (units/s)*"). Depending on the application, deceleration can also be monitored until the limit is reached.

Four different speed limits can be monitored on the SafeMC 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 contains the four different inputs "S_RequestSLSx", [x = 1..4].

The standard (non safety-oriented) application must use a closed-loop control appropriate for the level of danger to decelerate the movement and then maintain the respective speed limit.

Information:

The safety function SLS requires safe encoder evaluation of the speed. If the function is programmed in the safe application and if no safe encoder is detected or an encoder error is detected, then the SafeMC module immediately changes to the Functional Fail Safe state after the function block is activated!

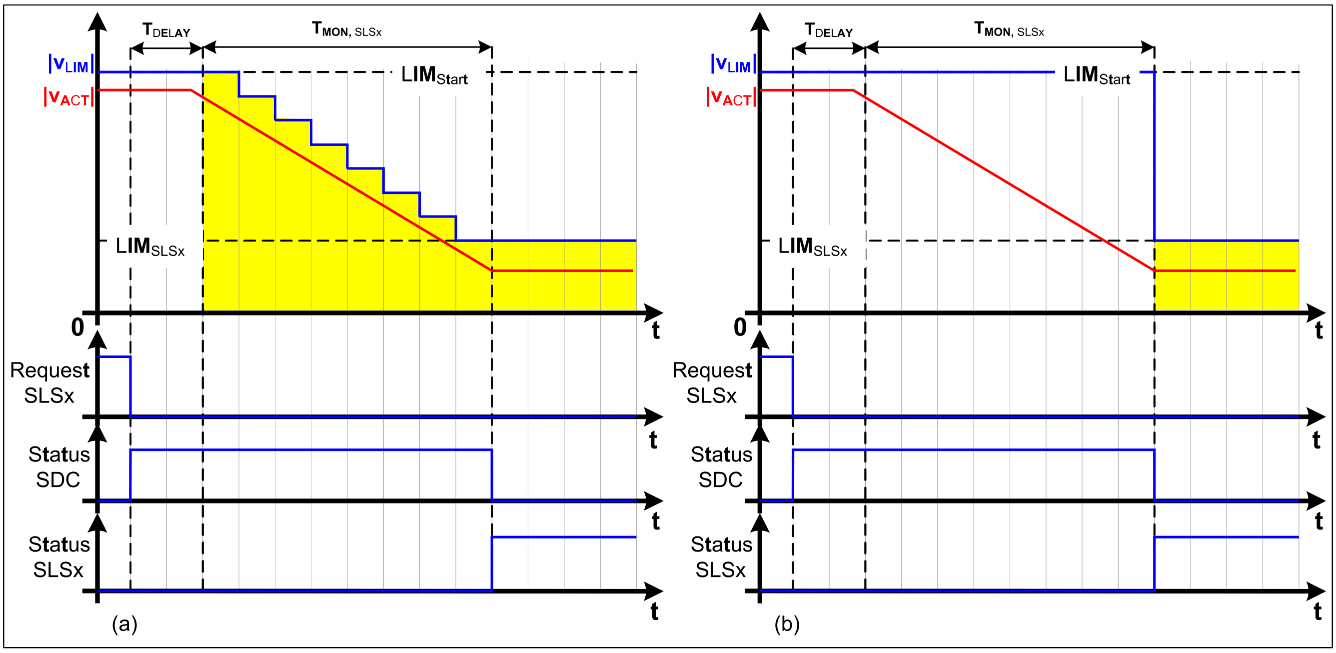


Figure 70: Safely Limited Speed, SLS

Danger!

In cases involving external forces (e.g. hanging loads), this can cause dangerous movement!
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 changes to the error state "Functional Fail Safe", which must be confirmed.
Torque and power to the drive are switched off, causing the drive to spin out!
An error will cause a synchronous axis to lose its synchronicity! This will reset the output on the function block S_NotErrFUNC!

The purpose of the ramp delay time T_{DELAY} is to compensate for the different runtimes of functional and safe applications.

If the delay time $T_{mon,\ SLS}$ is set to 0, then the speed limit will be monitored right after the request is made for the safety function.

Information:

The functional safe state of the SLS function has been achieved if the drive has not exceeded a defined speed limit and this limit is being monitored for safety. The respective bit is set once the functional safe state has been achieved.

The following parameters in SafeDESIGNER affect the behavior of the safety function:

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 monitoring (in addition to the time) when the SLS function is activated	Activated
Early Limit Monitoring	Activated/ Deactivated	Monitoring of the deceleration ramp is prematurely terminated if the value drops below the lower limit for a defined amount of time	Deactivated
Speed Limits			
Safe Speed-limit 1 for SLS	[units/s]	Speed Limit 1 for SLS	0
Safe Speed-limit 2 for SLS	[units/s]	Speed Limit 2 for SLS	0
Safe Speed-limit 3 for SLS	[units/s]	Speed Limit 3 for SLS	0
Safe Speed-limit 4 for SLS	[units/s]	Speed Limit 4 for SLS	0
Safety Ramp Monitoring Times			
Ramp Monitoring Time for SLS1 (us)	[µs]	Deceleration monitoring time for SLS1	0
Ramp Monitoring Time for SLS2 (us)	[µs]	Deceleration monitoring time for SLS2	0
Ramp Monitoring Time for SLS3 (us)	[µs]	Deceleration monitoring time for SLS3	0
Ramp Monitoring Time for SLS4 (us)	[µs]	Deceleration monitoring time for SLS4	0
Safety Additional Parameters			
Delay time to start ramp monitoring (us)	[µs]	Delay time between request of ramp monitoring and 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 183: SLS safety function parameters

Like with SS1 and SS2, the deceleration ramp monitoring can be adjusted according to the requirements, so that either only the deceleration time $T_{MON,\ SLSx}$ - see figure 7 (b) - or both the deceleration time and the deceleration ramp - see figure 7 (a) - are monitored.
The parameter "*Ramp monitoring for SLS*" configures the behavior of the delay monitor.

SLS - Stopping procedure with ramp-based monitoring

"Ramp monitoring for SLS" = Activated

With this configuration, the configurable deceleration ramp is monitored in addition to time 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 parameter, "*Deceleration Ramp*".

A timer is started when the safety function is requested. Monitoring of the deceleration ramp begins after the delay time for the request "*Delay time to start ramp monitoring (µs)*". The monitored ramp always begins at the currently monitored limit and is calculated using the configured slope.
If the monitoring ramp reaches the respective speed limit "*Safe Speedlimit 1, 2, 3, 4 for SLS (units/s)*" or if the monitoring time "*Ramp Monitoring Time for SLS1, 2, 3,4 (µs)*" has expired, then the status of the safety function will be set and the enabled speed limit monitored.

Early activation of the safety state can be configured using the parameter "*Early Limit Monitoring*" = Activated. 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!

If the monitored ramp or the enabled safe speed is exceeded, the remaining 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 remaining 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.
Within this amount of time, the drive could accelerate to its maximum before spinning out.
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 safe application, then the ability to enable/disable it must be tested when commissioning the machine!
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!

SLS - Stopping procedure with time-monitoring

"Ramp monitoring for SLS" = Deactivated

This configuration provides true time-monitoring of the delay.
A timer is started when the safety function is requested. Within this time frame, the drive must implement a stopping procedure that is appropriate for the respective dangerous situation using the functional application. After the delay time for the request, "*Delay time to start ramp monitoring (µs)*" and the monitoring time, "*Ramp Monitoring Time for SLS1, 2, 3, 4 (µs)*" have expired, the speed limit will be monitored safely.

Danger!

If the speed limit is exceeded, the remaining 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 remaining 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.
Within this amount of time, the drive could accelerate to its maximum before spinning out.
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 safe application, then the ability to enable/disable it must be tested when commissioning the machine!
The test should contain at least one violation of each speed limit being used.
The error response must be tested accordingly!

3.3.10 Safe Maximum Speed, SMS

The difference between SMS and SLS is that SMS cannot be actively initiated. It is either activated (parameter "*Safe Maximum Speed*" = Used) or deactivated (parameter "*Safe Maximum Speed*" = Unused) in the configuration.

When activated, the current speed is constantly monitored according to a defined limit (parameter "*Safe Maximum Speed (units/s)*").

Information:

The safety function SMS requires safe encoder evaluation of the speed.
If the function is programmed in the safe application and if no safe encoder is detected or an encoder error is detected, then the SafeMC module immediately changes to the Functional Fail Safe state after the function block is activated!

The following parameters in SafeDESIGNER affect the behavior of the safety function:

Parameter	Unit	Description	Default value
General settings			
Safe Maximum Speed	Used / Unused	SMS safety function activated or deactivated	Used
Speed Limits			
Maximum speed limit for SMS	[units/s]	Speed limit of the maximum speed	0

Table 184: SMS safety function parameters

Danger!

If the monitored speed limit is exceeded, the remaining distance must be calculated based on the error response time.
It must be ensured that the spin-out movement and remaining 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.
Within this amount of time, the drive could accelerate to its maximum before spinning out. 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 SMS is used in the safe application, then it must be tested when commissioning the machine!
The configured limit must be exceeded! The error response must be tested accordingly!

Danger!

In cases involving external forces (e.g. hanging loads), this can cause dangerous movement!
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!

3.3.11 Safely Limited Increment, SLI

With the SLI safety function, the movement is monitored for a defined number of increments (parameter "*Safe Increments (units)*").

Information:

The safety function SLI requires safe encoder evaluation of the speed and position.
If the function is programmed in the safe application and if no safe encoder is detected or an encoder error is detected, then the SafeMC module immediately changes to the Functional Fail Safe state after the function block is activated!

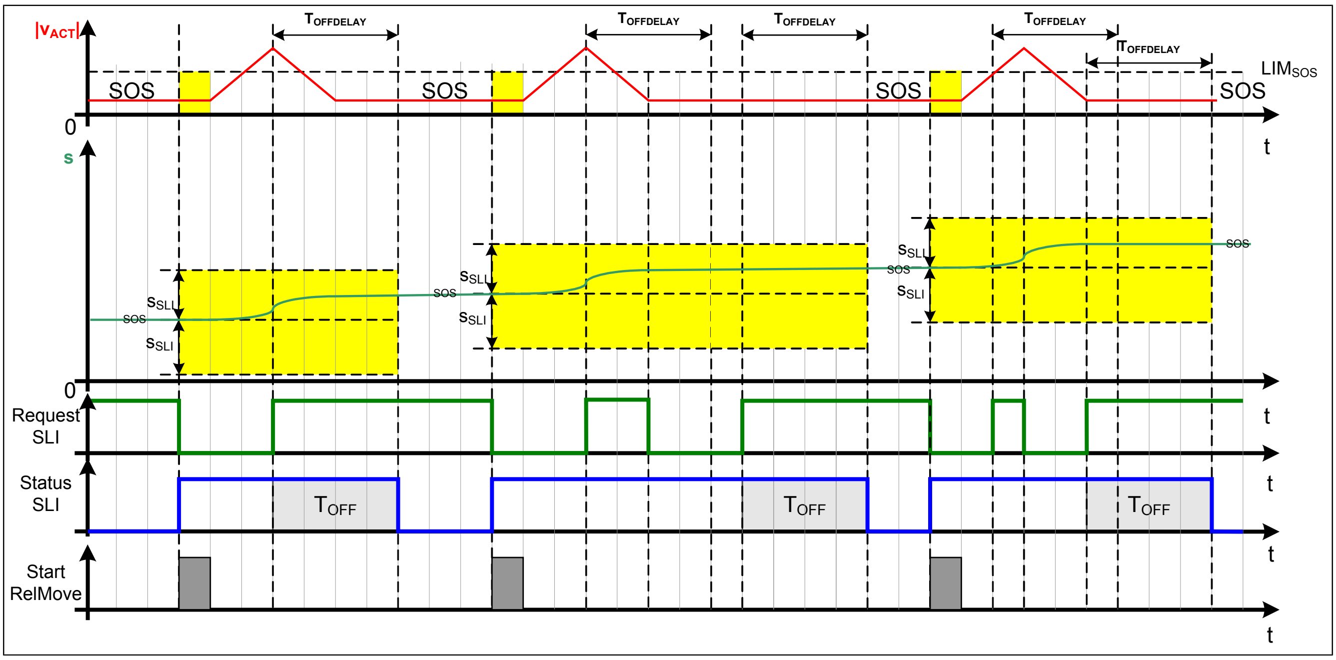


Figure 71: Safely Limited Increment, SLI

Information:

The SLI safety function is only effective when used in combination with at least a second safety function. This could be one of the safety functions such as SOS, SS2, or SLS.

Information:

The functional safe state of the SLI function has been achieved if the drive has not exceeded a defined increment size and this limit is being monitored for safety.
The respective bit is set once the functional safe state has been achieved.

The following parameters in SafeDESIGNER affect the behavior of the safety function:

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 moveable increments when SLI is active	0
SLI OFF Delay	[µs]	Switch off delay of SLI	0

Table 185: SLI safety function parameters

The safe axis must be stopped when the function is activated. To do this, the speed is monitored for adhering to the speed standstill tolerance (parameter "*Speed Tolerance (units /s)*").

A position window is established, which is monitored safely. This position window depends on the configured safe increment size (parameter "*Safe Increments (units)*"). The functional application must guarantee that this position window is not exceeded.

After the safety function is deactivated, the monitor remains active only for the configured time T_{OFF} (parameter "*SLI Off Delay (µs)*". This prevents continuous movement caused by constant inching!

Danger!

If a speed limit for requesting the function or if the position window is violated, then the module changes to the error state "Functional Fail Safe", which must be confirmed.
Torque and power to the drive are switched off, causing the drive to spin out! An error will cause a synchronous axis to lose its synchronicity.
This will reset the output on the function block S_NotErrFUNC!

Danger!

In cases involving external forces (e.g. hanging loads), this can cause dangerous movement!
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.
Within this amount of time, the drive could accelerate to its maximum before spinning out.
The resulting remaining distance must be accounted for when configuring the permissible increments and must not present any danger.
The dangerous movement must be determined by a risk analysis.

Danger!

If the safety function SLI is used in the safe application, then the ability to enable/disable it must be tested when commissioning the machine!
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!

3.3.12 Safe Direction, SDI

The SDI safety function monitors the defined direction of movement.

Either the positive or the negative direction can be monitored. The two inputs *"S_RequestSDIpos"* and *"S_RequestSDIneg"* provided on the function block can be used for this purpose.

Information:

The safety function SDI requires safe encoder evaluation of the position.
If the function is programmed in the safe application and if no safe encoder is detected or an encoder error is detected, then the SafeMC module immediately changes to the Functional Fail Safe state after the function block is activated!

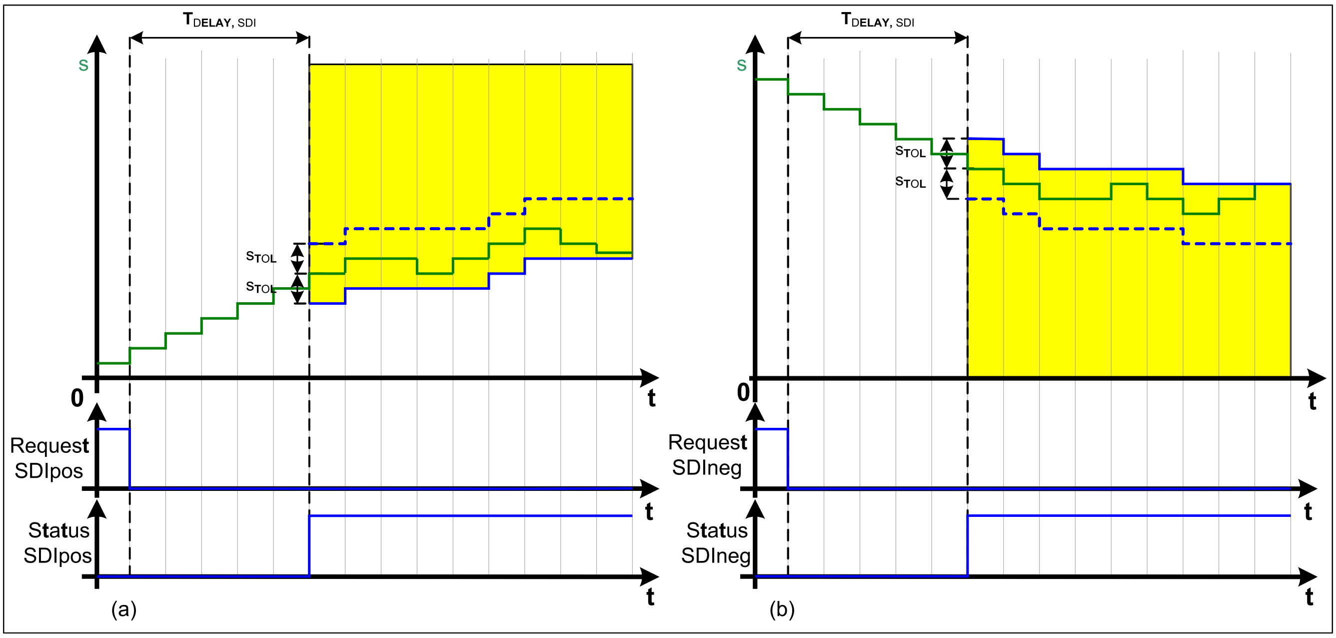


Figure 72: Safe Direction, SDI

Information:

The safe direction 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 function has been achieved if the drive has not violated a defined direction of movement and this direction of movement is being monitored for safety.
The respective bit is set once the functional safe state has been achieved.

The following parameters in SafeDESIGNER affect the behavior of the safety function:

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 request of SDI and activation of the safety function	0

Table 186: SDI safety function parameters

The purpose of the delay time $T_{DELAY,SDI}$ (parameter "*Delay time to start SDI (µs)*") is to compensate for the different runtimes of functional and safe applications.

When monitoring the direction of movement, then standstill tolerance s_{TOL} (parameter "*Position Tolerance (units)*") is not permitted to be exceeded in the forbidden direction of movement. When moving in the permitted direction of movement, the position pointer moves along like a slave pointer.

Danger!

If the safe direction of movement is violated, then the module changes to the error state "Functional Fail Safe", which must be confirmed. Torque and power to the drive are switched off, causing the drive to spin out!
An error will cause a synchronous axis to lose its synchronicity!
This will reset the output on the function block S_NotErrFUNC!

Danger!

In cases involving external forces (e.g. hanging loads), this can cause dangerous movement!
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.
Within this amount of time, the drive could accelerate to its maximum before spinning out. The resulting remaining distance must be accounted for 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 safety function SDI is used in the safe application, then the ability to enable/disable each of the directions of movement that are being used must be tested 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!

3.3.13 Safe referencing

Note:

The safe homing safety function is only available in safety release R1.4 and higher!

The safety function "safe homing" is used to establish a reference between the encoder position and the machine position.

Depending on the homing mode, it might be necessary for the drive to performing a homing procedure. A reference 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

Information:

Safe homing requires safe evaluation of the position.
If the function is programmed in the safe application and if no safe encoder is detected or an encoder error is detected, then the SafeMC module immediately changes to the Fail Safe state after the function block is activated! The Fail Safe state can only be exited by powering off and then on again!

A positive edge on the control bit *S_RequestHoming* will start safe homing and simultaneously reset the status bit *S_SafePositionValid*.
As soon as the homing procedure is completed, the status bit *S_SafePositionValid* will be set and the control bit *S_RequestHoming* must be reset.
The homing procedure must be complete within the monitoring time $T_{MON,REF}$ (parameter "*Homing Monitoring Time (µs)*"), or else the SafeMC module will change to the Functional Fail Safe state.

The homing procedure will be aborted if the control bit *S_RequestHoming* is reset before the procedure is completed.

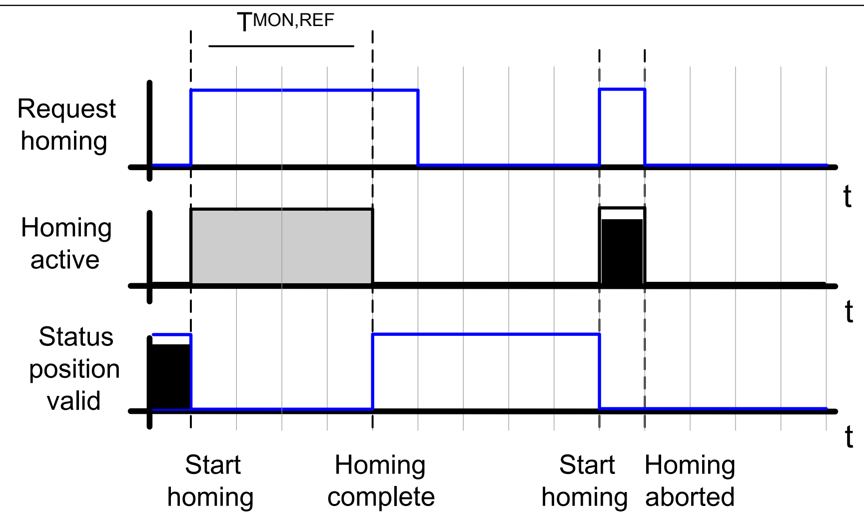


Figure 73: Safe homing

Information:

The safe homing function is a pre-requisite for the safety functions SLP and SMP and for using the safe position. The status S_SafePositionValid will remain set to SAFEFALSE until safe homing has been performed!

The following parameters in SafeDESIGNER affect the behavior of the safety function:

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	Selection of homing mode	Directly
Edge of reference switch	Positve/ Negative	Selection of switching edge for 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.	Positive
Trigger direction	Positve/ Negative	Selection of 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	Selection of whether or not to use a reference pulse for homing	Not Used
Blocking distance (% encoder reference system)	%	Distance within which evaluation of the reference pulse will be suppressed. It is calculated starting at the configured reference switch edge and indicated as a % of the encoder reference system. A single rotation is used as the encoder reference system for rotary encoders.	0

Table 187: Parameters for the "safe homing" safety function

Danger!

If an error occurs during homing procedure, then the module changes to the error state "Functional Fail Safe", which must be confirmed.
The function block output *S_NotErrFUNC* is reset and the drive becomes torque-free and force-free, causing it to spin out!
An error will cause a synchronous axis to lose its synchronicity.

Danger!

If the safe position is used in SafeDESIGNER, then the PositionValid output of the SafeMC_Position 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 usage, then the axis can be referenced using the Direct mode.

Direct mode

The mode Direct is used if the current position of the axis is known and has only to be applied to the SafeMC module.

The following scenario is an example of how this mode can be used:

- A functional homing procedure is initially carried out on the ACOPOS
- It then moves to a specified position
- If the positioning is correct, the operator uses a safe button for confirmation → a safe homing procedure is initiated internally with Direct mode

When referencing with Direct mode, the actual position of the axis is set to the value specified in the parameter "*Home position or home offset*" immediately after the homing command (positive edge on the input *S_RequestHoming*).

The input *S_ReferenceSwitch* will not be evaluated.

The following parameters in SafeDESIGNER directly affect the behavior of the safety function:

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	Selection of homing mode	Directly
Reference pulse	Used/ Not Used	Selection of whether or not to use a reference pulse for homing	Not Used
General settings			
Safe Maximum Position	Used / Unused	Activates the SMP safety function by 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
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 188: Parameters for the "safe homing" safety function - Direct mode

Information:

The axis must be at standstill when the request is made.
The values configured under "Safety Standstill and Direction Tolerances" are monitored to this regard.
If the standstill tolerances are violated, then the module changes to the error state "Functional Fail Safe", which must be confirmed. The function block output *S_NotErrFUNC* is reset and the drive becomes torque-free and force-free, causing it to spin out!

Information:

A reference pulse must not be used in Direct mode!
If a reference pulse is enabled ("*Reference pulse*" = Used), then the system will enter Fail Safe state when checking the configuration during startup.
The Fail Safe state can only be exited by powering off/on and changing the safe application!

Information:

If Safe Maximum Position has been enabled in the configuration (Parameter "*Safe Maximum Position*" = Used), then the value configured on the parameter "*Home position or home offset*" must be within the permissible SMP window (parameters "*Safe Lower Position Limit for SMP (units)*" and "*Safe Upper Position Limit for SMP (units)*").
If this is not the case, then the system will enter Fail Safe state when checking the configuration during startup.
The Fail Safe state can only be exited by powering off/on and changing the safe application!

Danger!

In cases involving external forces (e.g. hanging loads), this can cause dangerous movement!
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!

Reference Switch mode

The mode "Reference Switch" correlates with the referencing modes "Switch Gate", "Abs Switch" and "End Switch" on the ACOPOSmulti.

Information:

If the reference switch input "*S_ReferenceSwitch*" is not wired on the function block, then the SafeMC module will change to Fail Safe state.
The Fail Safe state can only be exited by powering off/on and changing the safe application!

Depending on the configuration, the ACOPOSmulti will pass over the reference switch/limit switch multiple times.

Danger!

The reference switch/limit switch is part of the safety function and must therefore be accounted for in the risk analysis.

Use a debounced, safety-oriented position switch!

The machine manufacturer is responsible for implementing a suitable switch!

After the homing command (positive edge on the input *S_RequestHoming*), the SafeMC module then uses the home switch edge that matches the configuration "*Edge of reference switch*" and "*Trigger direction*", as long as this is passed over below the "*Max Trigger Speed*".
The home switch edge will be ignored if the reference switch is passed over at a speed higher than the "*Max Trigger Speed*".

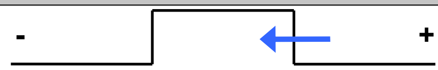
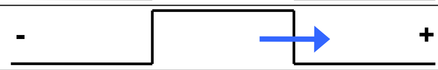
Configuration	Reference switch evaluation
Edge of reference switch = Negative Trigger direction = Negative	
Edge of reference switch = Positive Trigger direction = Negative	
Edge of reference switch = Negative Trigger direction = Positive	
Edge of reference switch = Positive Trigger direction = Positive	

Table 189: Selecting the home switch edge

Information:

After the homing command is made, the homing procedure must be completed within the configured time "*Homing Monitoring Time (µs)*". Otherwise, the module will change to the acknowledgeable error state "Functional Fail Safe".
The function block output *S_NotErrFUNC* is reset and the torque and power to the drive are switched off, causing it to spin out!
An error will cause a synchronous axis to lose its synchronicity.

The following parameters in SafeDESIGNER directly affect the behavior of the safety function:

Parameters	Units	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 Cor-rection	Selection of homing mode	Directly
Edge of reference switch	Positive/ Negative	Selection of switching edge for 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.	Positive
Trigger direction	Positive/ Negative	Selection of 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	Selection of whether or not to use a reference pulse for homing	Not Used

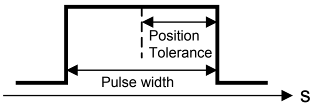
Table 190: Parameters for the "safe homing" safety function - Reference Switch mode

Parameters	Units	Description	Default value
Blocking distance (% encoder reference system)	%	Distance within which evaluation of the reference pulse will be suppressed. It is calculated starting at the configured reference switch edge and indicated as a % of the encoder reference system. A single rotation is used as the encoder reference system for rotary encoders.	0
Position Tolerance	[units]	Position tolerance for standstill and direction monitoring	0

Table 190: Parameters for the "safe homing" safety function - Reference Switch mode

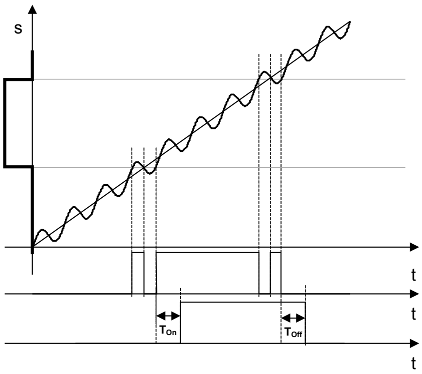
Danger!

The standstill "Position Tolerance" must be smaller 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.



Error in the referenced absolute position due to the delay caused by the filter times must be taken into consideration!

Reference pulse = Not Used

If the reference pulse is disabled, then the reference position will be assumed immediately when the home switch edge is successfully processed.

Reference pulse = Used

This mode is recommended when the positions of ACOPOSmulti and the SafeMC module must match exactly. Processing 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 every single turn overflow.

When "*Reference pulse*" = Used, the reference position will not be entered under the first valid reference pulse after the home switch edge has been reached.

After the valid home switch edge has been processed, the processing of the reference pulse will be suppressed for the distance configured in the parameter "*Blocking distance (% encoder reference system)*“. The next reference pulse is only processed once this distance has been passed, at which point the home position is applied.

A valid homing procedure requires that the direction of movement does not change between when the home switch edge is passed and the valid reference pulse and that the speed limit "*Max Trigger Speed*" is not exceeded.

Information:

If the direction of movement does change while searching for the reference pulse, then the reference switch must be passed over again.

Information:

If the speed limit "*Max Trigger Speed*" is exceeded while searching for the reference pulse, then the module changes to the acknowledgeable error state "Functional Fail Safe".
The function block output *S_NotErrFUNC* is reset and the drive becomes torque-free and force-free, causing it to spin out!
An error will cause a synchronous axis to lose its synchronicity.

Danger!

In cases involving external forces (e.g. hanging loads), this can cause dangerous movement!
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!

Mode-Home Offset/Home Offset with Correction

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 homing command *Home Offset* uses this offset directly, while *Home Offset with Correction* mode accounts for any encoder overrun that might occur in the permissible range of movement.
The offset is configured in SafeDESIGNER on the parameter "*Home position or home Offset*".

The input *S_ReferenceSwitch* will not be evaluated.

The following parameters in SafeDESIGNER directly affect the behavior of the safety function:

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 Cor-rection	Selection of homing mode	Directly
General settings			
Safe Maximum Position	Used / Unused	Activates the SMP safety function by 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 191: Parameters for the safety function "safe homing" - Modus Home Offset/Home Offset with Correction

Danger!

This homing mode can only be used for absolute encoders (single-turn encoder/multi-turn encoder/linear encoder). Using another encoder for this mode will cause the SafeMC module to change to Fail Safe state.
The Fail Safe state can only be exited by powering off/on and changing the safe application!

Information:

If the security functions SMP and/or SLP 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 larger than the encoder counting range, then the SafeMC module will change to Fail Safe state.
The Fail Safe state can only be exited by powering off/on and changing the safe application!

For more information, see 2.3.3 "Safe encoder counting range" on page 133.

Danger!

In cases involving external forces (e.g. hanging loads), this can cause dangerous movement!
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 well suited for absolute encoders which provide unique position values over the entire movement range. Using the homing offset, the encoder position over the entire movement range can be represented as the correct machine position.

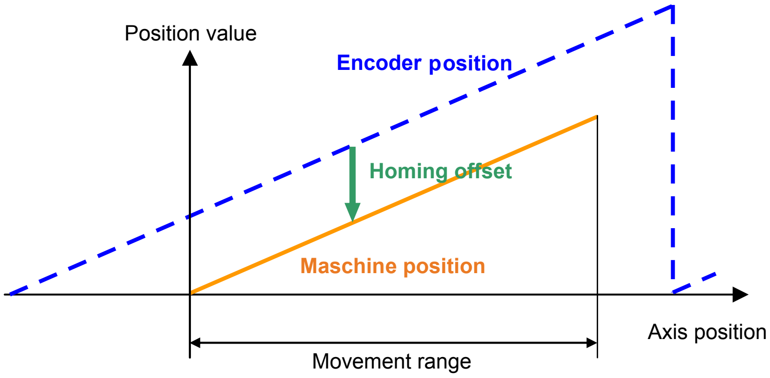


Figure 74: Home Offset referencing method

The Home Offset can be determined by carrying out a calibration move (e.g. Homing with Reference Switch).

Home Offset with Correction

In this homing mode, after setting the Home Offset a check is made to see 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-related encoder counting range is corrected:

Information:

The SMP safety function must be activated when using this mode. If SMP is deactivated, then the SafeMC module will change to Fail Safe state.
The Fail Safe state can only be exited by powering off/on and changing the safe application!

Counting range correction is needed when using absolute encoders if the encoder provides a unique position value over the entire movement range but an encoder overflow occurs within the movement range. Here, the Home Offset depends on if the machine was calibrated at a position to the right or the left of the overflow point.

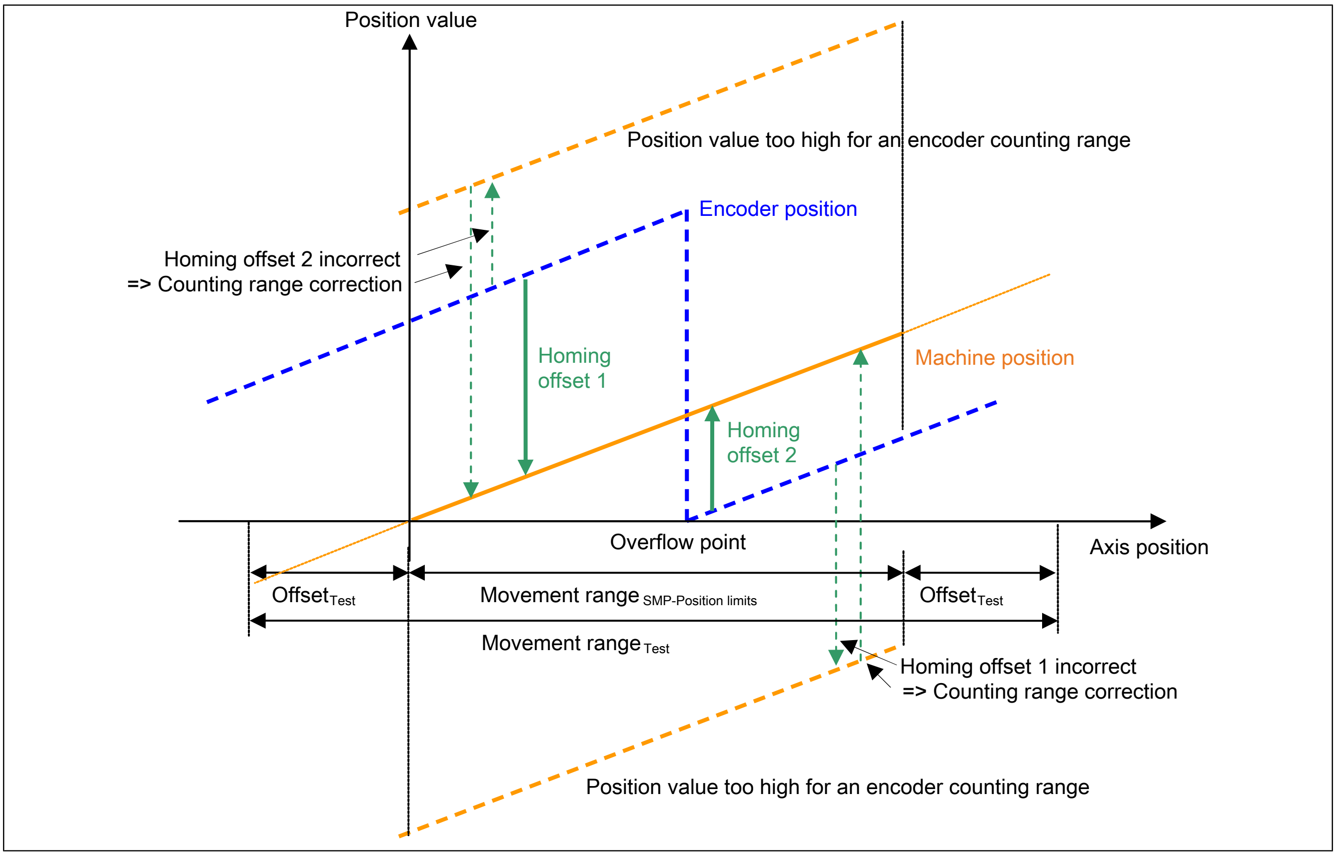


Figure 75: Referencing method - Home Offset with Correction

To the right of the overflow point, Home Offset 1 which is valid for the left side would lead to an incorrect position value. To the left of the overflow point, Home Offset 2 which is valid for the right side would lead to an incorrect position value. This can be compensated for with counting range correction.

Information:

Counting range correction only functions if the encoder range is larger than or equal to the movement range ! Keep in mind that only the safety-related part of the encoder counting range is used.

3.3.14 Safely Limited Position, SLP

Note:

This function is only available in safety release R1.4 and higher!

The purpose of the SLP safety function is to monitor a specified position window.

The parameters "*Safe Lower Position Limit for SLP*" and "*Safe Upper Position Limit for SLP*" can be used to configured the lower and upper position limits of the monitoring range.

The following parameters in SafeDESIGNER affect the behavior of the safety function:

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 request of SLP and start of monitoring	0

Table 192: SLP safety function parameters

The SLP safety function is requested when the input *S_RequestSLP* is set to SAFEFALSE.

Monitoring of the position window will begin after the amount of time configured in "*Delay time to start SLP*" has expired.

The status bit "*S_SafetyActiveSLP*" will be set to SAFETRUE if no errors occur while monitoring is active.

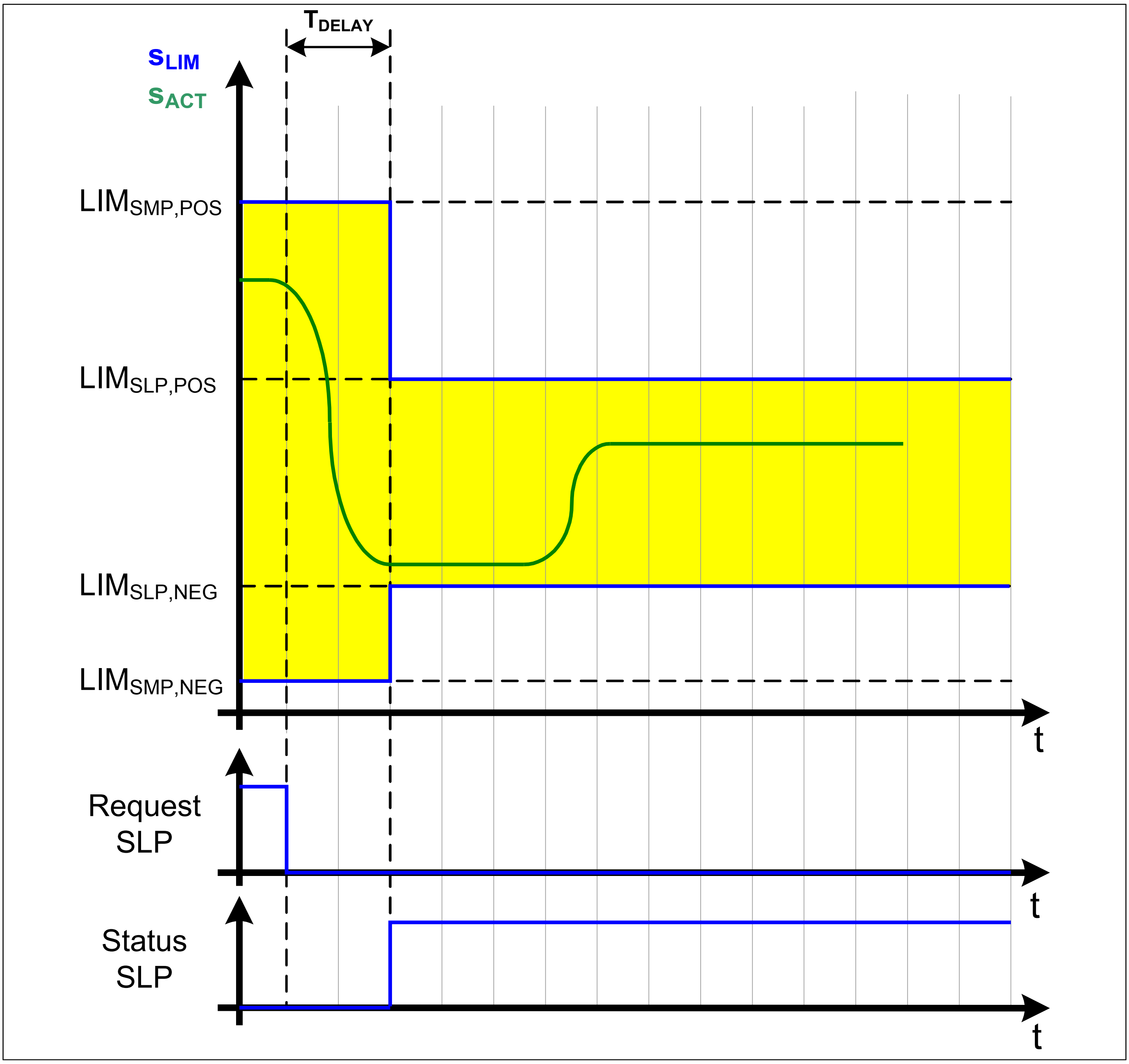


Figure 76: Safely Limited Position, SLP

Information:

The axis must be homed successfully before using the function Safely Limited Position.
If a homing procedure was not completed successfully or if the status "*S_SafePositionValid*" changes, then the request for the SLP safety function will cause the module to change to the acknowledgeable error state "Functional Fail Safe".
Torque and power to the drive are switched off, causing the drive to spin out! An error will cause a synchronous axis to lose its synchronicity.
This will reset the output on the function block *S_NotErrFUNC*!

Danger!

In cases involving external forces (e.g. hanging loads), this can cause dangerous movement!
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 keep shorten the distance remaining when the position window is exceeded as best as possible, a position-dependent speed limit will also be monitored in addition to the position.

Danger!

In the worst case, the monitored position window can be passed while the axis is spinning out. 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 so that the drive will come to a full stop before the limit is reached, using the configured deceleration ramp.

The permitted speed moving toward the upper position limit is

$$v_{LIM,POS} = \sqrt{2(LIM_{SLP,POS} - s) * a}$$

while toward the lower position limit, it is

$$v_{LIM,NEG} = \sqrt{2(s - LIM_{SLP,NEG}) * a}$$

The position-dependent speed limit is illustrated in the following image.

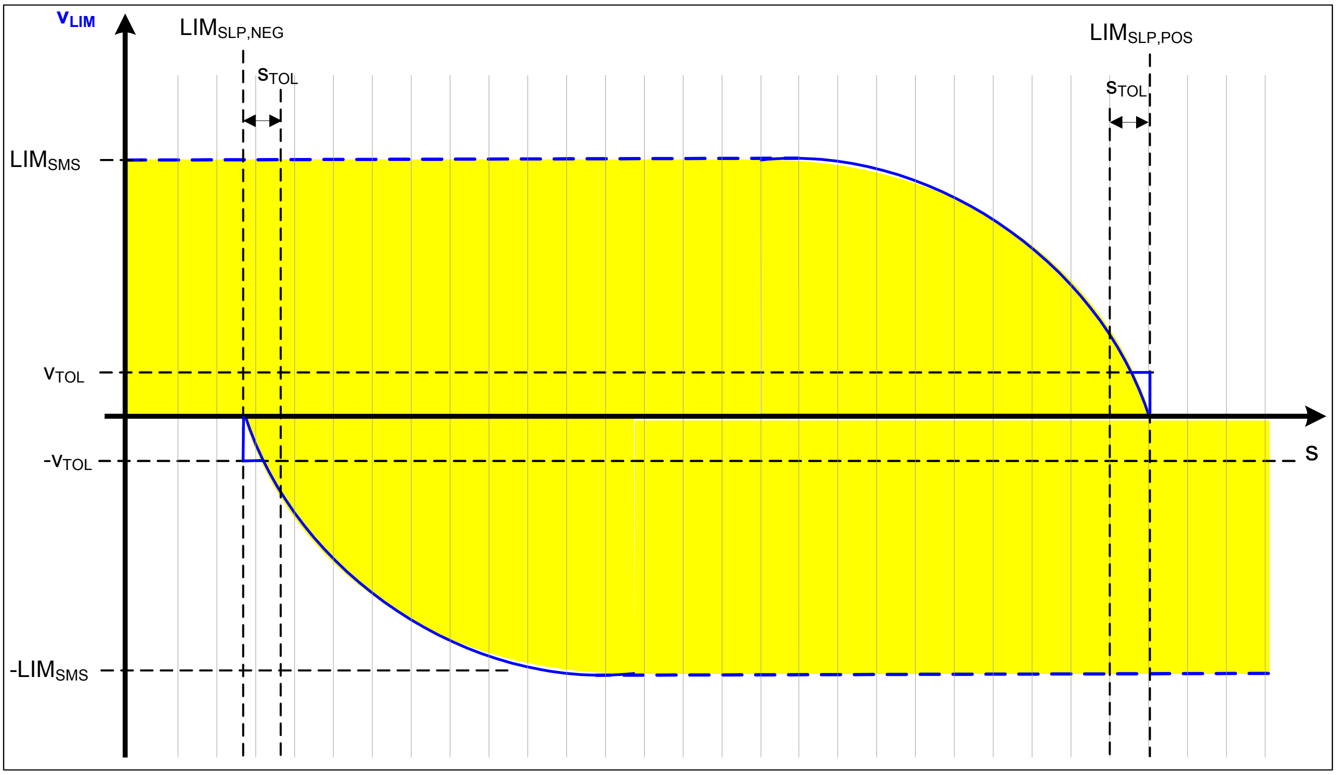


Figure 77: Position-dependent speed window

Danger!

If the position window or position-dependent speed limit is violated or if the status *S_SafePositionValid* changes while the safety function SLP is active, then the module will change to the acknowledgeable error state "Functional Fail Safe".
The function block output *S_NotErrFUNC* is reset and the drive becomes torque-free and force-free, causing it to spin out!
An error will cause a synchronous axis to lose its synchronicity.

Danger!

If the safety function SLP is used in the safe application, then the activation and deactivation of this function 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!

3.3.15 Safe Maximum Position, SMP

Note:

This function is only available in safety release R1.4 and higher!

The difference between SMP and SLP is that SMP cannot be actively initiated. It is either activated or deactivated by the configuration.

When activated, the current position is constantly monitored according to a defined position window.

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 / Unused	Activates the SMP safety function by 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
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 193: SMP safety function parameters

The parameters "*Safe Lower Position Limit for SMP*" and "*Safe Upper Position Limit for SMP*" can be used to configured the lower and upper position limits of the monitoring range.

The safety function SMP only works with homed axes because it requires a safe absolute position.
When SMP is configured, a 15 minute timeout begins once the pulse disabling is enabled, within which the homing procedure must take place.
After successfully completing the homing procedure and as long as there were no errors during monitoring, the status bit "*S_SafetyActiveSMP*" is set to SAFETRUE.

Information:

The axis must be homed successfully before using the function Safe Maximum Position.
If a homing procedure is not successfully completed within 15 minutes after enabling the pulse disabling or if the status *S_SafePositionValid* changes on an axis that has already been homed or if the position window or position-dependent speed limit is violated, then the module will change to the acknowledgeable error state "Functional Fail Safe".
The function block output *S_NotErrFUNC* is reset and the drive becomes torque-free and force-free, causing it to spin out! An error will cause a synchronous axis to lose its synchronicity.

As with the safety function SLP, the Safe Maximum Position function also monitors a position-dependent speed limit in addition to the position, in order to keep the remaining distance as short as possible if the position window is exceeded. For more information, please refer to "Safely Limited Position, SLP".

Danger!

In the worst case, the monitored position window can be passed while the axis is spinning out. 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.
An attempt to move beyond the standstill tolerance in the unsafe direction (i.e. away from the position window) will cause the module to enter the acknowledgeable error state "Functional Fail Safe".

Danger!

If the safety function SMP is used in the safe 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!

**In cases involving external forces (e.g. hanging loads), this can cause dangerous movement!
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!**

3.4 Safe encoder connection monitoring

3.4.1 Elimination of errors

Danger!

To ensure safe operation up to and including the motor shaft, any errors on the connection between the motor shaft and encoder must be identified and prevented.
There are specific guidelines that must be followed when installing an EnDat 2.2 Functional Safety encoder from the company Heidenhain.
The motor manufacturer must ensure that these specifications are adhered to.

Danger!

The frictional connection between the cone-shaped shaft of the rotor and EnDat measurement device is dimensioned for maximum rotor acceleration in accordance with the Heidenhain installation instructions. This acceleration value must not be exceeded in the worst case. The maximum acceleration is monitored on the SafeMC module and can be configured using the parameter "*Maximum acceleration*".

Danger!

If the terminal screw for the coupling ring comes loose on installed measurement devices, then the form-fit pin will be the only thing holding the encoder to the motor housing. A movement in accordance with the installation tolerances is possible. The encoder is not able to record this movement. This remnant movement must be accounted for in the safety functions.

3.4.2 Safe monitoring without elimination of errors

Note:

This function is only available in safety release R1.4 and higher!

In some applications, the mechanical elimination of errors is not needed and can be replaced by the safety-oriented "Encoder Monitoring" in the SafeMC module.

Danger!

Safety Release 1.4 or higher is required in order to use safety-oriented monitoring of the encoder-motor connection!

Danger!

Only the safety functions (SS1, SS2, SLS, SMS, SLI, SDI), in which the safe speed and/or the safe incremental position are monitored can be used.

Danger!

The application must meet the following requirements for safety-oriented monitoring of the encoder-motor connection:

- **Encoder connection monitoring can only be used for encoders that are integrated in a closed loop 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 set position change (Alive Testing) must be enabled in the safe application and sufficiently strict limits must be monitored!**
- **The safety functions SLP and/or SMP 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 effectively.**
- **There is no way to monitor the encoder connection if the set value remains constant.**
- **An encoder connection error 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 SafeMC module (overridden). When lag errors occur, only the error reactions STO or STO1 are possible with induction stop.**

Danger!

Take note that a slip on the encoder shaft connection can cause a short forward movement.

The maximum rotary angle φ of the forward movement on the motor shaft depends on the motor used. For permanently excited synchronous motors, φ = 360°/2 p_z (for B&R standard motors, p_z = 3 and the angle is therefore 60°).

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 the maximum acceleration $a_{max} = \frac{M_{max}}{J}\left[\frac{rad}{s^2}\right]$ **and the number of motor pole pairs** p_z

Danger!

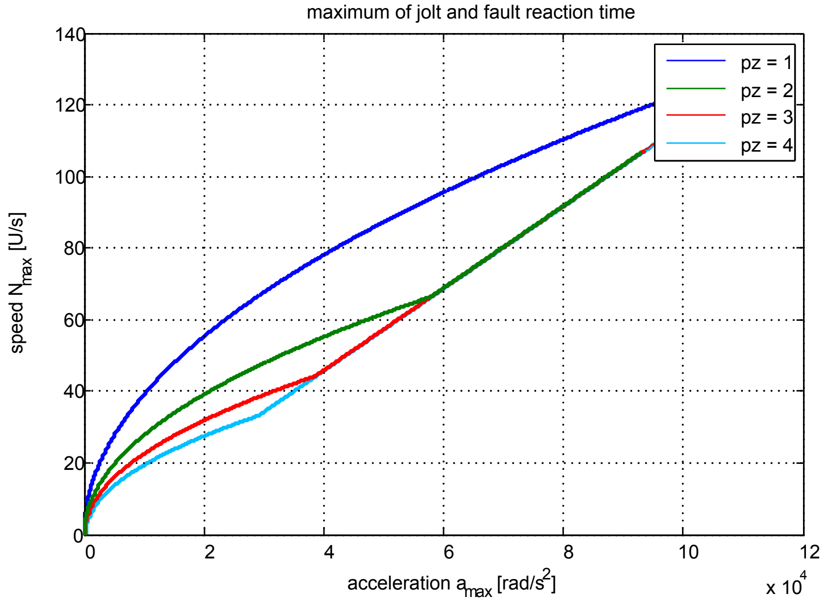
When viewing the worst-case scenario for a safety function, the highest value of the maximum speed of the forward movement n_{Jolt} **and the speed must be used as maximum speed due to the maximum error response time** $n_{T_{worstcase}}$.

$$n_{max} = max(n_{Jolt}, n_{T_{worstcase}}) = max\left(\frac{1}{2\pi}\sqrt{\frac{6a_{max}}{p_z}}, \frac{T_{worstcase}}{2\pi} \cdot a_{max}\right)$$

with the 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 spin-out!**

$$n_{worstcase} = n_{LIM} + n_{max}$$



Information:

In order to check the plausibility of the set value 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 15min.
If this is not done, then the module changes to the error state "Functional Fail Safe", which must be confirmed. The function block output *S_NotErrFUNC* is reset and the drive becomes torque-free and force-free, causing it to spin out!
An error will cause a synchronous axis to lose its synchronicity.

Danger!

In cases involving external forces (e.g. hanging loads), this can cause dangerous movement!
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 24h timeout begins after successfully checking the plausibility of the set value.
The timeout is reset any time the set position changes by more than twice the position lag error tolerance.
If the set position does not change during 24h of continuous controller operation, then the module changes to the acknowledgeable error state "Functional Fail Safe". The function block output *S_NotErrFUNC* is reset and the drive becomes torque-free and force-free, causing it to spin out! An error will cause a synchronous axis to lose its synchronicity.

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 SafeMC module.	Activated
Encoder Speed Monitoring	Activated/ Deactivated	Activates/deactivates the monitoring of the speed error generated on the SafeMC module.	Activated
Set position alive testing	Activated/ Deactivated	Activates/deactivates the monitor that detects whether the set position generated on the ACOPOSmulti is frozen.	Activated
Encoder Monitoring Tolerances			
Encoder Monitoring Position Tolerance	[units]	Position lag error tolerance for encoder monitoring	0
Encoder Monitoring0 Speed Tolerance	[units/s]	Speed error tolerance for encoder monitoring	0

Table 194: Encoder Monitoring safety function parameters

Danger!

The machine manufacturer is responsible for deciding 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!

Activation of 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 monitor cannot be used for safety purposes and a mechanical solution for detecting errors must be implemented!

Configuration rule for position lag error limit

The position lag error limit 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 limit accordingly higher.

Danger!

The position lag error limit cannot be higher than half of one pole length!

When the safety function is enabled, the size of the position lag error limit value ds_{lim} affects how long it will take to look for errors and therefore also the error response time and estimation of the remaining distance.

This must be accounted for by the machine manufacturer in the risk analysis!

Information:

Provide a reserve of 1 unit at parameter "encoder monitoring position tolerance" because of rounding errors.

Configuration rule for speed error limit

The speed error limit 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 set values (e.g. at maximum acceleration) and then setting the speed error limit accordingly higher.

Danger!

When the safety function is enabled, the size of the speed error limit value ds_{lim} affects how long it will take to look for errors and therefore also the error response time and estimation of the remaining distance.

This must be accounted for by the machine manufacturer in the risk analysis!

Information:

Provide a reserve of 1 unit/s at parameter "encoder monitoring speed tolerance" because of rounding errors.

3.5 Error prevention

> ## Danger!
> **Validation**
>
> **Each of the safety functions that are used must be validated separately.**
> **Furthermore, the entire safety application (and therefore also the interaction of the individual functions) must be tested.**

3.5.1 Exceeding monitored limits

The SafeMC module monitors limits that can be configured. The drive itself however is controlled by the functional application on the standard PLC.

The following points must be considered in order to prevent the violation of a monitored limit:

- 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 the movement limitations. Make sure that the different configurations of the unit system match in the safe application and in the functional application!

> ## Danger!
> **Any violation of a monitored limit will cause the module to change to the error state "Functional Fail Safe", which must be confirmed.**
>
> **The function block output *S_NotErrFUNC* is reset and the drive becomes torque-free and force-free, causing it to spin out!**
>
> **Depending on the configuration, the motor holding brake will also be switched to 0 V.**
>
> **An error will cause a synchronous axis to lose its synchronicity.**
>
> **Check the Safety Logger in Automation Studio for detailed information about monitoring!**

3.5.2 Plausibility errors

Plausibility errors (limit values, data types, variable/constant), which occur when the function block is used, are detected and reported by the function block or compiler.

However, this is not always possible in the event of connection errors.

The function block cannot check whether:

- Actual parameter values or constants within the validity range are in fact incorrect for the safety function executed. However, a static TRUE signal at the Reset input is detected by the function block and reported as an error.
- Actual parameters have been connected incorrectly.
- I/O formal parameters have not been connected by mistake.

Please note, therefore:

> ## Danger!
> **The connection of the safety function (sub-application) is your responsibility.**
>
> **Check the connection when validating the sub-application.**

3.5.3 Signal level changing or toggling sporadically or impermissible signals

Signal level changes or toggles sporadically at:

- Edge-controlled input formal parameters, if error avoidance measures are not taken this signal will be interpreted by the function block as an edge and an undesired action will be initiated accordingly in the function block.
- State-controlled input formal parameters, if error avoidance measures are not taken an undesired action will be initiated accordingly by the signal.

Impermissible signals at input formal parameters can lead to unexpected startup or result in the non-execution of a requested action or in an error message.

Possible causes of these signals:

- Programming error in the application program (user error)
- Cross circuit, short circuit or cable break (user error, wiring error)
- Error in the standard control system

To prevent this, the following measures can be taken depending on the safety function:

- Use of safe device signals.
- Additional measures to prevent a hazard if a signal from a standard control system is used (e.g. execution of an additional function start following reset of a triggered safety function or once an error has been removed).
- Line control in the safe control system.
- Suitable cabling when using standard signals from the standard control system.
- Checking the source code in the application program with final validation of the safety function.

The measures listed above can also be taken in combination in order to safely avoid errors.

Take note that a signal change detected at a state-controlled formal parameter will be output as diagnostic code.

3.5.4 Simultaneous edge change

To reduce the risk of unexpected startup, make sure that the Reset formal parameter is only connected with the signal of a manual reset device. This signal is based on your risk analysis.

3.5.5 Machine/system startup without safeguard function test

A faulty safeguard is only detected following a function test. A function test is not supported by the function block. Without additional measures, a faulty safeguard can result in errors.

> ## Danger!
>
> **You are responsible for performing safeguard function tests.**
> **You must therefore validate the safeguard.**

Possible causes of a faulty safeguard:

- faulty devices (hardware errors)
- Cross circuit, short circuit, and cable break (user error, wiring error)

3.6 Input parameters

Information:

Detailed informations about the safety functions see at section "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 safe application, then the respective input should not be connected.

Information:

If a safety function should not be used in the application, then the respective input variables should remain open.

Danger!

All of 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 least the activate input and the S_AxisID must be connected. Otherwise, the SafeMC module will not be operated by the SafeLOGIC. As a result, the pulse disabling and the 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

- Enabling the function block

Data type

- BOOL

Connection

- Constant or variable

Function description

This input parameter is used to activate the function block.

- If you activate or deactivate safe devices, link Activate to a variable, which indicates the status (deactivated or activated) of the relevant safe devices. This ensures that the function block does not output a triggered safety function as diagnostic information in the event that a device is deactivated.
- Furthermore, Activate can be connected to a constant (TRUE) in order to activate the function block.

TRUE

The function block is active.

FALSE

The function block is not active.
All binary output parameters are set to FALSE.
The DiagCode diagnostic parameter is set to WORD#16#0000.

If you want to control the function block diagnostics accordingly in your diagnostic concept in the event of error messages from safe devices and/or in the event of deactivated safe devices, connect Activate to a signal that indicates the status of the safe devices, which are involved in the safety function supported by the function block. Create this signal only from safe devices, whose I/O signals are connected to the function block via actual parameters. This prevents triggered safety functions from being reported by deactivated safe devices. This measure is only used to control the diagnostics in the event of deactivated safe devices.

3.6.3 S_RequestSTO

General function

- Select/deselect the safety function "Safe Torque Off", STO

Data type

- SAFEBOOL

Connection

- Constant or variable

Function description

This input parameter is used to select or deselect the safety function STO.

TRUE

Safety function is deselected; the safe pulse disabling is not active!

FALSE

Safety function is selected; the safe pulse disabling is active! Torque and power are switched off on the drive.

Not connected

The safety function is disabled.

Relevant configuration parameters

- None

3.6.4 S_RequestSTO1

General function

- Select/deselect the safety function "Safe Torque Off, One Channel", STO1

Data type

- SAFEBOOL

Connection

- Constant or variable

Function description

This input parameter is used to select or deselect the safety function STO1.

TRUE

Safety function is deselected; the safe pulse disabling is not active!

FALSE

Safety function is selected; depending on the configuration, the HighSide or LowSide of the safe pulse disabling is active! Torque and power are switched off on the drive.

Not connected

The safety function is disabled.

Relevant configuration parameters

Parameter	Unit	Description	Default value
General settings			
Channel selection for One Channel STO (STO1)	HighSide/ LowSide	Selection of HighSide or LowSide IGBT in the One-ChannelSTO function	HighSide

Table 195: STO1 safety function parameters

3.6.5 S_RequestSBC

General function

- Selects/deselects the safety function "Safe Brake Control", SBC

Data type

- SAFEBOOL

Connection

- Constant or variable

Function description

This input parameter is used to select or deselect the safety function SBC.

TRUE

Safety function is deselected. The motor holding brake is active and can be used by the functional application.

FALSE

Safety function is selected. The motor holding brake is switched to 0 V!

Not connected

The safety function is disabled.

Relevant configuration parameters

Parameter	Unit	Description	Default value
Safety Additional Parameters			
Delay time to start SBC (us)	[µs]	Delay time between request of SBC and activation of the safety function	0

Table 196: SBC safety function parameters

3.6.6 S_RequestSOS

General function

- Selects/deselects the safety function "Safe Operating Stop", SOS

Data type

- SAFEBOOL

Connection

- Constant or variable

Function description

This input parameter is used to select or deselect the safety function SOS.

TRUE

Safety function is deselected. Standstill tolerances are not being monitored.

FALSE

Safety function is selected. Standstill tolerances are being monitored.

Not connected

The safety function is disabled.

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 197: SOS safety function parameters

Information:

The safety function requires safe evaluation of the position or speed.
If an error is detected in the evaluation, then the SafeMC module changes to the acknowledgeable "Functional Fail Safe" state!

Information:

If multiple safety functions are simultaneously active, then the lowest value for speed will always be 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 SafeMC module to enter the Fail Safe state. If this occurs, it can only be made operational again by changing the safe application and restarting!

3.6.7 S_RequestSS1

General function

- Selects/deselects the safety function "Safe Stop 1", SS1

Data type

- SAFEBOOL

Connection

- Constant or variable

Function description

This input parameter is used to select or deselect the safety function SS1.

TRUE

Safety function is deselected; Safe Stop 1 is not active!

FALSE

Safety function is selected. Safe pulse disabling is activated after the end of ramp monitoring.

Not connected

The safety function is disabled.

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			
Ramp monitoring for SS1	Activated/ Deactivated	Activates ramp monitoring (in addition to the time) when the SS1 function is requested	Activated
Early Limit Monitoring	Activated/ Deactivated	Monitoring of the deceleration ramp is prematurely terminated if the value drops below the lower limit for a defined amount of time	Deactivated
Safety Ramp Monitoring Times			
Ramp Monitoring Time for SS1 (us)	[µs]	Deceleration monitoring time for SS1	0
Safety Additional Parameters			
Delay time to start ramp monitoring (us)	[µs]	Delay time between request of ramp monitoring and 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 198: SS1 safety function parameters

Information:

The safety function requires safe evaluation of the position or speed.
If an error is detected in the evaluation, then the SafeMC module changes to the acknowledgeable "Functional Fail Safe" state!

Information:

In order to use the function without safe encoder evaluation, "*Ramp monitoring for SS1*" and "*Early Limit Monitoring*" must both be disabled.

Information:

If multiple safety functions are simultaneously active, then the lowest value for speed will always be 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 SafeMC module to enter the Fail Safe state. If this occurs, it can only be made operational again by changing the safe application and restarting!

3.6.8 S_RequestSS2

General function

- Selects/deselects the safety function "Safe Stop 2", SS2

Data type

- SAFEBOOL

Connection

- Constant or variable

Function description

This input parameter is used to select or deselect the safety function SS2.

TRUE

Safety function is deselected; Safe Stop 2 is not active!

FALSE

Safety function is selected. Standstill monitoring is activated after the end of ramp monitoring.

Not connected

The safety function is disabled.

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			
Ramp monitoring for SS2	Activated/ Deactivated	Activates ramp monitoring (in addition to the time) when the SS2 function is activated	Activated
Early Limit Monitoring	Activated/ Deactivated	Monitoring of the deceleration ramp is prematurely terminated if the value drops 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 monitoring time for SS2	0
Safety Additional Parameters			
Delay time to start ramp monitoring (us)	[µs]	Delay time between request of ramp monitoring and 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 199: SS2 safety function parameters

Information:

The safety function requires safe evaluation of the position or speed.
If an error is detected in the evaluation, then the SafeMC module changes to the acknowledgeable "Functional Fail Safe" state!

Information:

If multiple safety functions are simultaneously active, then the lowest value for speed will always be 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 SafeMC module to enter the Fail Safe state. If this occurs, it can only be made operational again by changing the safe application and restarting!

3.6.9 S_RequestSLS1

General function

- Selects/deselects the safety function "Safely Limited Speed", Speed Limit 1

Data type

- SAFEBOOL

Connection

- Constant or variable

Function description

This input parameter is used to select or deselect the safety function SLS1.

TRUE

Safety function is deselected; SLS1 is not active!

FALSE

Safety function is selected. Speed Limit 1 is monitored after the end of ramp monitoring.

Not connected

The safety function is disabled.

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			
Ramp monitoring for SLS	Activated/ Deactivated	Activates ramp monitoring (in addition to the time) when the SLS function is activated	Activated
Early Limit Monitoring	Activated/ Deactivated	Monitoring of the deceleration ramp is prematurely terminated if the value drops below the lower limit for a defined amount of time	Deactivated
Speed Limits			
Safe Speed-limit 1 for SLS	[units/s]	Speed Limit 1 for SLS	0
Safety Ramp Monitoring Times			
Ramp Monitoring Time for SLS1 (us)	[µs]	Deceleration monitoring time for SLS1	0
Safety Additional Parameters			
Delay time to start ramp monitoring (us)	[µs]	Delay time between request of ramp monitoring and 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 200: SLS1 safety function parameters

Information:

The safety function requires safe evaluation of the position or speed.
If an error is detected in the evaluation, then the SafeMC module changes to the acknowledgeable "Functional Fail Safe" state!

Information:

If multiple safety functions are simultaneously active, then the lowest value for speed will always be 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 SafeMC module to enter the Fail Safe state. If this occurs, it can only be made operational again by changing the safe application and restarting!

3.6.10 S_RequestSLS2

General function

- Selects/deselects the safety function "Safely Limited Speed", Speed Limit 2

Data type

- SAFEBOOL

Connection

- Constant or variable

Function description

This input parameter is used to select or deselect the safety function SLS2.

TRUE

Safety function is deselected; SLS2 is not active!

FALSE

Safety function is selected. Speed Limit 2 is monitored after the end of ramp monitoring.

Not connected

The safety function is disabled.

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			
Ramp monitoring for SLS	Activated/ Deactivated	Activates ramp monitoring (in addition to the time) when the SLS function is activated	Activated
Early Limit Monitoring	Activated/ Deactivated	Monitoring of the deceleration ramp is prematurely terminated if the value drops below the lower limit for a defined amount of time	Deactivated
Speed Limits			
Safe Speed-limit 2 for SLS	[units/s]	Speed Limit 2 for SLS	0
Safety Ramp Monitoring Times			
Ramp Monitoring Time for SLS2 (us)	[µs]	Deceleration monitoring time for SLS2	0
Safety Additional Parameters			
Delay time to start ramp monitoring (us)	[µs]	Delay time between request of ramp monitoring and 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 201: SLS2 safety function parameters

Information:

The safety function requires safe evaluation of the position or speed.
If an error is detected in the evaluation, then the SafeMC module changes to the acknowledgeable "Functional Fail Safe" state!

Information:

If multiple safety functions are simultaneously active, then the lowest value for speed will always be 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 SafeMC module to enter the Fail Safe state. If this occurs, it can only be made operational again by changing the safe application and restarting!

3.6.11 S_RequestSLS3

General function

- Selects/deselects the safety function "Safely Limited Speed", Speed Limit 3

Data type

- SAFEBOOL

Connection

- Constant or variable

Function description

This input parameter is used to select or deselect the safety function SLS3.

TRUE

Safety function is deselected; SLS3 is not active!

FALSE

Safety function is selected. Speed Limit 3 is monitored after the end of ramp monitoring.

Not connected

The safety function is disabled.

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			
Ramp monitoring for SLS	Activated/ Deactivated	Activates ramp monitoring (in addition to the time) when the SLS function is activated	Activated
Early Limit Monitoring	Activated/ Deactivated	Monitoring of the deceleration ramp is prematurely terminated if the value drops below the lower limit for a defined amount of time	Deactivated
Speed Limits			
Safe Speed-limit 3 for SLS	[units/s]	Speed Limit 3 for SLS	0
Safety Ramp Monitoring Times			
Ramp Monitoring Time for SLS3 (us)	[µs]	Deceleration monitoring time for SLS3	0
Safety Additional Parameters			
Delay time to start ramp monitoring (us)	[µs]	Delay time between request of ramp monitoring and 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 202: SLS3 safety function parameters

Information:

The safety function requires safe evaluation of the position or speed.
If an error is detected in the evaluation, then the SafeMC module changes to the acknowledgeable "Functional Fail Safe" state!

Information:

If multiple safety functions are simultaneously active, then the lowest value for speed will always be monitored.

The following application rule must be observed:
$LIM_{SOS} \le LIM_{SLS4} \le LIM_{SLS3} \le LIM_{SLS2} \le LIM_{SLS1} \le LIM_{SMS} < NormSpeed$

Failure to follow the application rule will cause the SafeMC module to enter the Fail Safe state. If this occurs, it can only be made operational again by changing the safe application and restarting!

3.6.12 S_RequestSLS4

General function

- Selects/deselects the safety function "Safely Limited Speed", Speed Limit 4

Data type

- SAFEBOOL

Connection

- Constant or variable

Function description

This input parameter is used to select or deselect the safety function SLS4.

TRUE

Safety function is deselected; SLS4 is not active!

FALSE

Safety function is selected. Speed Limit 4 is monitored after the end of ramp monitoring.

Not connected

The safety function is disabled.

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			
Ramp monitoring for SLS	Activated/ Deactivated	Activates ramp monitoring (in addition to the time) when the SLS function is activated	Activated
Early Limit Monitoring	Activated/ Deactivated	Monitoring of the deceleration ramp is prematurely terminated if the value drops below the lower limit for a defined amount of time	Deactivated
Speed Limits			
Safe Speed-limit 4 for SLS	[units/s]	Speed Limit 4 for SLS	0
Safety Ramp Monitoring Times			
Ramp Monitoring Time for SLS4 (us)	[µs]	Deceleration monitoring time for SLS4	0
Safety Additional Parameters			
Delay time to start ramp monitoring (us)	[µs]	Delay time between request of ramp monitoring and 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 203: SLS4 safety function parameters

Information:

The safety function requires safe evaluation of the position or speed.
If an error is detected in the evaluation, then the SafeMC module changes to the acknowledgeable "Functional Fail Safe" state!

Information:

If multiple safety functions are simultaneously active, then the lowest value for speed will always be 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 SafeMC module to enter the Fail Safe state. If this occurs, it can only be made operational again by changing the safe application and restarting!

3.6.13 S_RequestSLI

General function

- Selects/deselects the safety function "Safely Limited Increment", SLI

Data type

- SAFEBOOL

Connection

- Constant or variable

Function description

This input parameter is used to select or deselect the safety function SLI.

TRUE

Safety function is deselected; SLI is not active!

FALSE

Safety function is selected. A safe range of increments is monitored.

Not connected

The safety function is disabled.

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 moveable increments when SLI is active	0
SLI OFF Delay	[µs]	Switch off delay of SLI	0

Table 204: SLI safety function parameters

Information:

The safety function requires safe evaluation of the position or speed.
If an error is detected in the evaluation, then the SafeMC module changes to the acknowledgeable "Functional Fail Safe" state!

3.6.14 S_RequestSDIpos

General function

- Selects/deselects the safety function "Safe Direction", movement is allowed in the positive direction

Data type

- SAFEBOOL

Connection

- Constant or variable

Function description

This input parameter is used to select or deselect the safety function SDI, movement is allowed in the positive direction of movement.

TRUE

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 disabled.

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 request of SDI and activation of the safety function	0

Table 205: SDI safety function parameters

Information:

The safety function requires safe evaluation of the position or speed.
If an error is detected in the evaluation, then the SafeMC module changes to the acknowledgeable "Functional Fail Safe" state!

3.6.15 S_RequestSDIneg

General function

- Selects/deselects the safety function "Safe Direction", movement is allowed in the negative direction

Data type

- SAFEBOOL

Connection

- Constant or variable

Function description

This input parameter is used to select or deselect the safety function SDI, movement is allowed in the negative direction of movement.

TRUE

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 disabled.

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 request of SDI and activation of the safety function	0

Table 206: SDI safety function parameters

Information:

The safety function requires safe evaluation of the position or speed.
If an error is detected in the evaluation, then the SafeMC module changes to the acknowledgeable "Functional Fail Safe" state!

3.6.16 S_RequestSLP

General function

- Selects/deselects the safety function "Safely Limited Position", SLP

Data type

- SAFEBOOL

Connection

- Constant or variable

Function description

This input parameter is used to select or deselect the safety function SLP.

TRUE

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 disabled.

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 request of SLP and start of monitoring	0

Table 207: SLP safety function parameters

Information:

The safety function requires safe evaluation of the position or speed.
If an error is detected in the evaluation, then the SafeMC module changes to the acknowledgeable "Functional Fail Safe" state!

Information:

The following application rule must be observed:
$LIM_{SMP,NEG} \leq LIM_{SLP,NEG} \leq LIM_{SLP,POS} \leq LIM_{SMP,POS}$
Failure to follow the application rule will cause the SafeMC module to enter the Fail Safe state. If this occurs, it can only be made operational again by changing the safe application and restarting!

Information:

The axis must be homed prior to using this safety function.
If a homing procedure was not completed successfully or if the status "*S_SafePositionValid*" changes, then the request for the SLP safety function will cause the module to change to the acknowledgeable error state "Functional Fail Safe".
Torque and power to the drive are switched off, causing the drive to spin out! An error will cause a synchronous axis to lose its synchronicity. This will reset the output on the function block *S_NotErrFUNC*!

3.6.17 S_RequestHoming

General function

- Selects/deselects the safety function "safe homing"

Data type

- SAFEBOOL

Connection

- Constant or variable

Function description

This input parameter is used for starting a safe homing procedure. A positive edge on the input starts the safety function.

Positive edge: Changes FALSE to TRUE

Starts safe homing.

Negative edge: Changes TRUE to FALSE

If still active, the homing procedure will be terminated by the negative edge. This state transition has no effect if the homing procedure has already been completed.

Not connected

The safety function is disabled.

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	Selection of homing mode	Directly
Edge of reference switch	Positve/ Negative	Selection of switching edge for 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.	Positive
Trigger direction	Positve/ Negative	Selection of 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	Selection of whether or not to use a reference pulse for homing	Not Used
Blocking distance (% encoder reference system)	%	Distance within which evaluation of the reference pulse will be suppressed. It is calculated starting at the configured reference switch edge and indicated as a % of the encoder reference system. A single rotation is used as the encoder reference system for rotary encoders.	0

Table 208: Parameters for the "safe homing" safety function

Information:

The safety function requires safe evaluation of the position or speed.
If an error is detected in the evaluation, then the SafeMC module changes to the acknowledgeable "Functional Fail Safe" state!

Information:

The safe homing function is a pre-requisite for the safety functions SLP and SMP and for using the safe position.
The status *S_SafePositionValid* 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

Function description

This input parameter serves as 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, which for example was scanned to the safe application via a safe input module (X20SIxxxx), should be linked to the input.

Not connected

The reference switch is not used!

Information:

If the homing mode "*Reference Switch*" is configured and the reference switch input "*S_ReferenceSwitch*" is not wired on the function block, then the SafeMC module will change to the Fail Safe state.
The Fail Safe state can only be exited by powering off/on and changing the safe application!

Information:

The input "*S_ReferenceSwitch*" is only evaluated with the homing mode "*Reference Switch*".
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 SafeMC module in to Operational state after startup

Data type

- BOOL

Connection

- Variable

Function description

Reset input for confirming the "Functional Fail Safe" state.

A positive switching edge triggers the reset function.

Depending on the configuration of the parameter "Automatic Reset at Startup", a positive switching edge might be needed to get the SafeMC module from the "Init" state to the "Operational" state after starting up.

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 209: Parameter Reset

3.6.20 S_AxisID

General function

- This input parameter assigns a real axis to the function block.

Data type

- SAFEINT

Connection

- Constant

Function description

You can assign the axis by dragging and dropping it onto the respective parameter in the SafeDESIGNER.

Information:

There can only be one combination of AxisID and the SF_SafeMC_BR or SF_SafeMC_BR_V2 function block in the safe application. Otherwise, it will not be possible to compile the safe application.

3.7 Output parameters

The output parameters provide information about the state of the SafeMC module and the individual safety functions.

3.7.1 Ready

General function

- Message: Function block active/not active.

Data type

- BOOL

Connection

- Variable

Function description

This output parameter indicates whether or not the function block is active.

TRUE

The function block is active (Activate = TRUE) and the output parameters indicate the current state of the safety function.

FALSE

The function block is not active (Activate = FALSE) and the function block outputs are set to FALSE.

3.7.2 S_SafetyActiveSTO

General function

- Status information about the safety function "Safe Torque Off", STO

Data type

- SAFEBOOL

Connection

- Variable

Function description

Returns the functional safe state of the safety function STO.

TRUE

Safety function STO is active and currently in its safe state.

FALSE

Safety function STO is not requested, the function or the SafeMC module is currently in an error state or the function block has not been activated.

3.7.3 S_SafetyActiveSTO1

General function

- Status information for the safety function "Safe Torque Off, One Channel", STO1

Data type

- SAFEBOOL

Connection

- Variable

Function description

Returns the functional safe state of the safety function STO1.

TRUE

Safety function STO1 is active and currently in its safe state.

FALSE

Safety function STO1 is not requested, the function or the SafeMC module is currently in an error state or the function block has not been activated.

3.7.4 S_SafetyActiveSBC

General function

- Status information for the safety function "Safe Brake Control", SBC

Data type

- SAFEBOOL

Connection

- Variable

Function description

Returns the functional safe state of the safety function SBC.

TRUE

Safety function SBC is active and currently in its safe state.

FALSE

Safety function SBC is not requested, the function or the SafeMC module is currently in an error state or the function block has not been activated.

3.7.5 S_SafetyActiveSOS

General function

- Status information for the safety function "Safe Operating Stop", SOS.

Data type

- SAFEBOOL

Connection

- Variable

Function description

Returns the functional safe state of the safety function SOS.

TRUE

Safety function SOS is active and currently in its safe state.

FALSE

Safety function SOS is not requested, the function or the SafeMC module is currently in an error state or the function block has not been activated.

3.7.6 S_SafetyActiveSS1

General function

- Status information for the safety function "Safe Stop 1", SS1.

Data type

- SAFEBOOL

Connection

- Variable

Function description

Returns the functional safe state of the safety function SS1.

TRUE

Safety function SS1 is active and currently in its safe state.

FALSE

Safety function SS1 is not requested, has not yet achieved its safe state, the function or the SafeMC module is currently in an error state or the function block has not been activated.

3.7.7 S_SafetyActiveSS2

General function

- Status information for the safety function "Safe Stop 2", SS2.

Data type

- SAFEBOOL

Connection

- Variable

Function description

Returns the functional safe state of the safety function SS2.

TRUE

Safety function SS2 is active and currently in its safe state.

FALSE

Safety function SS2 is not requested, has not yet achieved its safe state, the function or the SafeMC module is currently in an error state or the function block has not been activated.

3.7.8 S_SafetyActiveSLS1

General function

- Status information the safety function "Safely Limited Speed" Speed Limit 1

Data type

- SAFEBOOL

Connection

- Variable

Function description

Returns the functional safe state of the safety function SLS1.

TRUE

Safety function SLS1 is active and currently in its safe state.

FALSE

Safety function SLS1 is not requested, has not yet achieved its safe state, the function or the SafeMC module is currently in an error state or the function block has not been activated.

3.7.9 S_SafetyActiveSLS2

General function

- Status information the safety function "Safely Limited Speed" Speed Limit 2

Data type

- SAFEBOOL

Connection

- Variable

Function description

Returns the functional safe state of the safety function SLS2.

TRUE

Safety function SLS2 is active and currently in its safe state.

FALSE

Safety function SLS2 is not requested, has not yet achieved its safe state, the function or the SafeMC module is currently in an error state or the function block has not been activated.

3.7.10 S_SafetyActiveSLS3

General function

- Status information the safety function "Safely Limited Speed" Speed Limit 3

Data type

- SAFEBOOL

Connection

- Variable

Function description

Returns the functional safe state of the safety function SLS3.

TRUE

Safety function SLS3 is active and currently in its safe state.

FALSE

Safety function SLS3 is not requested, has not yet achieved its safe state, the function or the SafeMC module is currently in an error state or the function block has not been activated.

3.7.11 S_SafetyActiveSLS4

General function

- Status information the safety function "Safely Limited Speed" Speed Limit 4

Data type

- SAFEBOOL

Connection

- Variable

Function description

Returns the functional safe state of the safety function SLS4.

TRUE

Safety function SLS4 is active and currently in its safe state.

FALSE

Safety function SLS4 is not requested, has not yet achieved its safe state, the function or the SafeMC module is currently in an error state or the function block has not been activated.

3.7.12 S_SafetyActiveSLI

General function

- Status information the safety function "Safely Limited Increment"

Data type

- SAFEBOOL

Connection

- Variable

Function description

Returns the functional safe state of the safety function SLI.

TRUE

Safety function SLI is active and currently in its safe state.

FALSE

Safety function SLI is not requested, the function or the SafeMC module is currently in an error state or the function block has not been activated.

3.7.13 S_SafetyActiveSDIpos

General function

- Status information for the safety function "Safe Direction", movement is allowed in the positive direction

Data type

- SAFEBOOL

Connection

- Variable

Function description

Returns the functional safe state of the safety function SDIpos.

TRUE

Safety function SDIpos is active and currently in its safe state.

FALSE

Safety function SDIpos is not requested, the function or the SafeMC module is currently in an error state or the function block has not been activated.

3.7.14 S_SafetyActiveSDIneg

General function

- Status information for the safety function "Safe Direction", movement is allowed in the negative direction

Data type

- SAFEBOOL

Connection

- Variable

Function description

Returns the functional safe state of the safety function SDIneg.

TRUE

Safety function SDIneg is active and currently in its safe state.

FALSE

Safety function SDIneg is not requested, the function or the SafeMC module is currently in an error state or the function block has not been activated.

3.7.15 S_SafetyActiveSLP

General function

- Status information for the safety function "Safely Limited Position", SLP

Data type

- SAFEBOOL

Connection

- Variable

Function description

Returns the functional safe state of the safety function SLP.

TRUE

Safety function SLP is active and currently in its safe state.

FALSE

Safety function SLP is not requested, the function or the SafeMC module is currently in an error state or the function block has not been activated.

3.7.16 S_SafetyActiveSMP

General function

- Status information for the safety function "Safe Maximum Position", SMP

Data type

- SAFEBOOL

Connection

- Variable

Function description

Returns the functional safe state of the safety function SMP.

TRUE

Safety function SMP is active and currently in its safe state.

FALSE

Monitoring of the SMP position limits is not active. Monitoring is not yet active because the module has not yet been homed, the function or the SafeMC module is currently in an error state or the function block has not been activated.

3.7.17 S_SafePositionValid

General function

- Status information for the safety function "safe homing" and the safe position

Data type

- SAFEBOOL

Connection

- Variable

Function description

This output parameter specifies whether or not the axis has been safely home 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 SafeMC module is in an error state or the function block has not yet been activated.
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 SafeMC module!

Danger!

The value of the output parameter S_SafePosition is only valid if the output parameter S_SafePositionValid is SAFETRUE. Otherwise, it is invalid and can no longer be used.

3.7.18 S_SafetyActiveSDC

General function

- Information about the status of the ramp monitor

Data type

- SAFEBOOL

Connection

- Variable

Function description

This output parameter specifies the status of ramp monitoring.

TRUE

Ramp monitoring is active.

FALSE

Ramp monitoring is not active, the module is currently in an error state or the function block has not been activated.

> **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

Function description

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 module is in an error state or the function block has not yet been activated.

3.7.20 S_NotErrFUNC

General function

- Information about the error state of the SafeMC module

Data type

- SAFEBOOL

Connection

- Variable

Function description

This output parameter specifies the error status of the SafeMC module.

TRUE

No error was found on the SafeMC module.

FALSE

Am SafeMC Modul wurde ein Fehler (z. B. die Überschreitung eines überwachten Limits) festgestellt oder der Funktionsblock wurde nicht aktiviert.
Im Fehlerfall kann die Zusatzinformation zum Fehler im Safety Logger des Automation Studios entnommen werden!
Handelt es sich hierbei um einen funktionalen Fehler, kann dieser quittiert werden, indem das Signal am Eingang Reset von FALSE auf TRUE wechselt (positive Flanke)!

Danger!

This signal should only be used for status information. This only applies in relation to the requested safety functions.
S_NotErrFUNC does not represent the functional safe state of the SafeMC module!

Danger!

It is your responsibility to ensure that all necessary repairs are made if an error occurs because subsequent errors could create a dangerous situation!

3.7.21 Error

General function

- Function block error message

Data type

- BOOL

Connection

- Variable

Function description

This formal parameter indicates a pending block error message.

TRUE

The activated function block has detected an error. DiagCode indicates the error code.

FALSE

The function block is not activated or the activated function block has not detected any errors. DiagCode indicates the state.

> **Danger!**
>
> **It is your responsibility to ensure that all necessary repairs are made if an error occurs because subsequent errors could create a dangerous situation!**

In order to exit an error state (Error= TRUE), the signal on the Reset input must change from FALSE to TRUE (positive edge).

3.7.22 DiagCode

General function

- Function block diagnostic message

Data type

- WORD

Connection

- Variable

Function description

Block-specific diagnostic and status messages are output and automatically made available to the higher-level diagnostic tools via this output parameter.

Higher-level diagnostic tools cannot confirm block diagnostic messages. This is done exclusively in the **safe** application program.

The function block indicates the presence of an error message at the DiagCode output via the Error output parameter.

Diagnostic code

The diagnostic code is indicated in the WORD data type. The values of the diagnostics codes and their meaning are described below.

For status messages ($0xxx_{hex}$, $8xxx_{hex}$) the function block sets Error to FALSE.

For 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 active.	Activate the function block by setting Activate to TRUE.
8001	Init	The function block has been activated and the SafeMC module is in the Init state. The SafeMC module startup inhibit is active.	Configure the parameter "Startreset" accordingly or change to a positive edge on the Reset input.
8002	Operational	The SafeMC module is in the internal Operational state. No safety function is selected. The speed limit SMS is monitored according to the configuration.	No action required.
8003	Wait for Confirmation	The SafeMC 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. This will provide you with detailed information about the currently pending error. Depending on the type of error, check the functional and safe application when functional errors occur, check the module configuration or replace the faulty module!

Table 210: SF_SafeMC_BR_V2: Diagnostic codes

3.7.24 AxisStatus

General function

- Diagnostics message from the function block, representation of the axis status bits in a DWORD

Data type

- DWORD

Connection

- Variable

Function description

The AxisStatus output returns bit-coded information about the status of the 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 211: SF_SafeMC_BR_V2: SafeMC module status bits

Chapter 5
PLCopen Safety

3.8 State machine

The state machine shown is implemented on the SafeMC module.

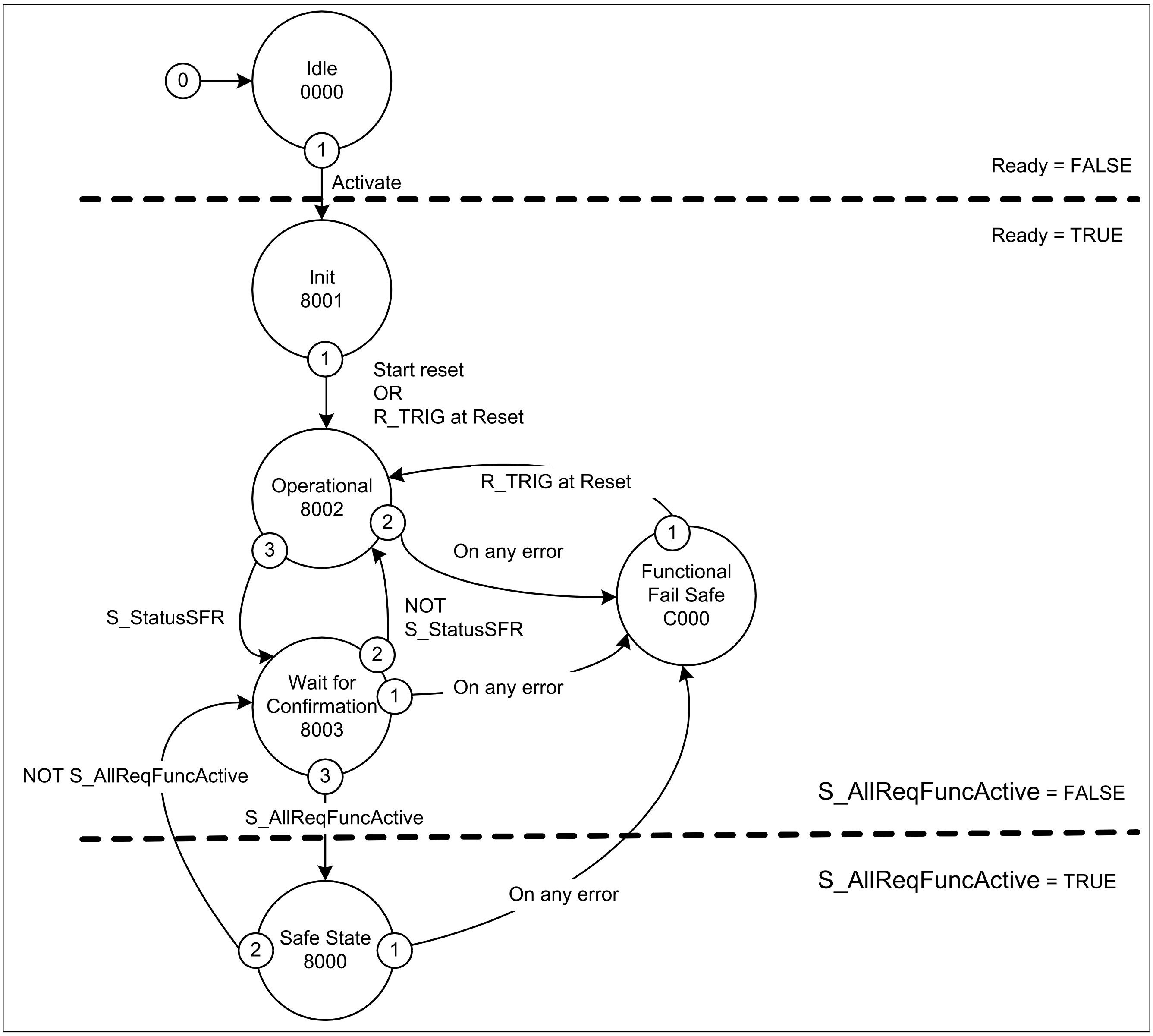


Figure 78: SF_SafeMC_BR_V2: State machine

The individual states are provided on the DiagCode output parameter. In this sense, the function block provides a representation of the SafeMC module's state machine.

3.9 Signal sequence diagram for the function block

Es kann kein generelles Signalablauf-Diagramm des Funktionsbausteins angegeben werden, da dieses von den an- bzw. abgewählten Sicherheitsfunktionen abhängig ist.
Die Signalablauf-Diagramme der einzelnen Sicherheitsfunktionen sind im Abschnitt "Integrated safety functions" dargestellt!

4 SF_SafeMC_Speed_BR

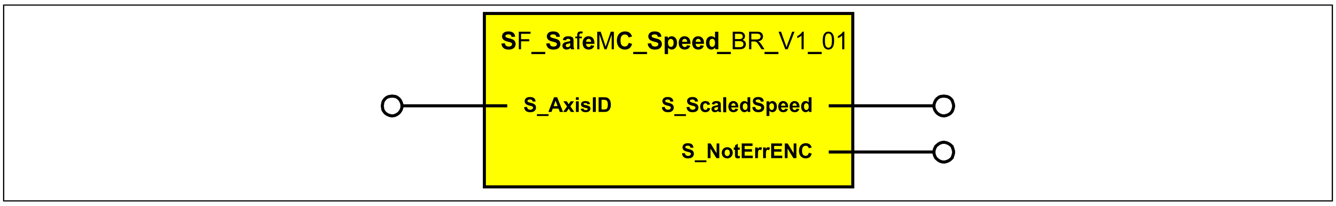


Figure 79: Function block SF_SafeMC_Speed_BR

4.1 Formal Parameters of the Function Block

In the following, a "variable" may designate either a variable or a graphic connection.

Name	Type	Connection	Signal Type[1)]	Initial Value	Description/General Function
S_AxisID	SAFEINT	Constant	State	-1	Assigns an axis to the function block

Table 212: SF_SafeMC_Speed_BR: Brief overview of the input parameters

1) Evaluation of input parameter signals in the function block. The signals must be controlled accordingly by the user.

Name	Type	Connection	Signal Type[2)]	Initial Value	Description/General Function
S_ScaledSpeed	SAFEINT	Variable	Value	-	Scaled safe speed
S_NotErrENC	SAFEBOOL	Variable	State	SAFEFALSE	No encoder error has been detected (=SAFETRUE), the signal S_ScaledSpeed is valid

Table 213: SF_SafeMC_Speed_BR: Brief overview of the output parameters

1) Output of output parameter signals. The signals must be evaluated and/or further processed accordingly by the user.

Type	Description	Size in Bits	Format Option
SAFEBOOL	Bit	1	Bool (signal source: safe device)
SAFEINT	Integer	16	Binary number, hexadecimal number, unsigned decimal number (signal source: safe device)

Table 214: SF_SafeMC_Speed_BR: Formats of the data types used

4.2 Function

The primary purpose of the function block SF_SafeMC_Speed_BR is to establish a link between the safe speed of an axis and the respective encoder error status. An assignment is then made to a defined safe axis.

The function block SF_SafeMC_Speed_BR 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 is then only valid when this output parameter is TRUE!

Danger!

If the speed signal is not validated, then an invalid speed value could be used in the safe application. This can result in hazardous situations!

4.3 Error prevention

Danger!

Validation

Each of the safety functions that are used must be validated separately.
Furthermore, the entire safety application (and therefore also the interaction of the individual functions) must be tested.

4.3.1 Plausibility errors

Plausibility errors (limit values, data types, variable/constant), which occur when the function block is used, are detected and reported by the function block or compiler.
However, this is not always possible in the event of connection errors.

The function block cannot check whether:

- Actual parameter values or constants within the validity range are in fact incorrect for the safety function executed. However, a static TRUE signal at the Reset input is detected by the function block and reported as an error.
- Actual parameters have been connected incorrectly.
- I/O formal parameters have not been connected by mistake.

Please note, therefore:

> **Danger!**
>
> **The user is responsible for the connection of the safety function (sub-application).**
>
> **The connection for validating the sub-application must be checked**

4.3.2 Validate the speed signal

To ensure valid evaluation of the speed signal, the corresponding encoder error status bit must also always be checked.
The speed signal is then only valid when this output parameter is TRUE!

> **Danger!**
>
> **If the speed signal is not validated, then an invalid speed value could be used in the safe application. This can result in hazardous situations!**

4.3.3 Machine/system startup without safeguard function test

A faulty safeguard is only detected following a function test. A function test is not supported by the function block. Without additional measures, a faulty safeguard can result in errors.

> **Danger!**
>
> **The user is responsible for performing safeguard function tests.**
> **This means that the safeguard must be validated!**

Possible causes of a faulty safeguard:

- faulty devices (hardware errors)
- Cross circuit, short circuit, and cable break (user error, wiring error)

4.4 Input parameters

4.4.1 S_AxisID

General function

- This input parameter assigns a real axis to the function block.

Data type

- SAFEINT

Connection

- Constant

Function description

You can assign the axis by dragging and dropping it onto the respective parameter in the SafeDESIGNER.

> **Information:**
>
> **The combination of AxisID and function block SF_SafeMC_Speed_BR can be used more than once in the safe application!**

4.5 Output parameters

4.5.1 S_ScaledSpeed

General function

- Indicates the current value of the scaled safe speed

Data type

- SAFEINT

Connection

- Variable

Function description

This output parameter Indicates the current value of the scaled safe speed for a real axis.

> **Danger!**
>
> **The value of the output parameter S_ScaledSpeed is only valid if the output parameter S_NotErrENC is TRUE. Otherwise, it is invalid and can no longer be used.**

4.5.2 S_NotErrENC

General function

- Information about the error state of the safe encoder signal

Data type

- SAFEBOOL

Connection

- Variable

Function description

This output parameter indicates the error state of the signal for a defined safe encoder.
If an encoder error is detected or if the SafeMC 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 output parameter S_ScaledSpeed is valid.

FALSE

The encoder signal from a defined safe axis is faulty or the axis itself is in an error state. Further information about the error can be found in the Safety Logger in Automation Studio.

> **Danger!**
>
> **This signal should only be used for status information. This only applies in relation to the requested safety functions.**
> **S_NotErrENC does not represent the functional safe state of the SafeMC module!**

> **Danger!**
>
> **The value of the output parameter S_ScaledSpeed is only valid if the output parameter S_NotErrENC is TRUE. Otherwise, it is invalid and can no longer be used.**

4.6 Signal sequence diagram for the function block

A signal sequence diagram cannot be specified for this function block.

4.7 Application example

The following application example illustrates a potential comparison of the scaled safe speed and a fixed value in the safe application.

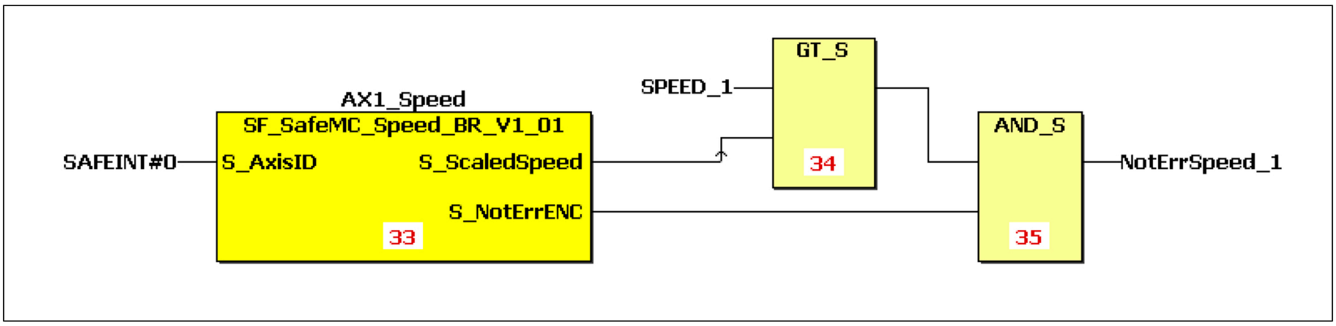


Figure 80: SF_SafeMC_Speed_BR: Evaluation of the scaled safe speed

5 SF_SafeMC_Position_BR

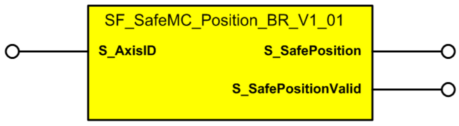


Figure 81: Function block SF_SafeMC_Position_BR

Information:

The function block SF_SafeMC_Position_BR_V1_01 cannot be used without safety release 1.4.

If safety release 1.3 is being used, then SafeDESIGNER returns an error when compiling the safety application!

5.1 Formal Parameters of the Function Block

In the following, a "variable" may designate either a variable or 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 215: SF_SafeMC_Position_BR: Brief overview of the input parameters

1) Evaluation of 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 216: SF_SafeMC_Position_BR: Brief overview of the output parameters

1) Output of output parameter signals. The signals must be evaluated and/or further processed accordingly by the user.

Type	Description	Size in Bits	Format Option
SAFEBOOL	Bit	1	Bool (signal source: safe device)
SAFEINT	Integer	16	Binary number, hexadecimal number, unsigned decimal number (signal source: safe device)
SAFEDINT	Long	32	Binary number, hexadecimal number, unsigned decimal number (signal source: safe device)

Table 217: SF_SafeMC_Position_BR: Formats of the data types used

5.2 Function

The primary purpose of the function block SF_SafeMC_Position_BR is to establish a link between the safe position of an axis and the respective status. An assignment is then made to a defined safe axis.

The function block SF_SafeMC_Position_BR 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 is only considered homed and valid if this output parameter indicates SAFETRUE!

Danger!

If the position signal is not validated, then an invalid position could be used in the safe application. This can result in hazardous situations!

5.3 Error prevention

> **Danger!**
>
> **Validation**
>
> **Each of the safety functions that are used must be validated separately.**
> **Furthermore, the entire safety application (and therefore also the interaction of the individual functions) must be tested.**

5.3.1 Plausibility errors

Plausibility errors (limit values, data types, variable/constant), which occur when the function block is used, are detected and reported by the function block or compiler.
However, this is not always possible in the event of connection errors.

The function block cannot check whether:

- Actual parameter values or constants within the validity range are in fact incorrect for the safety function executed.
- Actual parameters have been connected incorrectly.
- I/O formal parameters have not been connected by mistake.

Therefore the following must be taken into account:

> **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 position signal

To ensure valid evaluation of the position signal, the corresponding status bit S_PositionValid must also always be checked.
The position is only considered homed and valid if this output parameter indicates SAFETRUE!

> **Danger!**
>
> **If the position signal is not validated, then an invalid position could be used in the safe application. This can result in hazardous situations!**

5.3.3 Machine/system startup without safeguard function test

A faulty safeguard is only detected following a function test. A function test is not supported by the function block. Without additional measures, a faulty safeguard can result in errors.

> **Danger!**
>
> **The user is responsible for performing safeguard function tests.**
> **This means that the safeguard must be validated!**

Possible causes of a faulty safeguard:

- faulty devices (hardware errors)
- Cross circuit, short circuit, and cable break (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

Function description

You can assign the axis by dragging and dropping it onto the respective parameter in the SafeDESIGNER.

Information:

The combination of AxisID and function block SF_SafeMC_Position_BR can be used more than once in the safe application!

5.5 Output parameters

5.5.1 S_SafePosition

General function

- Indicates the current safe position in units

Data type

- SAFEDINT

Connection

- Variable

Function description

This output parameter Indicates the current value of the safe position for a real axis in units.

> **Danger!**
>
> **The value of the output parameter S_SafePosition is only valid if the output parameter S_SafePositionValid is SAFETRUE. Otherwise, it is invalid and can no longer be used.**

5.5.2 S_SafePositionValid

General function

- Status information for the safety function "safe homing" and the safe position

Data type

- SAFEBOOL

Connection

- Variable

Function description

This output parameter specifies whether or not the axis has been safely home 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 SafeMC module is in an error state or the function block has not yet been activated.
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 SafeMC module!**

> **Danger!**
>
> **The value of the output parameter S_SafePosition is only valid if the output parameter S_SafePositionValid is SAFETRUE. Otherwise, it is invalid and can no longer be used.**

Danger!

This signal should only be used for status information.

S_SafePositionValid does not represent the functional safe state of the SafeMC module!

Danger!

The value of the output parameter S_SafePosition is only valid if the output parameter S_SafePositionValid is SAFETRUE. Otherwise, it is invalid and can no longer be used.

5.6 Signal sequence diagram for 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 use for the function Safe Position Monitor on the SafeLOGIC.

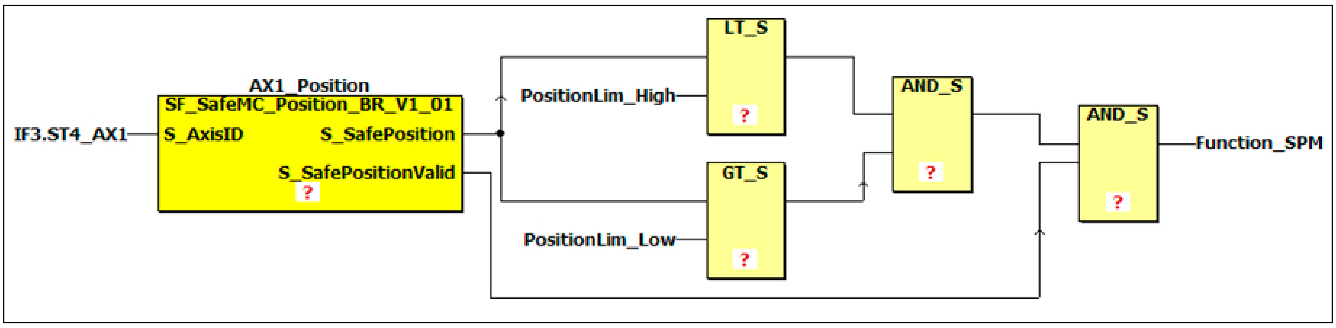


Figure 82: SF_SafeMC_Position_BR: Function "Safe Position Monitor"

Chapter 6 • SafeDESIGNER

See Integrated Safety User's Manual MASAFETY1-ENG, "SafeDESIGNER" chapter.

Chapter 7 • Standards and certifications

1 Applicable European directives

- EMC directive 2004/108/CE
- Low-voltage directive 2006/95/CE
- Machine guideline 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 including specific test methods
IEC 61800-5-1	Electrical drive systems with adjustable speed • Part 5-1: Safety requirements - Electrical, thermal and power requirements (IEC 61800-5-1:2003)
EN 61800-5-2	Adjustable speed electrical power drive systems • Part 5-2: Safety requirements - Functional requirements
IEC/EN 61131-2	Programmable logic controllers • Part 2: Equipment requirements and tests
EN 60204-1	Safety of machinery - Electrical equipment on machines • Part 1: General requirements
IEC 61508	Functional safety of electrical/electronic/programmable electronic safety-related systems
EN 50178-1	Electronic equipment for high voltage systems
EN 1037	Safety of machinery - Prevention of unexpected start-up
EN 954-1 [1)]	Safety of machinery - Safety-related parts of control systems • Part 1: General design principles
EN ISO 13849-1	Safety of machinery - Safety-related parts of control systems • Part 1: General design principles
EN 62061	Safety of machinery - Functional safety of safety-related electrical, electronic and programmable electronic control systems
UL 508C	Power Conversion Equipment

Table 218: Applicable standards for ACOPOS servo drives

1) Replaced by EN ISO 13849-1.

2.1 Limit values

The limit values specified from section Table 219: Mechanical conditions during operation to section Table 238: Additional environmental limits 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 IEC 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 1 m/s² acceleration

Table 219: Mechanical conditions during operation

1) This machine directive only applies to logic units for safety functions that are initially being placed on the market by B&R for sale or use.
2) limit values from CISPR11, group 2, class A (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 220: Mechanical conditions during transport

1) Only valid for components in original packaging
2) The values in "Operation" apply to components that are not in their original packaging.

3.2 Climate conditions in accordance with IEC 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 221: Climate conditions during operation

Storage

IEC 60721-3-1, class 1K4	
	EN 61800-2
Storage temperature	-25 to +55°C

Table 222: Climate conditions (temperature) during storage

IEC 60721-3-1, class 1K3	
	EN 61800-2
Relative humidity during storage	5 to 95%, non-condensing

Table 223: Climate conditions (humidity) during storage

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 224: 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 BGIA: EMC and functional safety for drive systems 8/2009, item 5.

4.1 Evaluation criteria (performance criteria)

Performance criteria (PC)	Description
A	Test object not influenced during test
B	Test object only temporarily influenced during test
C	No automatic system reboot (reset required)
FS	Functional safety - Behavior of test object in accordance with EN 61800-5-2, Item 6.2.5.3

Table 225: Evaluation criteria (performance criteria) for immunity to disturbances

4.2 Low Frequency Disturbances in accordance with IEC 61800-3

The following limits are valid for industrial environments (category C3[3)]).

3) limits from CISPR11, group 2, class A (second environment).

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 226: Limits 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 227: 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 228: 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 229: Limit values for voltage dips and short-term interruptions

Asymmetric voltage und frequency changes

IEC 61000-2-4, class 3		
	EN 61800-3	**Performance criteria**
Asymmetric 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 230: Limit values for asymmetric voltages and frequency changes

4.3 High Frequency Disturbances in accordance with IEC 61800-3

These immunity tests are valid for industrial environments (category C3[4]).

Electrostatic discharge

Tests in accordance with IEC 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	4kV	B	6kV	FS
Discharge through the air to plastic housing parts	8kV		15kV	

Table 231: Limits for electrostatic discharge

1) The total number of discharges depends on the required Safety Integrity Level (SIL) and can be found in BGIA: EMC and functional safety for drive systems 8/2009, item 5.

Electromagnetic fields

Tests in accordance with IEC 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 27 GHz ... 3 V/m, 80% amplitude modulation at 1 kHz	FS

Table 232: Limits for electromagnetic fields

4) limits from CISPR11, group 2, class A (second environment).

Burst

Tests in accordance with IEC 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
Lines for measurement and control functions in the process environment	2 kV, 1 min		4kV	
Signal interfaces, other lines	1 kV, 1 min		2kV	

Table 233: Limits for burst

1) The duration of the effect depends on the required Safety Integrity Level (SIL) and can be found in BGIA: EMC and functional safety for drive systems 8/2009, item 5.

Surge

Tests in accordance with IEC 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, unsymmetrical	B	2 kV (2 Ω) [2], DM, symmetrical 4 kV (12 Ω) [2], CM, unsymmetrical	FS

Table 234: Limits for surge

1) The number of pulses depends on the required Safety Integrity Level (SIL) and can be found in BGIA: EMC and functional safety for drive systems 8/2009, item 5.
2) The impedance was added from IEC 61000-4-5 because it is not defined in IEC 61800-3.

High frequency conducted disturbances

Tests in accordance with IEC 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
Lines for measurement and control functions in the process environment				
Signal interfaces, other lines				

Table 235: Limits for conducted disturbances (radio frequency)

5 Requirements for emissions (EMC)

5.1 High Frequency Emissions in accordance with IEC 61800-3

These emission tests are valid for industrial environments (category C3[5]).

Conducted emissions on the power connections

Tests in accordance with IEC 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 up to 70	80 dB (µV) Decreases with the logarithm of the frequency up 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 236: Limits for conducted emissions on the power connections

Electromagnetic emissions

Tests in accordance with IEC 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 237: Limit values for electro-magnetic emissions

1) The limit values were increased by 10 dB (µV/m) when measuring from distances of 10 m.

5) limits from CISPR11, group 2, class A (second environment).

6 Other Environmental Limit Values in accordance with IEC 61800-2

	EN 61800-2
Degree of pollution in accordance with IEC 61800-2, 4.1.2.1.	2 (non-conductive pollution)
Overvoltage cat. in accordance with IEC 60364-4-443:1999	III
EN 60529 protection	IP20
Reduction of the continuous current at installation altitudes over 500 m above sea level	10% per 1000 m
Maximum installation altitude	4000 m [1)]

Table 238: Additional environmental limits

1) Requirements that go above and beyond this need to be arranged with B&R.

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	All harmonized EN standards for the applicable directives have been met.
Russian Federation	GOST-R certification has been obtained for the export of all B&R ACOPOS servo drives to the Russian Federation.
	All important B&R servo drives have the FS - Functional Safety - certification mark from TÜV Rheinland.

Table 239: International certifications

8 Standards and definitions for safety technology

Stop functions in accordance with IEC 60204-1:2006 (Electrical Equipment for Machines, Part 1: General Requirements)

The following three stop function categories exist:

Category	Description
0	Stop by immediately switching off the power to the machine drive elements (i.e. uncontrolled stop).
1	A controlled stop where the power to the machine drive elements remains on until the stop procedure is completed. The power is switched off after the stop is complete.
2	A controlled stop, the power to the machine drive elements is not switched off.

Table 240: Overview of stop function categories

The necessary stop functions must be determined based on a risk assessment for 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 IEC 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.
- The power to the machine drive elements which 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. Additionally, 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. [6)]

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[1)].

Performance Levels (PL) in accordance with EN ISO 13849-1 (Safety of Machinery – Safety-related Parts of Control Systems, Part 1: General Design Principles)

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 so 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 - bias current fail-safe, etc.).	**Caution!** **An error can cause the loss of safety functionality.**

Table 241: Overview of Performance Levels (PL)

6) In accordance with the national foreword of the valid German-language version of IEC 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 components must be designed in such a way that their safety functionality is checked at 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 recognized 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 recognized. A buildup of errors can cause the 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 recognized the next time (or before) the safety function is required. If this type of recognition is not possible, a buildup of errors is not permitted to cause the safety functionality to fail.	**Information:** **Safety functionality remains active when an error occurs. Errors are recognized in time to prevent safety functionality from failing.**

Table 241: 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:

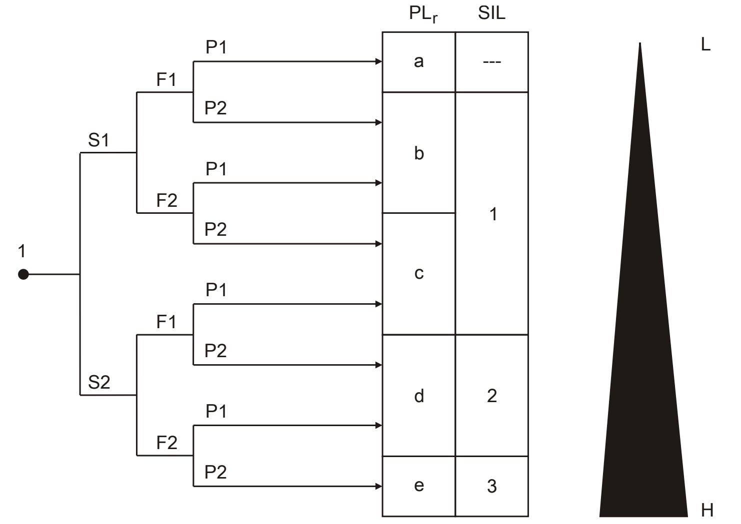


Figure 83: Risk diagram for determining the PL_r for each safety function in accordance with EN ISO 13849-1, Appendix A

Legend

1 Starting point for assessing the impact on risk reduction
L Low impact on risk reduction
H High impact on risk reduction
PL_r Necessary 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 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, short interventions in danger zone), 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

Chapter 8 • CE declaration of conformity

This technical data sheet was originally created in German. The German edition therefore represents the original instruction manual in accordance with 2006/42/EC machine guidelines. Technical data sheets in other languages are to be interpreted as translations of this original instruction manual.

Product manufacturer:

Bernecker + Rainer

Industrie-Elektronik Ges.m.b.H.

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AUSTRIA

The CE declaration of conformity can be downloaded from the B&R website at **http://br-automation.com**.

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