ACOPOSmulti SafeMC
User´s Manual

Perfection in Automation
www.br-automation.com

ACOPOSmulti SafeMC

User's Manual

Version: **1.00 (March 2010)**

Best. No.: **MAACPMSAFEMC-ENG**

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 does its best 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

Table 1: Manual history

2. 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

3. Release information

Manual version	Valid for
V1.00	

Table 3: Release information

4. Qualified personnel

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

- qualified personnel that are familiar with relevant safety concepts for automation technology and the applicable national standards and guidelines.
- 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.

5. Safety guidelines

5.1 Organization of safety notices

The safety notices in this manual are organized as follows:

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

Table 4: Description of the safety notices used

5.2 General information

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, flight control systems, flight safety, the control of mass transportation systems, medical life support systems and the control of weapons systems.

Danger!

Drive systems and servo motors can have bare parts with voltages applied (e. g. terminals) or hot surfaces. Additional sources of danger result from moving machine parts. Improperly removing the required covers, inappropriate use, incorrect installation or incorrect operation can result in severe personal injury or damage to property.

All tasks, such as transport, installation, commissioning and service, are only permitted to be carried out by qualified personnel. Qualified personnel are persons familiar with transport, mounting, installation, commissioning and operation of the product and have the respective qualifications (e. g. IEC 60364). National accident prevention guidelines must be followed.

The safety guidelines, 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!

5.3 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 EC directive 2006/42/EG (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 living areas, shops and 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 the user's manual. The connection and environmental specifications must be met!

Danger!

Electronic devices are generally not failsafe. If the drive systems fails, the user is responsible for making sure that the motor is placed in a secure state.

5.4 Protection against electrostatic discharges

Electrical components that are vulnerable to electrostatic discharge (ESD) must be handled accordingly.

5.4.1 Packaging

Electrical components with housing do not require any special ESD packaging, but must be handled correctly (see "Electrical components with housing").

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

5.4.2 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 the circuit boards.

Electrical components without housing

In addition to "Electrical components with housing", the following also applies:

- Any persons handling electrical components or devices that will be installed in the electrical components must be grounded.
- Components can only be touched on the small sides or on the front plate.
- Components should always be stored in a suitable medium (ESD packaging, conductive foam, etc.).
  Metallic surfaces are not suitable storage surfaces!
- Electrostatic discharges should be avoided on the components (e.g. through charged plastics).
- A minimum distance of 10 cm must be kept 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.).
- The increased ESD protective measures for individual components are not necessary for our customers for handling B&R products.

5.5 Transport and storage

During transport and storage, devices must be protected from excessive stress (mechanical load, temperature, humidity, aggressive atmospheres, etc.).

Drive systems contain components sensitive to electrostatic charges which can be damaged by inappropriate handling. It is therefore necessary to provide the required safety precautions against electrostatic discharges during installation or removal of drive systems.

5.6 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!

Installation must take place according to the user's manual using suitable equipment and tools.

Devices must be installed without voltage applied and by qualified personnel. Before installation, voltage to the switching 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 4 "Sizing").

5.7 Operation

5.7.1 Protection against touching electrical parts

Danger!

To operate drive systems, it is necessary for certain parts to carry dangerous voltages over 42 VDC. A life-threatening electrical shock could occur if you come into contact with these parts. This could result in death, severe injury or material damage.

Before turning on a drive system, make sure that the housing is properly connected to ground (PE rail). The ground connection must be made, even when testing the drive system or when operating it for a short time!

Before turning the device on, make sure that all parts with voltage applied are securely covered. During operation, all covers and switching 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 result in death, severe injury or material damage.

Control and high power contacts can have voltage applied, even when the motor is not turning. Touching the contacts when the device is switched on is not permitted.

Before working on drive systems, they must be disconnected from the power mains and prevented from being switched on again.

Danger!

Risk of electric shock

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:

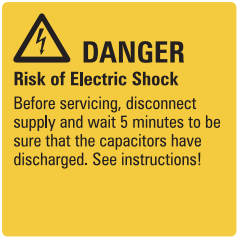


Figure 1: Warning label on the ACOPOSmulti module

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 according to IEC 60364-4-41 or EN 61800-5-1 and that correspond to SELV / PELV.

Never remove the electrical connections from the drive system with voltage applied. In unfavorable conditions, arcs can occur causing personal injury and damage to contacts.

5.7.2 Protection from dangerous movements

Danger!

Incorrect control of motors can cause unwanted and dangerous movements! Such incorrect behavior can have various causes:

- **Incorrect installation or an error when handling the components**
- **Incorrect or incomplete wiring**
- **Defective devices (drive system, motor, position encoder, cable, brake)**
- **Incorrect control (e. g. caused by software error)**

Some of these causes can be recognized and prevented by the drive system using internal monitoring. However, it is generally possible for the motor shaft to move every time the device is switched on! Therefore protection of personnel and the machine can only be guaranteed using higher level safety precautions.

The movement area of machines must be protected to prevent accidental access. This type of protection can be obtained by using stabile mechanical protection such as protective covers, protective fences, protective gates or photocells.

Removing, bridging or bypassing these safety features and entering the movement area is prohibited.

A sufficient number of emergency stop switches are to be installed directly next to the machine. The emergency stop equipment must be checked before commissioning the machine.

On free running motors, remove shaft keys or prevent them from being catapulted.

The holding brake built into the motors cannot prevent hoists from allowing the load to sink.

5.8 Lifespan

The calculation of the safety characteristics are based on a testing interval of 20 years.

This means that all B&R safety drive systems must be taken out of service one week (at the latest) before the 20 year time span expires (starting from B&R's delivery date).

Danger!

Operating the B&R drive systems and servo motors beyond the specified lifespan is not permitted! The user must ensure that all B&R drive systems and servo motors are removed from operation i.e. replaced by new B&R drive systems and servo motors before their lifespan expires.

5.9 Environmentally-friendly disposal

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

5.9.1 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	Electronics recycling
Cardboard box / paper packaging	Paper / cardboard recycling

Table 5: Environmentally-friendly separation of materials

Disposal must comply with the respective legal regulations.

Chapter 2 • System characteristics

1. SafeMC Module

1.1 General information

The SafeMC module is 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 ACOPOSmulti axis cannot be retrofitted!

1.2 Safety functions

The following functions are supported by the SafeMC module:

Safety function	EN ISO 13849-1	EN 61508 / EN 62061	Safe encoder evaluation required
Safe Torque Off (STO)	PI e	SIL 3	No
Safe Torque Off One Channel (STO1)	PI d	SIL 2	No
Safe Operation Stop (SOS)	PI d	SIL 2	Yes
Safe Stop 1 (SS1)	PL e (time monitored) PI d	SIL 3 (time monitored) SIL 2	No Yes
Safe stop 2 (SS2)	PI d	SIL 2	Yes
Safely Limited Speed (SLS)	PI d	SIL 2	Yes

Table 6: Safety functions and corresponding safety levels

Safety function	EN ISO 13849-1	EN 61508 / EN 62061	Safe encoder evaluation required
Safe Maximum Speed (SMS)	PI d	SIL 2	Yes
Safe Direction (SDI)	PI d	SIL 2	Yes
Safely Limited Increment (SLI)	PI d	SIL 2	Yes
Safe Brake Control (SBC)	PI e	SIL 3	No

Table 6: Safety functions and corresponding safety levels

Details of the individual safety functions

See Chapter 6 "Safety technology", on page 165.

2. Integrated Safety Technology

Seamless integration of safety technology during functional 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 stopping 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

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 POWERLINK Safety accomplish this all using standard Ethernet mechanisms. This allows these protocols to be combined with all conventional and, more importantly, newer Ethernet profiles. POWERLINK Safety 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 functional 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.

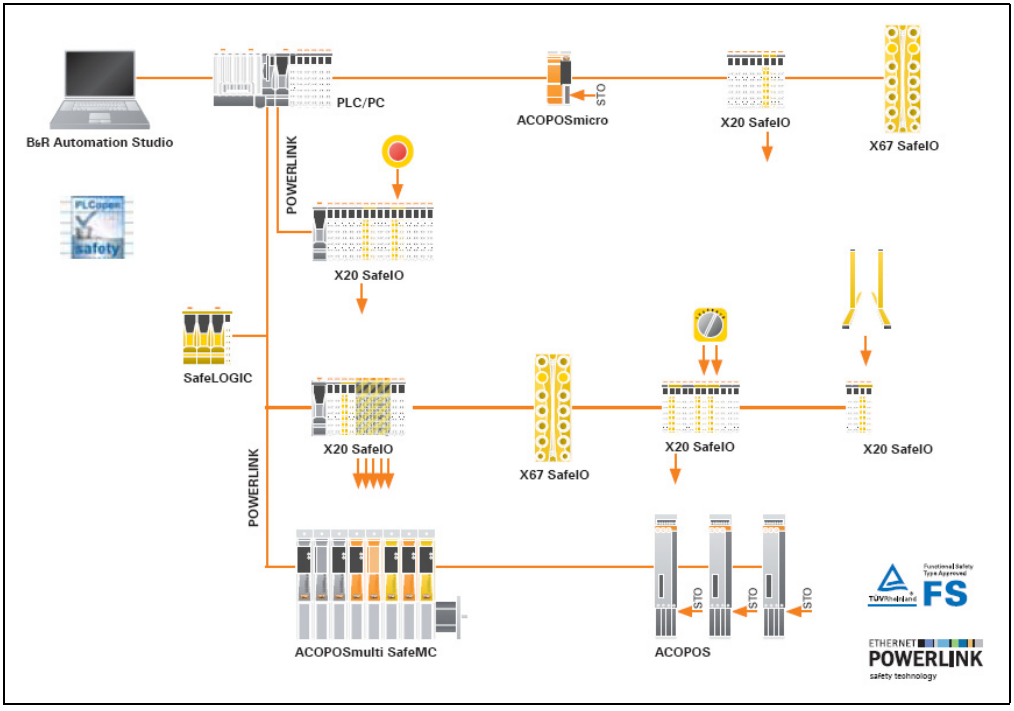


Figure 2: Integrated Safety Technology - Topology

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
- SG4 CPUs

4. System limits

The following limitations exist when using SafeMC modules:

- A SafeMC module can only securely communicate with one (1) SafeLOGIC module with SafeMC Support (X20SL8010, X20SL8011). It is not intended for a SafeMC module to securely communicate with several SafeLOGIC modules or with other safe modules (other SafeIO, other 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, SafeMC, 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 (one or two SafeMC modules), 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 8 SAFEBOOL variables per data direction.
- In a safety-related application, a maximum of 20 SafeLOGIC devices can interact.
- The output side reference data size of the SafeLOGIC is limited to 1490 bytes.
- 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 shut-off signal.

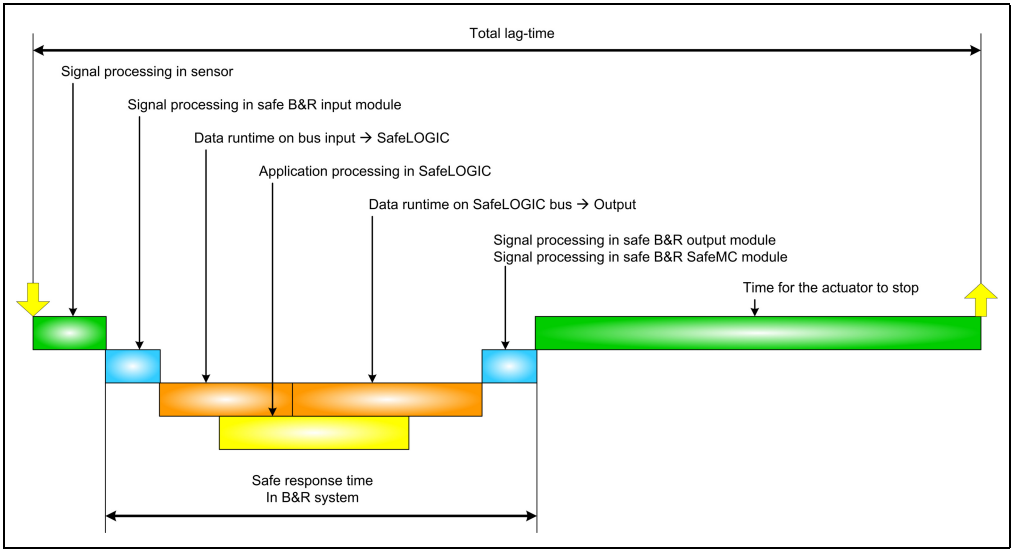


Figure 3: Total lag-time

As evident in figure 3, the safe response time in the B&R system is comprised of the following partial response times:

- Signal processing in the input module
- Data runtime on bus between input and SafeLOGIC
- Data runtime on bus between SafeLOGIC and output
- Signal processing in the SafeMC module

Danger!

The following chapters 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 will as the time until the actuator reaches a standstill.

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

5.1 Signal processing in safe B&R input module

Information about the safe signal processing in the safe B&R input module can be found in the Integrated Safety User's Manual MASAFETY1-ENG.

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 SafeLOGIC (or output) is the sum of the cycle times or CPU copy times in the transfer line.
- The POWERLINK MN (functional 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, the data runtimes are monitored on the bus using the POWERLINK Safety services. The time needed to process the application in SafeLOGIC 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 shut off by the SafeLOGIC if modified parameters in POWERLINK MN alter the data runtimes on the bus that 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 shut off by the SafeLOGIC if EMF disturbances cause data failures that lie outside of the SafeDESIGNER parameters defined in the parameter group "Safety_Response_Time".

5.3 Signal processing in safe B&R output module

Information about the safe signal processing in the safe B&R output module can be found in the Integrated Safety User's Manual MASAFETY1-ENG.

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.

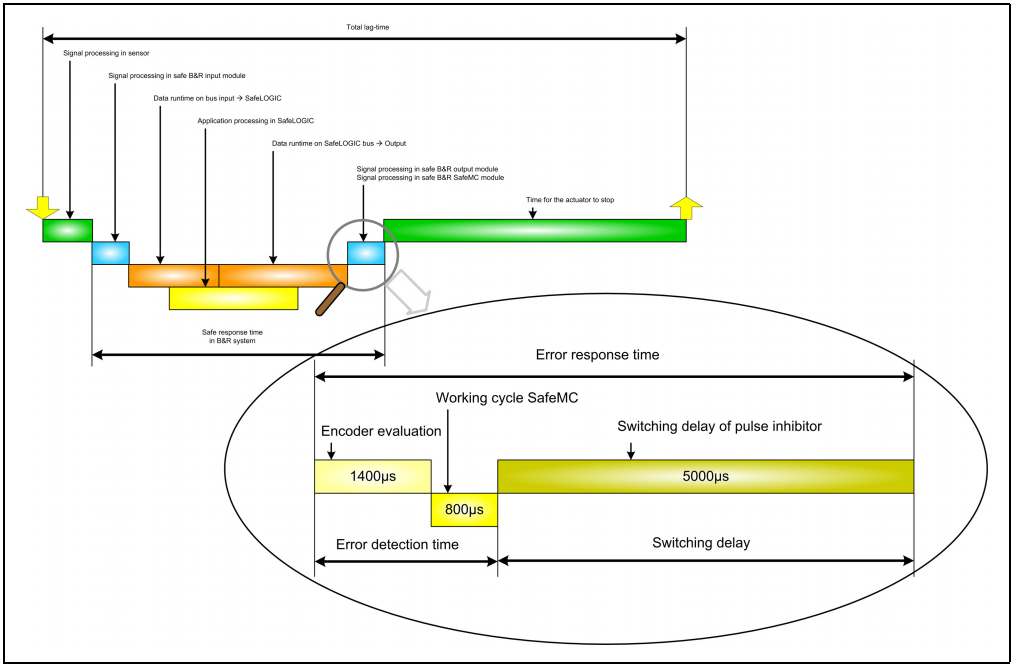


Figure 4: Safe error response time

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!

5.5 Calculation of the safe response times

The safe response time can be calculated using the response time calculator. A description of this can be found in the section "Calculating the safe response time" in the Integrated Safety User's Manual MASAFETY1-ENG.

5.6 Parameters for safe response time in the SafeDESIGNER

Generally, the parameters for safe response time are set the same for all stations involved in the application. This is why these parameters are configured in the SafeDESIGNER by the SafeLOGIC. For application situations in which individual safety functions require optimum response time behavior, the parameters for safe response time can be configured individually for this on the affected module.

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

<table>
<tr><th>Parameter</th><th>Description</th><th>Default value</th><th>Units</th></tr>
<tr><td>Manual_Configuration</td><td>Generally, the parameters for safe response time are set the same for all stations involved in the application. This is why these parameters are configured in the SafeDESIGNER by the SafeLOGIC. For application situations in which individual safety functions require optimum response time behavior, the parameters for safe response time can be configured individually for this on the affected module.</td><td>No</td><td>-</td></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 safe response time from the group "Safety_Response_Time" on the SafeLOGIC are valid for the module.</td></tr>
</table></td></tr>
<tr><td>Synchronous_Network_Only</td><td>This parameter determines the synchronization properties of the underlying network.</td><td>Yes</td><td>-</td></tr>
<tr><td></td><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.</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_CycleTime_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>
</table>

Parameter	Description	Default value	Units
Max_CPU_CrossLinkTask_CycleTime_us	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 no copy task was included for the response time. • Permissible values: 0 - 30000 µs	5000	µs
Min_X2X_CycleTime_us	This parameter corresponds with the minimum duration of communication between the SafeMC module and the POWERLINK interface. • Permissible values: 200 - 30000 µs	600	µs
Min_Powerlink_CycleTime_us	This parameter specifies the minimum POWERLINK cycle time used to calculate the safe response time. • Permissible values: 200 - 30000 µs	200	µs
Min_CPU_CrossLinkTask_CycleTime_us	This parameter specifies the minimum cycle time for the copy task in 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	0	µs
Worst_Case_Response_Time_us	This parameter specifies the limit value for monitoring the safe response time. • Permissible values: 3000 - 50000 µs	50000	µs

5.7 Minimum signal lengths

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

Danger!

Disruption of signals can result in serious safety errors. Test for the smallest possible pulse length in 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.

In the SafeLOGIC, the low phases of the signals can be extended with the functions of the restart inhibit or the signals can be extended with the Timer block.

Chapter 3 • SafeDESIGNER

See Integrated Safety User's Manual MASAFETY1-ENG, "SafeDesigner" chapter.

Chapter 4 • PLCopen

1. Definition of terms

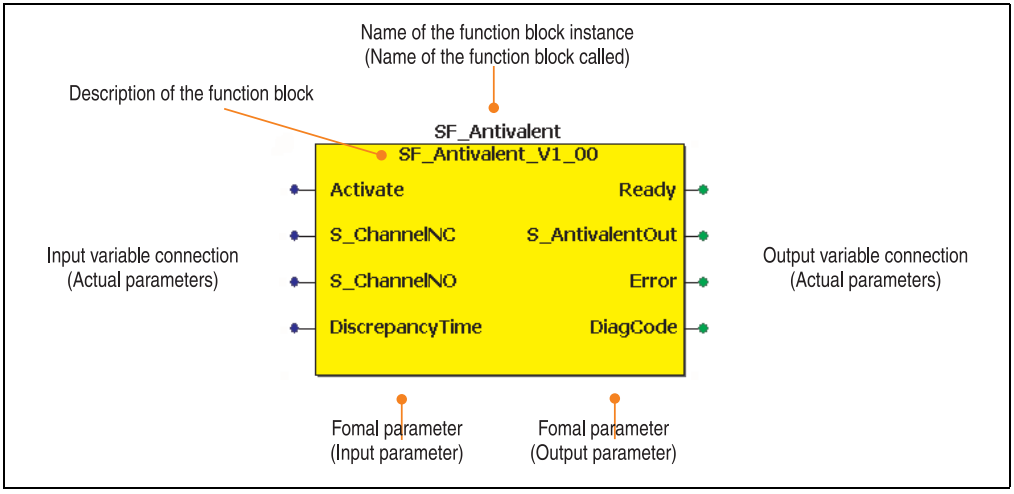


Figure 5: Description of a function block

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 label is created from the function (e.g. SF_Antivalent,
SF = safety function) and the version (Vx_yz). 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

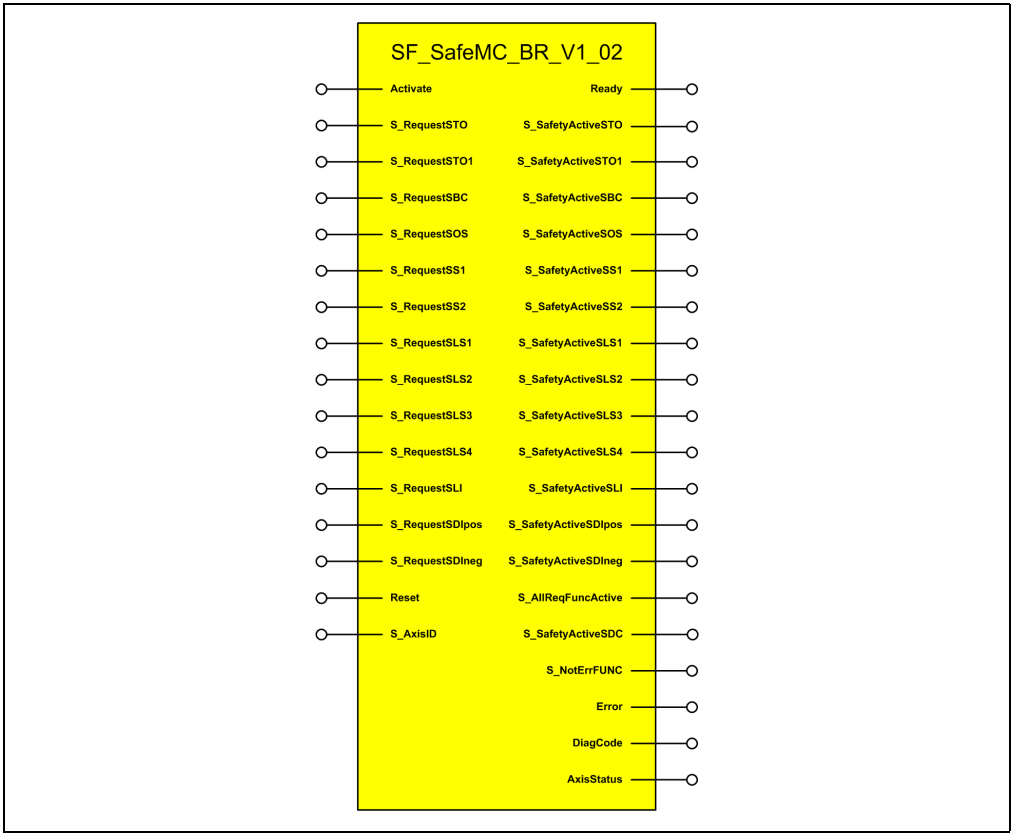


Figure 6: Function block SF_SafeMC_BR

2.1 Formal Parameters of the Function Block

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 7: 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.

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 8: 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)
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 9: 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.

2.2 Function

The function block makes it easy to use the safety functions implemented on the SafeMC.

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 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.

The following functions are supported by the SafeMC module:

Safety function	EN ISO 13849-1	EN 61508 / EN 62061	Safe encoder evaluation required
Safe Torque Off (STO)	PI e	SIL 3	No
Safe Torque Off One Channel (STO1)	PI d	SIL 2	No
Safe Operation Stop (SOS)	PI d	SIL 2	Yes
Safe Stop 1 (SS1)	PL e (time monitored) PI d	SIL 3 (time monitored) SIL 2	No Yes
Safe stop 2 (SS2)	PI d	SIL 2	Yes
Safely Limited Speed (SLS)	PI d	SIL 2	Yes
Safe Maximum Speed (SMS)	PI d	SIL 2	Yes
Safe Direction (SDI)	PI d	SIL 2	Yes
Safely Limited Increment (SLI)	PI d	SIL 2	Yes
Safe Brake Control (SBC)	PI e	SIL 3	No

Table 10: Safety functions and corresponding safety levels

2.3 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.

2.3.1 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 0V.

An error will cause a synchronous axis to lose its synchronicity.

Check the Safety Logger in Automation Studio for detailed information about monitoring!

2.3.2 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.

2.3.3 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.

Please note that a signal change detected at a state-controlled formal parameter will be output as diagnostic code.

2.3.4 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.

2.3.5 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)

2.4 Input parameters

2.4.1 General information about the "S_Request" inputs

The "S_Request" inputs are used to request the respective safety functions.

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.

2.4.2 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.

2.4.3 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

2.4.4 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	Units	Description
Channel selection for One Channel STO (STO1)	HighSide / LowSide	Selection of HighSide or LowSide IGBT in the OneChannelSTO function

Table 11: SafeMC parameter STO1

2.4.5 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 0V!

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 12: SafeMC parameter SBC

2.4.6 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 13: SafeMC parameter SOS

Information:

This safety function requires an EnDat 2.2 Safety encoder!

Information:

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:

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

2.4.7 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 14: SafeMC parameter SS1

Information:

This safety function requires an EnDat 2.2 Safety encoder!

If an EnDat 2.2 Safety encoder is not available, then "ramp monitoring" and "early limit monitoring" must be deactivated.

2.4.8 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 15: SafeMC 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:

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

2.4.9 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 16: SafeMC 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:

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

2.4.10 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 17: SafeMC 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:

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

2.4.11 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 18: SafeMC 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:

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

2.4.12 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 19: SafeMC 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:

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

2.4.13 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 20: SafeMC parameter SLI

Information:

This safety function requires an EnDat 2.2 Safety encoder!

2.4.14 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 21: SafeMC parameter SDIpos

Information:

This safety function requires an EnDat 2.2 Safety encoder!

2.4.15 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 22: SafeMC parameter SDIneg

Information:

This safety function requires an EnDat 2.2 Safety encoder!

2.4.16 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 23: SafeMC parameter Reset

2.4.17 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.

2.5 Output parameters

The output parameters provide information about the state of the SafeMC module and the individual safety functions.

2.5.1 Ready

General function

Message: Function block active/not active.

Data type

BOOL

Connection

Variable

Function description

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.

2.5.2 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.

2.5.3 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.

2.5.4 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.

2.5.5 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.

2.5.6 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.

2.5.7 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.

2.5.8 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.

2.5.9 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.

2.5.10 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.

2.5.11 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.

2.5.12 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 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.

2.5.13 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.

2.5.14 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.

2.5.15 S_SafetyActiveSDC

General function

Information about the status of the ramp monitor

Data type

SAFEBOOL

Connection

Variable

Function description

If the safety function SS1, SS2 or SLS is requested, then the deceleration ramp will be monitored first depending on the configuration. 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 status information.

2.5.16 S_AllReqFuncActive

General function

Information about the status of the requested safety functions

Data type

SAFEBOOL

Connection

Variable

Function description

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.

2.5.17 S_NotErrFUNC

General function

Information about the error state of the SafeMC module

Data type

SAFEBOOL

Connection

Variable

Function description

TRUE

No error was found on the SafeMC module.

FALSE

An error was detected on the SafeMC module (e.g. a monitored limit was exceeded) or the function block has not yet been activated.

In the event of an error, additional information about the error can be found in Automation Studio's Safety Logger.

If the error is a functional error, then it can be confirmed by changing the signal on the Reset input from FALSE to TRUE (positive edge)!

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!

2.5.18 Error

General function

Function block error message

Data type

BOOL

Connection

Variable

Function description

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).

2.5.19 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 specified in table 24 "Diagnostic codes", on page 86.

For status messages (0xxxhex, 8xxxhex) the function block sets Error to FALSE. For error messages (Cxxxhex) the function block sets Error to TRUE.

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. Depending on the configuration, the speed limit SMS is monitored and a violation was not detected.	No action required.
8003	Wait for Confirmation	The SafeMC module is in the Operational internal 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.

Table 24: Diagnostic codes

Code (hex)	State	Description	Possible remedy
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 24: Diagnostic codes

2.5.20 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 25: SafeMC module status bits

2.6 State machine

The following state machine is implemented on the SafeMC module:

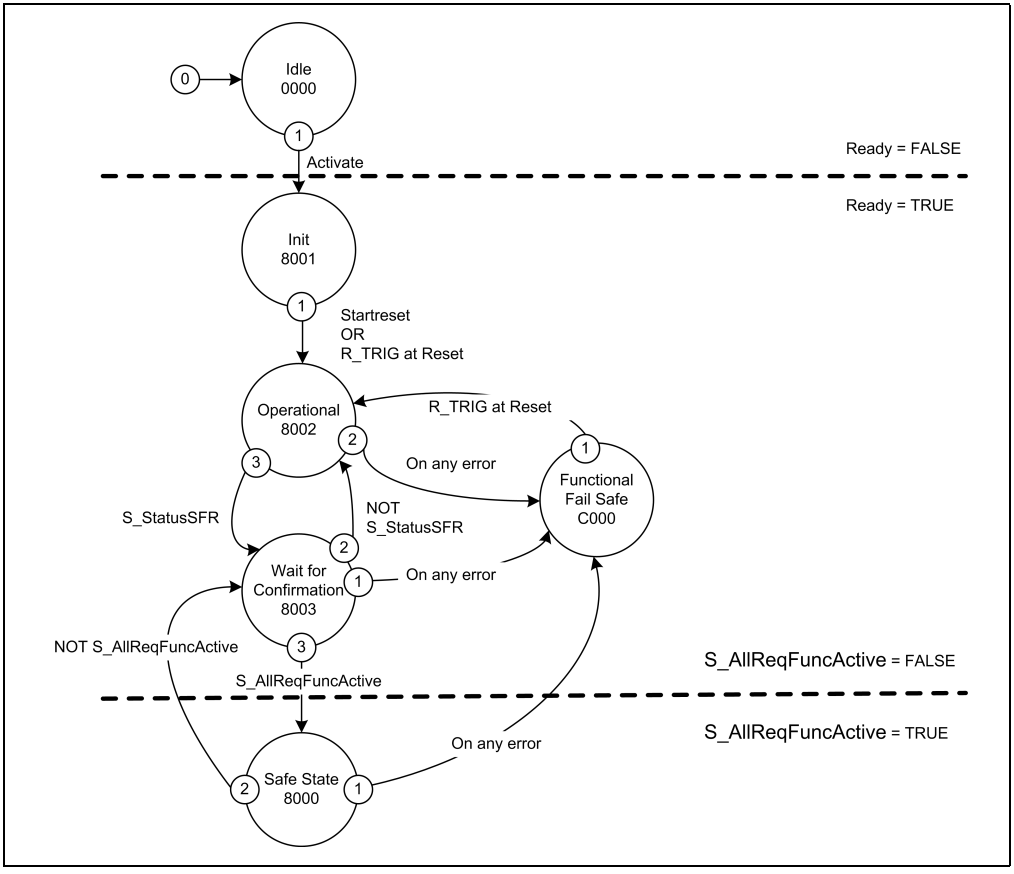


Figure 7: State machine

The individual states are provided on the DiagCode output parameter, as described in section 2.5.19 "DiagCode", on page 86. In this sense, the function block provides a representation of the SafeMC module's state machine.

2.7 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 1.2 "Safety functions", on page 23!

3. SF_SafeMC_Speed_BR

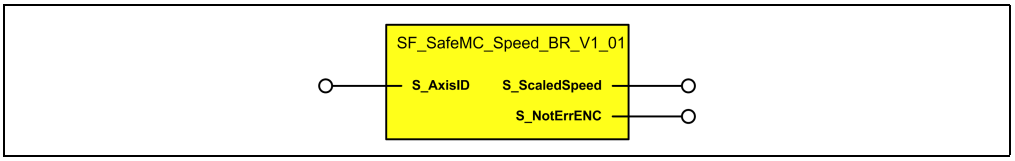


Figure 8: SF_SafeMC_Speed_BR

3.1 Formal parameters of the function block

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 26: Formats of the data types used

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 27: 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 1)	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 28: 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.

3.2 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!

3.3 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.**

3.3.1 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 connection of the safety function (sub-application) is your responsibility. Check the connection when validating the sub-application.

3.3.2 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!

3.3.3 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!

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)

3.4 Input parameters

3.4.1 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!

3.5 Output parameters

3.5.1 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.

3.5.2 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.

3.6 Signal sequence diagram for the function block

A signal sequence diagram cannot be specified for this function block.

3.7 Application example

The following application example illustrates a potential comparison of the scaled safe speed and a fixed value in the safe application.

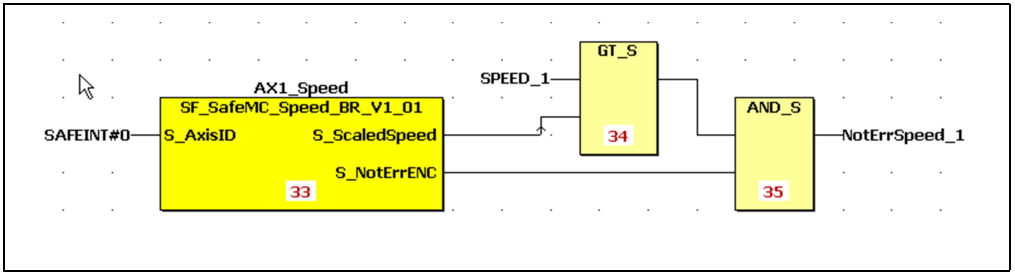


Figure 9: Evaluation of the scaled safe speed

Chapter 5 • ACOPOSmulti SafeMC

1. Module overview

1.1 Secure inverter modules, single-width, 1.4kW ... 11kW (single-axis modules)

1.1.1 Wall mounting

Model number	Short description	Page
8BVI0014HWSS.000-1	ACOPOSmulti inverter module, 1.9 A, HV, wall-mounting, SafeMC	108
8BVI0028HWSS.000-1	ACOPOSmulti inverter module, 3.8 A, HV, wall-mounting, SafeMC	108
8BVI0055HWSS.000-1	ACOPOSmulti inverter module, 7.6 A, HV, wall-mounting, SafeMC	108
8BVI0110HWSS.000-1	ACOPOSmulti inverter module, 15.1 A, HV, wall-mounting, SafeMC	108

Table 29: Module overview - Secure inverter modules, single-width, 1.4kW ... 11kW, single-axis modules (wall mounting)

1.1.2 Cold plate or feed-through mounting

Model number	Short description	Page
8BVI0014HCSS.000-1	ACOPOSmulti inverter module 1.9 A, HV, cold plate or feed-through mounting, SafeMC	108
8BVI0028HCSS.000-1	ACOPOSmulti inverter module 3.8 A, HV, cold plate or feed-through mounting, SafeMC	108
8BVI0055HCSS.000-1	ACOPOSmulti inverter module 7.6 A, HV, cold plate or feed-through mounting, SafeMC	108
8BVI0110HCSS.000-1	ACOPOSmulti inverter module 15.1 A, HV, cold plate or feed-through mounting, SafeMC	108

Table 30: Module overview - Secure inverter modules, single-width, 1.4kW ... 11kW, single-axis modules (Cold plate or feed-through mounting)

1.2 Secure inverter modules, single-width, 1.4kW ... 5.5kW (two-axis modules)

1.2.1 Wall mounting

Model number	Short description	Page
8BVI0014HWDS.000-1	ACOPOSmulti inverter module, 1.9 A, HV, wall mounting, SafeMC, 2 axes	116
8BVI0028HWDS.000-1	ACOPOSmulti inverter module, 3.8 A, HV, wall mounting, SafeMC, 2 axes	116
8BVI0055HWDS.000-1	ACOPOSmulti inverter module, 7.6 A, HV, wall mounting, SafeMC, 2 axes	116

Table 31: Module overview - Secure inverter modules, single-width, 1.4kW ... 5.5kW, two-axis modules (wall mounting)

1.2.2 Cold plate or feed-through mounting

Model number	Short description	Page
8BVI0014HCDS.000-1	ACOPOSmulti inverter module 1.9 A, HV, cold plate or feed-through mounting, SafeMC, 2 axes	116
8BVI0028HCDS.000-1	ACOPOSmulti inverter module 3.8 A, HV, cold plate or feed-through mounting, SafeMC, 2 axes	116
8BVI0055HCDS.000-1	ACOPOSmulti inverter module 7.6 A, HV, cold plate or feed-through mounting, SafeMC, 2 axes	116

Table 32: Module overview - Secure inverter modules, single-width, 1.4kW ... 5.5kW, two-axis modules (Cold plate or feed-through mounting)

1.3 Safe inverter modules, double-width, 16kW ... 32kW (single-axis modules)

1.3.1 Wall mounting

Model number	Short description	Page
8BVI0220HWSS.000-1	ACOPOSmulti inverter module, 22 A, HV, wall-mounting, SafeMC	123
8BVI0330HWSS.000-1	ACOPOSmulti inverter module, 33 A, HV, wall-mounting, SafeMC	123
8BVI0440HWSS.000-1	ACOPOSmulti inverter module, 44 A, HV, wall-mounting, SafeMC	123

Table 33: Module overview - Safe inverter modules, double-width, 16kW ... 32kW, single-axis modules (wall mounting)

1.3.2 Cold plate or feed-through mounting

Model number	Short description	Page
8BVI0220HCSS.000-1	ACOPOSmulti inverter module 22 A, HV, cold plate or feed-through mounting, SafeMC	123
8BVI0330HCSS.000-1	ACOPOSmulti inverter module 33 A, HV, cold plate or feed-through mounting, SafeMC	123
8BVI0440HCSS.000-1	ACOPOSmulti inverter module 44 A, HV, cold plate or feed-through mounting, SafeMC	123

Table 34: Module overview - Safe inverter modules, double-width, 16kW ... 32kW, single-axis modules (Cold plate or feed-through mounting)

2. Technical data

2.1 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 a regeneration choke.

The configuration significantly depends on the following factors:

- Cooling method
- Mean and maximum total power of the inverter and the peripheral supply (e.g. PLC, actuators, motor holding brakes, sensors)
- Mean and maximum power and current of the individual drive units (motors)

The configuration of an ACOPOSmulti drive system is done in 9 steps:

1) Determe cooling method
2) Determine the supply voltage range
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 the ACOPOSmulti power supply module based on the total power required for the ACOPOSmulti inverter modules (with a mains supply voltage < 400 VAC, the respective power rating must be taken into account according to the technical data of the power supply module)
7) 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)
8) Determine the total number of slots by adding the width units of all selected ACOPOSmulti modules (including optional slots)
9) Select the ACOPOSmulti mounting plate according to the total number of slots required and specified cooling method

2.2 Indicators

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

2.2.1 8BVI inverter modules with SafeMC

Single-axis modules

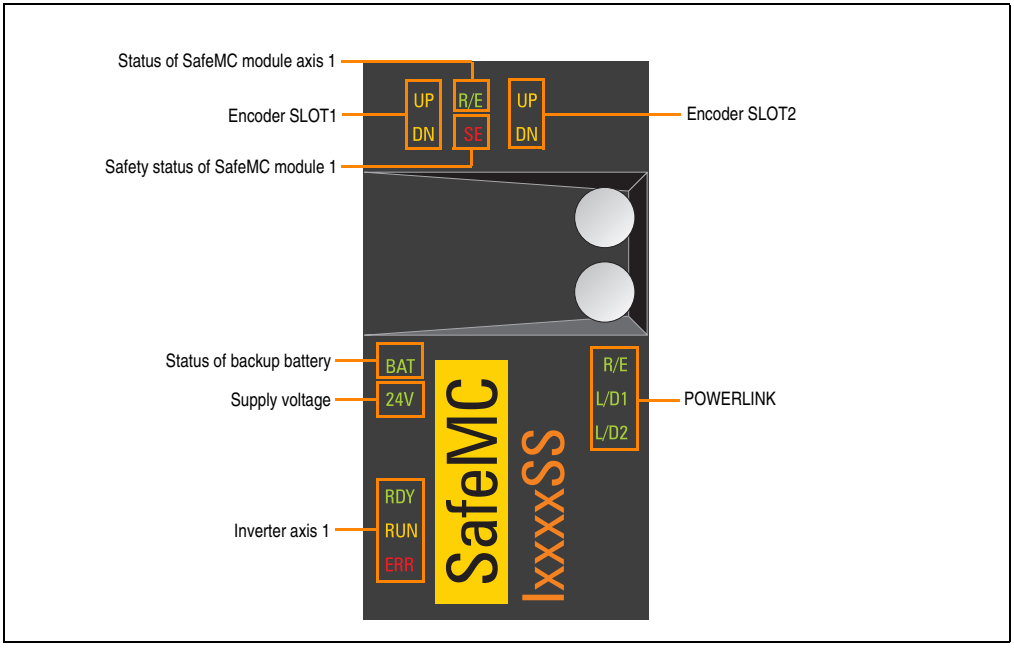


Figure 10: Indicator groups for 8BVI inverter modules with SafeMC (single-axis modules)

Status LEDs

Indicator group	Labeling	Color	Function	Description
POWERLINK	R/E	Green/red	Ready/Error	See 2.2.3 "LED status - POWERLINK", on page 103
	L/D1	Green	Link / Data activity Port 1	
	L/D2	Green	Link / Data activity Port 2	
Inverter axis 1	RDY	Green	Ready	See 2.2.2 "LED status RDY, RUN, ERR (8BVI, 8BVP, 8B0P)", on page 103
	RUN	Orange	Run	
	ERR	Red	Error	
Status of backup battery	BAT	Green/red	Ready / Error	See 2.2.4 "LED status - Backup battery", on page 104

Table 35: LED status - 8BVI inverter modules with SafeMC (single-axis modules)

Indicator group	Labeling	Color	Function	Description
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	Orange	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	Orange	Encoder direction of rotation -	
Status of SafeMC module axis 1	R/E	Green/red	Ready/Error	See 2.2.5 "LED status - SafeMC module", on page 104
Safety status of SafeMC module 1	SE	Red	Safe/Error	

Table 35: LED status - 8BVI inverter modules with SafeMC (single-axis modules) (cont.)

Two-axis modules

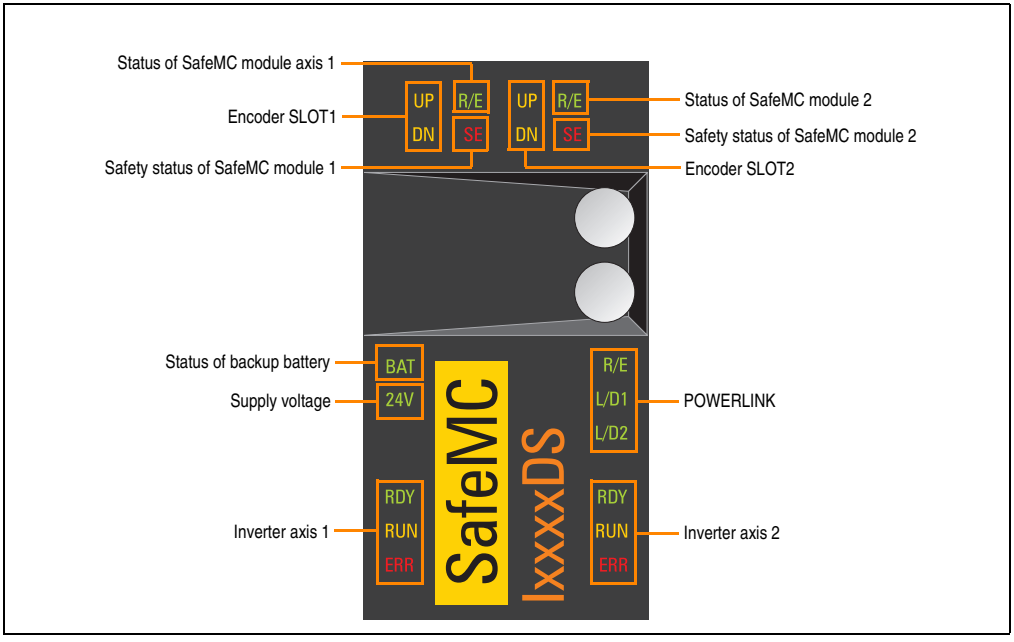


Figure 11: Indicator groups for 8BVI inverter modules with SafeMC (two-axis modules)

Status LEDs

Indicator group	Labeling	Color	Function	Description
POWERLINK	R/E	Green/red	Ready/Error	See 2.2.3 "LED status - POWERLINK", on page 103
	L/D1	Green	Link / Data activity Port 1	
	L/D2	Green	Link / Data activity Port 2	
Inverter axis 1	RDY	Green	Ready	See 2.2.2 "LED status RDY, RUN, ERR (8BVI, 8BVP, 8B0P)", on page 103
	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 2.2.4 "LED status - Backup battery", on page 104
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	Orange	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	Orange	Encoder direction of rotation -	
Status of SafeMC module axis 1	R/E	Green/red	Ready/Error	See 2.2.5 "LED status - SafeMC module", on page 104
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 36: LED status - 8BVI inverter modules with SafeMC (two-axis modules)

2.2.2 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 over-current • Data in EPROM not valid

Table 37 : LED status RDY, RUN, ERR (8BVI, 8BVP, 8B0P)

1) Firmware V2.130 and higher.

2.2.3 LED status - POWERLINK

Labeling	Color	Function	Description	
R/E	Green/red	Ready/Error	LED isn't 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 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 Port 2	Green (lit)	There is a physical connection to another station on the network.
			Green (blinking)	Activity Port 2

Table 38 : LED status - POWERLINK

2.2.4 LED status - Backup battery

Labeling	Color	Function	Description	
BAT	Green/red	Ready / Error	LED isn't 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 39 : LED status - Backup battery

2.2.5 LED status - SafeMC module

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

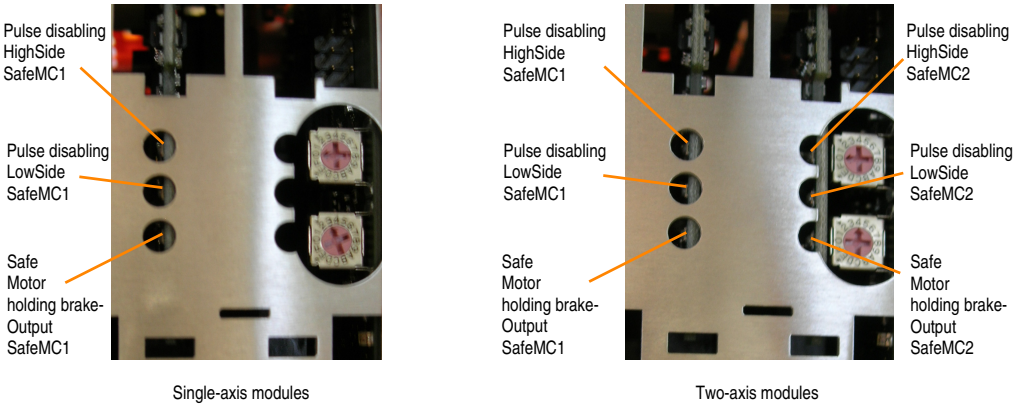


Figure 12: Additional LEDs for SafeMC modules

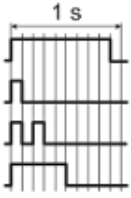
LED	Green	Red	Description
R / E	Off	Off	Module not supplied with current, no communication
	Single flash		Unlink mode
	Double flash		Firmware update
	Blinking		Preoperational mode
	On		RUN mode
	On	Single flash, inverse	Safety-related firmware invalid
		Triple flash, inverse	Update of safety-related firmware
		On	Communication error
	Off	On	Error
LED	**Color**	**Status**	**Description**
Status LED Pulse disabling output, high-side	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, low-side	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
			Boot phase or defective processor Safety pre-operational state Safe communication channel is not OK Boot phase, faulty firmware
		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 40: LED status - SafeMC module

Danger!

Static lit "SE" LEDs indicate a defective module, which must be changed immediately.
It is your responsibility to ensure that all necessary repairs are made if an error occurs because subsequent errors could create a dangerous situation!

2.2.6 Status changes when booting the operating system loader

The following timing is used for the indication diagram:

Block size: 50 ms
Repeats after: 3,000 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 41: Status changes when booting the operating system loader

1) Firmware V2.140 and higher.

2.2.7 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>Figure</th><th>Code switch</th><th>POWERLINK station number</th></tr>
<tr><td rowspan="3"> 

Cover closed Cover open</td><td>❶</td><td>16s position (high)</td></tr>
<tr><td>❷</td><td>1s position (low)</td></tr>
<tr><td colspan="2">The POWERLINK station number change takes effect the next time the ACOPOSmulti drive system is switched on.
Information:
In principle, station numbers between $01 and $FD are permitted.
However, station numbers between $F0 and $FD are reserved for future system expansions. For reasons of compatibility, we recommend avoiding these station numbers.
Station numbers $00, $FE and $FF are reserved and are therefore not allowed to be set.</td></tr>
</table>

Table 42: Setting the POWERLINK station number

2.3 Safe Inverter modules, single-width, 1.4kW ... 11kW (single-axis modules)

2.3.1 Order data

Model number	Short description	Figure
	Wall mounting	 8BVI0055HCSS.000-1 (symbol photo)
8BVI0014HWSS.000-1	ACOPOSmulti inverter module, 1.9 A, HV, wall-mounting, SafeMC	
8BVI0028HWSS.000-1	ACOPOSmulti inverter module, 3.8 A, HV, wall-mounting, SafeMC	
8BVI0055HWSS.000-1	ACOPOSmulti inverter module, 7.6 A, HV, wall-mounting, SafeMC	
8BVI0110HWSS.000-1	ACOPOSmulti inverter module, 15.1 A, HV, wall-mounting, SafeMC	
	Cold plate or feed-through mounting	
8BVI0014HCSS.000-1	ACOPOSmulti inverter module 1.9 A, HV, cold plate or feed-through mounting, SafeMC	
8BVI0028HCSS.000-1	ACOPOSmulti inverter module 3.8 A, HV, cold plate or feed-through mounting, SafeMC	
8BVI0055HCSS.000-1	ACOPOSmulti inverter module 7.6 A, HV, cold plate or feed-through mounting, SafeMC	
8BVI0110HCSS.000-1	ACOPOSmulti inverter module 15.1 A, HV, cold plate or feed-through mounting, SafeMC	

Required accessories				
Model number	**Amount**	**Short description**	**Comment**	**Page**
8TB2108.2010-00	1	Screw clamp, 8-pin, single-row, spacing: 5.08 mm, Label 1: numbered serially	Plug for X2 connection	---
8TB2104.203L-00	1	Screw clamp, 4-pin, single-row, spacing: 5.08 mm, Label 3: T- T+ B- B+, Coding L: 1010	Plug for X4A connection	---
8TB3104.204G-00	1	Screw clamp, 4-pin, single-row, spacing: 7.62 mm, Label 4: PE W V U, Coding G: 0110	Plug for X5A connection	---
8BCF0005.1221B-0	1	EnDat 2.2 cable, length 5 m, 1 x 4 x 0.14 mm² + 4 x 0.34 mm², EnDat Plug, 12-pin SpringTec socket, Servo plug, 9-pin DSUB plug, can be used in cable drag chains, UL/CSA lsited	---	---
8BCF0007.1221B-0	1	EnDat 2.2 cable, length 7 m, 1 x 4 x 0.14 mm² + 4 x 0.34 mm², EnDat Plug, 12-pin SpringTec socket, Servo plug, 9-pin DSUB plug, can be used in cable drag chains, UL/CSA lsited	---	---
8BCF0010.1221B-0	1	EnDat 2.2 cable, length 10 m, 1 x 4 x 0.14 mm² + 4 x 0.34 mm², EnDat Plug, 12-pin SpringTec socket, Servo plug, 9-pin DSUB plug, can be used in cable drag chains, UL/CSA lsited	---	---
8BCF0015.1221B-0	1	EnDat 2.2 cable, length 15 m, 1 x 4 x 0.14 mm² + 4 x 0.34 mm², EnDat Plug, 12-pin SpringTec socket, Servo plug, 9-pin DSUB plug, can be used in cable drag chains, UL/CSA lsited	---	---
8BCF0020.1221B-0	1	EnDat 2.2 cable, length 20 m, 1 x 4 x 0.14 mm² + 4 x 0.34 mm², EnDat Plug, 12-pin SpringTec socket, Servo plug, 9-pin DSUB plug, can be used in cable drag chains, UL/CSA lsited	---	---
8BCF0025.1221B-0	1	EnDat 2.2 cable, length 25 m, 1 x 4 x 0.14 mm² + 4 x 0.34 mm², EnDat Plug, 12-pin SpringTec socket, Servo plug, 9-pin DSUB plug, can be used in cable drag chains, UL/CSA lsited	---	---

Required accessories - Safe inverter modules, single-width, 1.4kW ... 11kW (single-axis modules)

Optional accessories				
Model number	**Amount**	**Short description**	**Comment**	**Page**
8BAC0120.000-1	Max. 1	ACOPOSmulti plug-in module, EnDat 2.1 interface	---	---
8BAC0120.001-1	Max. 1	ACOPOSmulti plug-in module, EnDat 2.2 interface	---	---
8BAC0122.000-1	Max. 1	ACOPOSmulti plug-in module, Resolver interface 10 kHz	---	---
8BAC0123.000-1	Max. 1	ACOPOSmulti plug-in module, Incremental encoder and SSI absolute encoder interface for RS422 signals	---	---
8BAC0123.001-1	Max. 1	ACOPOSmulti plug-in module, Incremental encoder interface for 5 V single-ended and 5 V differential signals	---	---
8BAC0123.002-1	Max. 1	ACOPOSmulti plug-in module, Incremental encoder interface for 24 V single-ended and 24 V differential signals	---	---
8BAC0124.000-1	Max. 1	ACOPOSmulti plug-in module, SinCos interface	---	---
8BAC0130.000-1	Max. 1	ACOPOSmulti plug-in module, 2 digital outputs, 50 mA, max. 62.5 kHz, 2 digital outputs, 500 mA, max. 1.25 kHz, 2 digital inputs - 24 VDC	---	---
8BAC0130.001-1	Max. 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	Max. 1	ACOPOSmulti plug-in module, 4 analog inputs ±10 V	---	---
8SCS002.0000-00	1	ACOPOSmulti shield component set: 1 clamping plate; 2 clamps D 4-13.5 mm; 4 screws	Shield component set for I/O cable with a cable diameter of 4 - 13.5 mm	---
8SCS000.0000-00	1	ACOPOSmulti shield component set: 1 shield plate 1x type 0; 1 hose clamp, W 9 mm, D 12-22 mm	Shield component set for motor cables with a cable diameter of 12 - 22 mm	---
8BXF001.0000-00	---	ACOPOSmulti fan module Replacement fan for ACOPOSmulti modules (8BxP/8B0C/8BVI/8BVE/8B0K)	Replacement fan for ACOPOSmulti modules (8BxP/8B0C/8BVI/8BVE/8B0K)	---

Table 45: Optional accessories - Safe inverter modules, single-width, 1.4kW ... 11kW (single-axis modules)

2.3.2 Technical data

Product ID **Wall mounting** **Cold plate or feed-through mounting**	**8BVI0014HWSS.000-1** **8BVI0014HCSS.000-1**	**8BVI0028HWSS.000-1** **8BVI0028HCSS.000-1**	**8BVI0055HWSS.000-1** **8BVI0055HCSS.000-1**	**8BVI0110HWSS.000-1** **8BVI0110HCSS.000-1**
General information				
C-UL-US listed	Yes			
Available cooling and mounting methods Wall mounting Cold plate or feed-through mounting	 Yes Yes			
Module width	1			
DC bus				
Voltage Max.	750 VDC 900 VDC			
Continuous power consumption [1]	1.46 kW	2.87 kW	5.6 kW	11.2 kW
Power loss depending on the switching frequency [2] Switching frequency 5 kHz Switching frequency 10 kHz Switching frequency 20 kHz	 $(0.6*I_M^2+1.3*I_M+60)$ W $(0.97*I_M^2+0.5*I_M+110)$ W $(1.7*I_M^2-0.7*I_M+225)$ W			 $(0.16*I_M^2+5.6*I_M+55)$ W $(0.49*I_M^2+4.7*I_M+95)$ W $(0.87*I_M^2-10*I_M+200)$ W
DC bus capacitance	165 µF			330 µF
Design	ACOPOSmulti backplane			
24 VDC supply				
Input voltage	25 VDC ±1.6%			
Input capacitance	23.5 µF			
Max. power consumption	12 W + $P_{24\ V\ Out}$ {0 ... 10 W} [3] + $P_{holding\ brake}$ + $P_{fan8B0M...}$ [4]			
Design	ACOPOSmulti backplane			
Motor connector				
Continuous power [1]	1.4 kW	2.8 kW	5.5 kW	11 kW
Continuous current [1]	1.9 A_{eff}	3.8 A_{eff}	7.6 A_{eff}	15.1 A_{eff}
Reduction of continuous current depending on switching frequency and cooling method [5] Switching frequency 20 kHz Wall mounting [6] Cold-plate installation [7] Feed-through mounting Switching frequency 10 kHz Wall mounting [6] Cold-plate installation [7] Feed-through mounting Switching frequency 5 kHz Wall mounting [6] Cold-plate installation [7] Feed-through mounting	 0.11 A/K (from 33°C) 0.13 A/K (from 46°C) In preparation No reduction No reduction In preparation **No reduction** **No reduction** In preparation	 0.12 A/K (from 33°C) 0.1 A/K (from 34°C) In preparation No reduction 0.6 A/K (from 58°C) In preparation **No reduction** **No reduction** In preparation	 0.13 A/K (from 4°C) [8] 0.14 A/K (from 5°C) [9] In preparation 0.2 A/K (from 49°C) 0.28 A/K (from 46°C) In preparation **No reduction** **0.65 A/K (from 57°C)** In preparation	 0.15 A/K (from -28°C) [8] 0.18 A/K (from -13°C) [9] In preparation 0.26 A/K (from 33°C) 0.32 A/K (from 35°C) In preparation **No reduction** **0.73 A/K (from 55°C)** In preparation
Reduction of continuous power depending on altitude Starting at 500 m above sea level	 0.19 A_{eff} per 1,000 m	0.38 A_{eff} per 1,000 m	0.76 A_{eff} per 1,000 m	1.51 A_{eff} per 1,000 m
Peak current	4.7 A_{eff}	9.5 A_{eff}	18.9 A_{eff}	37.7 A_{eff}

Table 46: Technical data - Safe inverter modules, single-width, 1.4kW ... 11kW (single-axis modules)

Product ID Wall mounting Cold plate or feed-through mounting	8BVI0014HWSS.000-1 8BVI0014HCSS.000-1	8BVI0028HWSS.000-1 8BVI0028HCSS.000-1	8BVI0055HWSS.000-1 8BVI0055HCSS.000-1	8BVI0110HWSS.000-1 8BVI0110HCSS.000-1
Rated switching frequency	5 kHz			
Possible switching frequencies [10]	5 / 10 / 20 kHz			
Electrical stress of the connected motor according to IEC TS 60034-25	Limit value curve A			
Protective measures Overload protection Short circuit and ground fault	 Yes Yes			
Maximum motor line length depending on the switching frequency [11] Switching frequency 5 kHz Switching frequency 10 kHz Switching frequency 20 kHz	 25 m 25 m 10 m			
Design U, V, W, PE Shield connection	 Plugs Yes			
Terminal connection cross sections Flexible and fine wire lines with wire tip sleeves Approbation data UL/C-UL-US CSA	 0.25 - 4 mm² 30 - 10 28 - 10			
Terminal cable outer-cross-section dimension of the shield connection	12 - 22 mm			
Motor holding brake connections				
Amount	1			
Output voltage [12]	24 VDC +5.8% / -0% [13]			
Continuous current	1.1 A			2.1 A
Max. internal resistance	0.5 Ω			0.3 Ω
Extinction potential	Approx. 30 V			
Max. extinction energy per switching operation	1.5 Ws			3 Ws
Max. switching frequency	0.5 Hz			
Protective measures Overload and short circuit protection Cable breakage monitoring Undervoltage monitoring	 Yes Yes Yes			
Response threshold for cable breakage monitoring	Approx. 0.25 A			Approx. 0.5 A
Response threshold for undervoltage monitoring	24 VDC +0% / -4%			

Table 46: Technical data - Safe inverter modules, single-width, 1.4kW ... 11kW (single-axis modules) (cont.)

Product ID Wall mounting Cold plate or feed-through mounting	8BVI0014HWSS.000-1 8BVI0014HCSS.000-1	8BVI0028HWSS.000-1 8BVI0028HCSS.000-1	8BVI0055HWSS.000-1 8BVI0055HCSS.000-1	8BVI0110HWSS.000-1 8BVI0110HCSS.000-1
Encoder interfaces [14) 15)]				
Amount [16)]	1			
Type	EnDat 2.2			
Connections	9-pin DSUB socket			
Indicators	UP/DN LEDs			
Electrical isolation Encoder - ACOPOSmulti	 No			
Encoder monitoring	Yes			
Maximum encoder cable length	100 m Depending on the cross section of the supply wires on the encoder cable [17)]			
Encoder supply Output voltage Load capability Protective measures / safeguards Overload protection Short circuit protection	 Typ. 12.5 V 350 mA Yes Yes			
Synchronous serial interface Signal transfer Data transfer rate	 RS485 6.25 Mbit/s			
Trigger inputs				
Amount	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			

Table 46: Technical data - Safe inverter modules, single-width, 1.4kW ... 11kW (single-axis modules) (cont.)

Product ID Wall mounting Cold plate or feed-through mounting	8BVI0014HWSS.000-1 8BVI0014HCSS.000-1	8BVI0028HWSS.000-1 8BVI0028HCSS.000-1	8BVI0055HWSS.000-1 8BVI0055HCSS.000-1	8BVI0110HWSS.000-1 8BVI0110HCSS.000-1
24 V Out				
Amount	2			
Output voltage DC bus voltage 260 ... 315 VDC DC bus voltage 315 ... 900 VDC	25 VDC * (DC bus voltage / 315) 24 VDC ±6%			
Fuse protection	500 mA (slow-blow) electronic, automatic reset			
Operational conditions				
Ambient temperature during operation Max. ambient temperature [18)]	5 to 40°C +55°C			
Relative humidity during operation	5 to 85%, non-condensing			
Installation at altitudes above sea level Maximum installation altitude [19)]	0 to 500 m 4,000 m			
Degree of pollution according to EN 60664-1	2 (non-conductive material)			
Overvoltage cat. according to IEC 60364-4-443:1999	III			
EN 60529 protection	IP20			
Storage and transport conditions				
Storage temperature	-25 to +55°C			
Relative humidity during storage	5 to 95%, non-condensing			
Transport temperature	-25 to +70°C			
Relative humidity during transport	Max. 95% at +40°C			
Mechanical characteristics				
Dimensions [20)] Width Height Depth Wall mounting Cold-plate Feed-through mounting	 53 mm 317 mm 263 mm 212 mm 209 mm			
Weight Wall mounting Cold plate or feed-through mounting	 Approx. 2.6 kg Approx. 2.1 kg	 Approx. 2.6 kg Approx. 2.1 kg	 Approx. 2.7 kg Approx. 2.2 kg	 Approx. 2.9 kg Approx. 2.4 kg

Table 46: Technical data - Safe inverter modules, single-width, 1.4kW ... 11kW (single-axis modules) (cont.)

1) Valid in the following conditions: Nominal DC bus voltage 750 VDC, nominal switching frequency 5 kHz, 40°C ambient temperature, installation altitudes < 500 m above sea level.
2) I_M ... Current on the motor connection [A].
3) The power consumption $P_{24\ V\ Out}$ corresponds to the power that is output on the module's X2 / +24 V Out 1 and X2 / +24 V Out 2 connections (max. 10 W).
4) The power consumption $P_{Fan8B0M...}$ corresponds to the portion of the power that is used by the fan modules in the mounting plate / by the 8B0M0040HFF0.000-1 fan module and can be found in the technical data for the respective 8B0M... mounting plate.
5) Valid for the following conditions: Nominal DC bus voltage 750 VDC, minimum permissible coolant flow volume (3 l/min). The nominal switching frequency values for the respective ACOPOSmulti inverter module are marked in bold.
6) The temperature specifications are based on the ambient temperature.
7) The temperature specifications are based on the return temperature of the cold plate mounting plate.

8) 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.

9) 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.

10) 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.

11) To avoid exceeding the EMC limit values, the maximum motor cable length per motor connection is reduced at switching frequencies > 10 kHz.

    Information:

    When using two motor cables that are connected in parallel, the maximum permissible motor cable lengths are reduced by half.

    The total length of all motor cables per backplane module is limited.

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) The EnDat encoder must be wired using a cable with a single shield and twisted pair signal lines.

15) Only EnDat 2.2 safety encoders can be connected!

16) SLOT 1 of the ACOPOSmulti module is occupied by the encoder interface.

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

$$l_{max} = \frac{7,9}{I_G} \cdot A \cdot \frac{1}{2 \cdot \rho}$$

    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)

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) 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). Additional requirements are to be arranged with B&R.

20) The dimensions refer to 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.

2.4 Safe Inverter modules, single-width, 1.4kW ... 5.5kW (two-axis modules)

2.4.1 General information

Double axis modules contain two complete standalone inverters in an inverter module.

2.4.2 Order data

Model number	Short description	Figure
	Wall mounting	 8BVI0055HCDS.000-1 (symbol photo)
8BVI0014HWDS.000-1	ACOPOSmulti inverter module, 1.9 A, HV, wall mounting, SafeMC, 2 axes	
8BVI0028HWDS.000-1	ACOPOSmulti inverter module, 3.8 A, HV, wall mounting, SafeMC, 2 axes	
8BVI0055HWDS.000-1	ACOPOSmulti inverter module, 7.6 A, HV, wall mounting, SafeMC, 2 axes	
	Cold plate or feed-through mounting	
8BVI0014HCDS.000-1	ACOPOSmulti inverter module 1.9 A, HV, cold plate or feed-through mounting, SafeMC, 2 axes	
8BVI0028HCDS.000-1	ACOPOSmulti inverter module 3.8 A, HV, cold plate or feed-through mounting, SafeMC, 2 axes	
8BVI0055HCDS.000-1	ACOPOSmulti inverter module 7.6 A, HV, cold plate or feed-through mounting, SafeMC, 2 axes	

Table 47: Order data - Safe inverter modules, single-width, 1.4kW ... 5.5kW (two-axis modules)

Required accessories				
Model number	**Amount**	**Short description**	**Comment**	**Page**
8TB2108.2010-00	1	Screw clamp, 8-pin, single-row, spacing: 5.08 mm, Label 1: numbered serially	Plug for X2 connection	---
8TB2104.203L-00	1	Screw clamp, 4-pin, single-row, spacing: 5.08 mm, Label 3: T- T+ B- B+, Coding L: 1010	Plug for X4A connection	---
8TB2104.203F-00	1	Screw clamp, 4-pin, single-row, spacing: 5.08 mm, Label 3: T- T+ B- B+, Coding F: 0101	Plug for X4B connection	---
8TB3104.204G-00	1	Screw clamp, 4-pin, single-row, spacing: 7.62 mm, Label 4: PE W V U, Coding G: 0110	Plug for X5A connection	---
8TB3104.204K-00	1	Screw clamp, 4-pin, single-row, spacing: 7.62 mm, Label 4: PE W V U, Coding K: 1001	Plug for X5B connection	---

Table 48: Required accessories - Safe inverter modules, single-width, 1.4kW ... 5.5kW (two-axis modules)

Required accessories				
Model number	**Amount**	**Short description**	**Comment**	**Page**
8BCF0005.1221B-0	1	EnDat 2.2 cable, length 5 m, 1 x 4 x 0.14 mm² + 4 x 0.34 mm², EnDat Plug, 12-pin SpringTec socket, Servo plug, 9-pin DSUB plug, can be used in cable drag chains, UL/CSA lsited	---	---
8BCF0007.1221B-0	1	EnDat 2.2 cable, length 7 m, 1 x 4 x 0.14 mm² + 4 x 0.34 mm², EnDat Plug, 12-pin SpringTec socket, Servo plug, 9-pin DSUB plug, can be used in cable drag chains, UL/CSA lsited	---	---
8BCF0010.1221B-0	1	EnDat 2.2 cable, length 10 m, 1 x 4 x 0.14 mm² + 4 x 0.34 mm², EnDat Plug, 12-pin SpringTec socket, Servo plug, 9-pin DSUB plug, can be used in cable drag chains, UL/CSA lsited	---	---
8BCF0015.1221B-0	1	EnDat 2.2 cable, length 15 m, 1 x 4 x 0.14 mm² + 4 x 0.34 mm², EnDat Plug, 12-pin SpringTec socket, Servo plug, 9-pin DSUB plug, can be used in cable drag chains, UL/CSA lsited	---	---
8BCF0020.1221B-0	1	EnDat 2.2 cable, length 20 m, 1 x 4 x 0.14 mm² + 4 x 0.34 mm², EnDat Plug, 12-pin SpringTec socket, Servo plug, 9-pin DSUB plug, can be used in cable drag chains, UL/CSA lsited	---	---
8BCF0025.1221B-0	1	EnDat 2.2 cable, length 25 m, 1 x 4 x 0.14 mm² + 4 x 0.34 mm², EnDat Plug, 12-pin SpringTec socket, Servo plug, 9-pin DSUB plug, can be used in cable drag chains, UL/CSA lsited	---	---

Table 48: Required accessories - Safe inverter modules, single-width, 1.4kW ... 5.5kW (two-axis modules)

Optional accessories				
Model number	**Amount**	**Short description**	**Comment**	**Page**
8SCS002.0000-00	1	ACOPOSmulti shield component set: 1 clamping plate; 2 clamps D 4-13.5 mm; 4 screws	Shield component set for I/O cable with a cable diameter of 4 - 13.5 mm	---
8SCS000.0000-00	Up to 2	ACOPOSmulti shield component set: 1 shield plate 1x type 0; 1 hose clamp, W 9 mm, D 12-22 mm	Shield component set for motor cables with a cable diameter of 12 - 22 mm	---
8BXF001.0000-00	---	ACOPOSmulti fan module Replacement fan for ACOPOSmulti modules (8BxP/8B0C/8BVI/8BVE/8B0K)	Replacement fan for ACOPOSmulti modules (8BxP/8B0C/8BVI/8BVE/8B0K)	---

Table 49: Optional accessories - Safe inverter modules, single-width, 1.4kW ... 5.5kW (two-axis modules)

2.4.3 Technical data

Product ID Wall mounting Cold plate or feed-through mounting	8BVI0014HWDS.000-1 8BVI0014HCDS.000-1	8BVI0028HWDS.000-1 8BVI0028HCDS.000-1	8BVI0055HWDS.000-1 8BVI0055HCDS.000-1
General information			
C-UL-US listed	Yes		
Available cooling and mounting methods Wall mounting Cold plate or feed-through mounting	 Yes Yes		
Module width	1		
DC bus			
Voltage Max.	750 VDC 900 VDC		
Continuous power consumption [1]	1.51 kW	2.93 kW	5.69 kW
Power loss depending on the switching frequency [2] 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		330 µF
Design	ACOPOSmulti backplane		
24 VDC supply			
Input voltage	25 VDC ±1.6%		
Input capacitance	23.5 µF		
Max. power consumption	16 W + $P_{24\ V\ Out}$ {0 ... 10 W} [3] + $P_{holding\ brake(s)}$ + $P_{fan8B0M...}$ [4]		
Design	ACOPOSmulti backplane		
Motor connector			
Continuous power [1]	1.4 kW	2.8 kW	5.5 kW
Continuous current [1]	1.9 A_{eff}	3.8 A_{eff}	7.6 A_{eff}
Reduction of continuous current depending on switching frequency and cooling method [5] Switching frequency 20 kHz Wall mounting [6] Cold-plate installation [7] Feed-through mounting Switching frequency 10 kHz Wall mounting [6] Cold-plate installation [7] Feed-through mounting Switching frequency 5 kHz Wall mounting [6] Cold-plate installation [7] Feed-through mounting	 0.11 A/K (from 15°C) 0.13 A/K (from 45°C) In preparation No reduction No reduction In preparation **No reduction** **No reduction** In preparation	 0.12 A/K (from 13°C) 0.12 A/K (from 34°C) In preparation No reduction 0.6 A/K (from 57°C) In preparation **No reduction** **No reduction** In preparation	 0.15 A/K (from -14°C) [8] 0.13 A/K (from 3°C) [9] In preparation 0.22 A/K (from 43°C) 0.28 A/K (from 43°C) In preparation **No reduction** **0.72 A/K (from 56°C)** In preparation
Reduction of continuous power depending on altitude Starting at 500 m above sea level	 0.19 A_{eff} per 1,000 m	 0.38 A_{eff} per 1,000 m	 0.76 A_{eff} per 1,000 m
Peak current	4.7 A_{eff}	9.5 A_{eff}	18.9 A_{eff}
Rated switching frequency	5 kHz		
Possible switching frequencies [10]	5 / 10 / 20 kHz		

Table 50: Technical data - Safe inverter modules, single-width, 1.4kW ... 5.5kW (two-axis modules)

Product ID **Wall mounting** **Cold plate or feed-through mounting**	**8BVI0014HWDS.000-1** **8BVI0014HCDS.000-1**	**8BVI0028HWDS.000-1** **8BVI0028HCDS.000-1**	**8BVI0055HWDS.000-1** **8BVI0055HCDS.000-1**
Electrical stress of the connected motor according to IEC TS 60034-25	Limit value curve A		
Protective measures Overload protection Short circuit and ground fault	 Yes Yes		
Maximum motor line length depending on the switching frequency [11)] Switching frequency 5 kHz Switching frequency 10 kHz Switching frequency 20 kHz	 25 m 25 m 10 m		
Design U, V, W, PE Shield connection	 Plugs Yes		
Terminal connection cross sections Flexible and fine wire lines with wire tip sleeves Approbation data UL/C-UL-US CSA	 0.25 - 4 mm² 30 - 10 28 - 10		
Terminal cable outer-cross-section dimension of the shield connection	12 - 22mm		
Motor holding brake connections			
Amount	2		
Output voltage [12)]	24 VDC +5.8% / +0% [13)]		
Continuous current	1.1 A		
Max. internal resistance	0.5 Ω		
Extinction potential	Approx. 30 V		
Max. extinction energy per switching operation	1.5 Ws		
Max. switching frequency	0.5 Hz		
Protective measures Overload and short circuit protection 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%		

Table 50: Technical data - Safe inverter modules, single-width, 1.4kW ... 5.5kW (two-axis modules) (cont.)

Product ID Wall mounting Cold plate or feed-through mounting	8BVI0014HWDS.000-1 8BVI0014HCDS.000-1	8BVI0028HWDS.000-1 8BVI0028HCDS.000-1	8BVI0055HWDS.000-1 8BVI0055HCDS.000-1
Encoder interfaces [14) 15)]			
Amount [16)]	2		
Type	EnDat 2.2		
Connections	9-pin DSUB socket		
Indicators	UP/DN LEDs		
Electrical isolation Encoder - ACOPOSmulti	 No		
Encoder monitoring	Yes		
Maximum encoder cable length	100 m Depending on the cross section of the supply wires on the encoder cable [17)]		
Encoder supply Output voltage Load capability Protective measures / safeguards Overload protection Short circuit protection	 Typ. 12.5 V 350 mA Yes Yes		
Synchronous serial interface Signal transfer Data transfer rate	 RS485 6.25 Mbit/s		
Trigger inputs			
Amount	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		
24 VDC Out			
Amount	2		
Output voltage DC bus voltage 260 ... 315 VDC DC bus voltage 315 ... 900 VDC	 25 VDC * (DC bus voltage / 315) 24 VDC ±6%		
Fuse protection	500 mA (slow-blow) electronic, automatic reset		

Table 50: Technical data - Safe inverter modules, single-width, 1.4kW ... 5.5kW (two-axis modules) (cont.)

Product ID Wall mounting Cold plate or feed-through mounting	8BVI0014HWDS.000-1 8BVI0014HCDS.000-1	8BVI0028HWDS.000-1 8BVI0028HCDS.000-1	8BVI0055HWDS.000-1 8BVI0055HCDS.000-1
Operational conditions			
Ambient temperature during operation Max. ambient temperature [18]	5 to 40°C +55°C		
Relative humidity during operation	5 to 85%, non-condensing		
Installation at altitudes above sea level Maximum installation altitude [19]	0 to 500 m 4,000 m		
Degree of pollution according to EN 60664-1	2 (non-conductive material)		
Overvoltage cat. according to IEC 60364-4-443:1999	III		
EN 60529 protection	IP20		
Storage and transport conditions			
Storage temperature	-25 to +55°C		
Relative humidity during storage	5 to 95%, non-condensing		
Transport temperature	-25 to +70°C		
Relative humidity during transport	Max. 95% at +40°C		
Mechanical characteristics			
Dimensions [20] Width Height Depth Wall mounting Cold-plate Feed-through mounting	 53 mm 317 mm 263 mm 212 mm 209 mm		
Weight Wall mounting Cold-plate Feed-through mounting	 Approx. 2.8 kg Approx. 2.3 kg Approx. 2.3 kg	 Approx. 2.8 kg Approx. 2.3 kg Approx. 2.3 kg	 Approx. 2.9 kg Approx. 2.3 kg Approx. 2.3 kg

Table 50: Technical data - Safe inverter modules, single-width, 1.4kW ... 5.5kW (two-axis modules) (cont.)

1) Valid in the following conditions: Nominal DC bus voltage 750 VDC, nominal switching frequency 5 kHz, 40°C ambient temperature, installation altitudes < 500 m above sea level.
2) I_M ... Average value of the currents on both motor connectors [A].
3) The power consumption $P_{24\ V\ Out}$ corresponds to the power that is output on the module's X2 / +24 V Out 1 and X2 / +24 V Out 2 connections (max. 10 W).
4) The power consumption $P_{Fan8B0M...}$ corresponds to the portion of the power that is used by the fan modules in the mounting plate / by the 8B0M0040HFF0.000-1 fan module and can be found in the technical data for the respective 8B0M... mounting plate.
5) Valid for the following conditions: Nominal DC bus voltage 750 VDC, minimum permissible coolant flow volume (3 l/min). The nominal switching frequency values for the respective ACOPOSmulti inverter module are marked in bold.
6) The temperature specifications are based on the ambient temperature.
7) The temperature specifications are based on the return temperature of the cold plate mounting plate.
8) 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.
9) 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.

10) 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.

11) To avoid exceeding the EMC limit values, the maximum motor cable length per motor connection is reduced at switching frequencies > 10 kHz.

Information:

When using two motor cables that are connected in parallel, the maximum permissible motor cable lengths are reduced by half.

The total length of all motor cables per backplane module is limited.

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) The EnDat encoder must be wired using a cable with a single shield and twisted pair signal lines.

15) Only EnDat 2.2 safety encoders can be connected!

16) SLOT 1 and SLOT 2 of the ACOPOSmulti module are occupied by the encoder interfaces.

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

$$l_{max} = \frac{7,9}{I_G} \cdot A \cdot \frac{1}{2 \cdot \rho}$$

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)

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) 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). Additional requirements are to be arranged with B&R.

20) The dimensions refer to 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.

2.5 Safe inverter module, double-width, 16kW ... 32kW (single-axis modules)

2.5.1 Order data

Model number	Short description	Figure
	Wall mounting	 8BVI0440HCSS.000-1 (symbol photo)
8BVI0220HWSS.000-1	ACOPOSmulti inverter module, 22 A, HV, wall-mounting, SafeMC	
8BVI0330HWSS.000-1	ACOPOSmulti inverter module, 33 A, HV, wall-mounting, SafeMC	
8BVI0440HWSS.000-1	ACOPOSmulti inverter module, 44 A, HV, wall-mounting, SafeMC	
	Cold plate or feed-through mounting	
8BVI0220HCSS.000-1	ACOPOSmulti inverter module 22 A, HV, cold plate or feed-through mounting, SafeMC	
8BVI0330HCSS.000-1	ACOPOSmulti inverter module 33 A, HV, cold plate or feed-through mounting, SafeMC	
8BVI0440HCSS.000-1	ACOPOSmulti inverter module 44 A, HV, cold plate or feed-through mounting, SafeMC	

Table 51: Order data - Safe inverter modules, double-width, 16kW ... 32kW (single-axis modules)

Required accessories				
Model number	**Amount**	**Short description**	**Comment**	**Page**
8TB2108.2010-00	1	Screw clamp, 8-pin, single-row, spacing: 5.08 mm, Label 1: numbered serially	Plug for X2 connection	---
8TB2104.203L-00	1	Screw clamp, 4-pin, single-row, spacing: 5.08 mm, Label 3: T- T+ B- B+, Coding L: 1010	Plug for X4A connection	---
8TB4104.204G-00 [1)]	1	Screw clamp, 4-pin, single-row, spacing: 10.16 mm, Label 4: PE W V U, Coding G: 0110	Plug for X5A connection	---
8TB4104.204G-10 [2)]	1	Screw clamp, 4-pin, single-row, spacing: 10.16 mm, Label 4: PE W V U, Coding G: 0110	Plug for X5A connection	---
8BCF0005.1221B-0	1	EnDat 2.2 cable, length 5 m, 1 x 4 x 0.14 mm² + 4 x 0.34 mm², EnDat Plug, 12-pin SpringTec socket, Servo plug, 9-pin DSUB plug, can be used in cable drag chains, UL/CSA lsited	---	---

Table 52: Required accessories - Safe inverter modules, double-width, 16kW ... 32kW (single-axis modules)

Required accessories				
Model number	**Amount**	**Short description**	**Comment**	**Page**
8BCF0007.1221B-0	1	EnDat 2.2 cable, length 7 m, 1 x 4 x 0.14 mm² + 4 x 0.34 mm², EnDat Plug, 12-pin SpringTec socket, Servo plug, 9-pin DSUB plug, can be used in cable drag chains, UL/CSA lsited	---	---
8BCF0010.1221B-0	1	EnDat 2.2 cable, length 10 m, 1 x 4 x 0.14 mm² + 4 x 0.34 mm², EnDat Plug, 12-pin SpringTec socket, Servo plug, 9-pin DSUB plug, can be used in cable drag chains, UL/CSA lsited	---	---
8BCF0015.1221B-0	1	EnDat 2.2 cable, length 15 m, 1 x 4 x 0.14 mm² + 4 x 0.34 mm², EnDat Plug, 12-pin SpringTec socket, Servo plug, 9-pin DSUB plug, can be used in cable drag chains, UL/CSA lsited	---	---
8BCF0020.1221B-0	1	EnDat 2.2 cable, length 20 m, 1 x 4 x 0.14 mm² + 4 x 0.34 mm², EnDat Plug, 12-pin SpringTec socket, Servo plug, 9-pin DSUB plug, can be used in cable drag chains, UL/CSA lsited	---	---
8BCF0025.1221B-0	1	EnDat 2.2 cable, length 25 m, 1 x 4 x 0.14 mm² + 4 x 0.34 mm², EnDat Plug, 12-pin SpringTec socket, Servo plug, 9-pin DSUB plug, can be used in cable drag chains, UL/CSA lsited	---	---

Table 52: Required accessories - Safe inverter modules, double-width, 16kW ... 32kW (single-axis modules)

1) Only for 8BVI0220HxSS.000-1.

2) Only for 8BVI0330HxSS.000-1 and 8BVI0440HxSS.000-1.

Optional accessories				
Model number	**Amount**	**Short description**	**Comment**	**Page**
8BAC0120.000-1	Max. 1	ACOPOSmulti plug-in module, EnDat 2.1 interface	---	---
8BAC0120.001-1	Max. 1	ACOPOSmulti plug-in module, EnDat 2.2 interface	---	---
8BAC0122.000-1	Max. 1	ACOPOSmulti plug-in module, Resolver interface 10 kHz	---	---
8BAC0123.000-1	Max. 1	ACOPOSmulti plug-in module, Incremental encoder and SSI absolute encoder interface for RS422 signals	---	---
8BAC0123.001-1	Max. 1	ACOPOSmulti plug-in module, Incremental encoder interface for 5 V single-ended and 5 V differential signals	---	---
8BAC0123.002-1	Max. 1	ACOPOSmulti plug-in module, Incremental encoder interface for 24 V single-ended and 24 V differential signals	---	---

Table 53: Optional accessories - Safe inverter modules, double-width, 16kW ... 32kW (single-axis modules)

Optional accessories				
Model number	**Amount**	**Short description**	**Comment**	**Page**
8BAC0124.000-1	Max. 1	ACOPOSmulti plug-in module, SinCos interface	---	---
8BAC0130.000-1	Max. 1	ACOPOSmulti plug-in module, 2 digital outputs, 50 mA, max. 62.5 kHz, 2 digital outputs, 500 mA, max. 1.25 kHz, 2 digital inputs - 24 VDC	---	---
8BAC0130.001-1	Max. 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	Max. 1	ACOPOSmulti plug-in module, 4 analog inputs ±10 V	---	---
8SCS000.0000-00 [1]	1	ACOPOSmulti shield component set: 1 shield plate 1x type 0; 1 hose clamp, W 9 mm, D 12-22 mm	Shield component set for motor cables with a cable diameter of 12 - 22 mm	---
8SCS002.0000-00	1	ACOPOSmulti shield component set: 1 clamping plate; 2 clamps D 4-13.5 mm; 4 screws	Shield component set for I/O cable with a cable diameter of 4 - 13.5 mm	---
8SCS007.0000-00 [2]	1	ACOPOSmulti shield component set: 1 shield mounting plate, 2x, 45°; 4 screws	Base plate for mounting shield component set 8SCS008.0000-00	---
8SCS008.0000-00 [2]	1	ACOPOSmulti shield component set: 1 shield plate, 2x, type 0; 1 hose clamp, W 9 mm, D 23-35 mm	Shield component set for motor cables with a cable diameter of 23 - 35 mm	---
8BXF001.0000-00	---	ACOPOSmulti fan module Replacement fan for ACOPOSmulti modules (8BxP/8B0C/8BVI/8BVE/8B0K)	Replacement fan for ACOPOSmulti modules (8BxP/8B0C/8BVI/8BVE/8B0K)	---

Table 53: Optional accessories - Safe inverter modules, double-width, 16kW ... 32kW (single-axis modules)

1) Only for 8BVI0220HxS0.000-1.

2) Only for 8BVI0330HxS0.000-1 and 8BVI0440HxS0.000-1.

2.5.2 Technical data

Product ID Wall mounting Cold plate or feed-through mounting	8BVI0220HWSS.000-1 8BVI0220HCSS.000-1	8BVI0330HWSS.000-1 8BVI0330HCSS.000-1	8BVI0440HWSS.000-1 8BVI0440HCSS.000-1
General information			
C-UL-US listed	Yes	In preparation	Yes
Available cooling and mounting methods Wall mounting Cold plate or feed-through mounting		Yes Yes	
Module width		2	
DC bus			
Voltage Max.		750 VDC 900 VDC	
Continuous power consumption [1]	16.2 kW	24.4 kW	32.5 kW
Power loss depending on the switching frequency [2] 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	 $(0.07*I_M^2+7.3*I_M+40)$ W $(0.2*I_M^2+11.1*I_M+130)$ W $(1.85*I_M^2+3.8*I_M+300)$ W	
DC bus capacitance	495 µF	990 µF	
Design	ACOPOSmulti backplane		
24 VDC supply			
Input voltage	25 VDC ±1.6%		
Input capacitance	32.9 µF		
Max. power consumption	20 W + $P_{24\ V\ Out}$ {0 ... 10 W} [3] + $P_{holding\ brake}$ + 2 * $P_{fan8B0M...}$ [4]		
Design	ACOPOSmulti backplane		
Motor connector			
Continuous power [1]	16 kW	24 kW	32 kW
Continuous current [1]	22 A_{eff}	33 A_{eff}	44 A_{eff}
Reduction of continuous current depending on switching frequency and cooling method [5] Switching frequency 20 kHz Wall mounting [6] Cold-plate installation [7] Feed-through mounting Switching frequency 10 kHz Wall mounting [6] Cold-plate installation [7] Feed-through mounting Switching frequency 5 kHz Wall mounting [6] Cold-plate installation [7] Feed-through mounting	 0.31 A/K (from -16°C) [8] 0.36 A/K (from 5°C) [9] In preparation 0.4 A/K (from 31°C) 0.5 A/K (from 49°C) In preparation **No reduction** **No reduction** In preparation	 0.36 A/K (from -77°C) [8] 0.32 A/K (from -82°C) [9] In preparation 0.5 A/K (from -10°C) [8] 0.62 A/K (from 6°C) [9] In preparation **1.57 A/K (from 40°C)** **0.8 A/K (from 45°C)** In preparation	
Reduction of continuous power depending on altitude Starting at 500 m above sea level	2.2 A_{eff} per 1,000 m	3.3 A_{eff} per 1,000 m	4.4 A_{eff} per 1,000 m

Table 54: Technical data - Safe inverter modules, double-width, 16kW ... 32kW (single-axis modules)

Product ID **Wall mounting** **Cold plate or feed-through mounting**	**8BVI0220HWSS.000-1** **8BVI0220HCSS.000-1**	**8BVI0330HWSS.000-1** **8BVI0330HCSS.000-1**	**8BVI0440HWSS.000-1** **8BVI0440HCSS.000-1**
Peak current	55 A_{eff}	83 A_{eff}	88 A_{eff}
Rated switching frequency	5 kHz		
Possible switching frequencies [10]	5 / 10 / 20 kHz		
Electrical stress of the connected motor according to IEC TS 60034-25	Limit value curve A		
Protective measures Overload protection Short circuit and ground fault	 Yes Yes		
Maximum motor line length depending on the switching frequency [11] Switching frequency 5 kHz Switching frequency 10 kHz Switching frequency 20 kHz	 25 m 25 m 25 m		
Design U, V, W, PE Shield connection	 Plugs Yes		
Terminal connection cross sections Flexible and fine wire lines with wire tip sleeves Approbation data UL/C-UL-US CSA	 0.5 - 6 mm² 20 - 8 20 - 8	 0.5 - 16 mm² 20 - 6 20 - 6	
Terminal cable outer-cross-section dimension of the shield connection	12 - 22 mm	23 - 35 mm	
Motor holding brake connections			
Amount	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 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%		

Table 54: Technical data - Safe inverter modules, double-width, 16kW ... 32kW (single-axis modules) (cont.)

Product ID Wall mounting Cold plate or feed-through mounting	8BVI0220HWSS.000-1 8BVI0220HCSS.000-1	8BVI0330HWSS.000-1 8BVI0330HCSS.000-1	8BVI0440HWSS.000-1 8BVI0440HCSS.000-1
Encoder interfaces [14) 15)]			
Amount [16)]	1		
Type	EnDat 2.2		
Connections	9-pin DSUB socket		
Indicators	UP/DN LEDs		
Electrical isolation Encoder - ACOPOSmulti	 No		
Encoder monitoring	Yes		
Maximum encoder cable length	100 m Depending on the cross section of the supply wires on the encoder cable [17)]		
Encoder supply Output voltage Load capability Protective measures / safeguards Overload protection Short circuit protection	 Typ. 12.5 V 350 mA Yes Yes		
Synchronous serial interface Signal transfer Data transfer rate	 RS485 6.25 Mbit/s		
Trigger inputs			
Amount	2		
Wiring	Sink		
Electrical isolation Input - inverter module Input - Input	 Yes No		
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		

Table 54: Technical data - Safe inverter modules, double-width, 16kW ... 32kW (single-axis modules) (cont.)

Product ID Wall mounting Cold plate or feed-through mounting	8BVI0220HWSS.000-1 8BVI0220HCSS.000-1	8BVI0330HWSS.000-1 8BVI0330HCSS.000-1	8BVI0440HWSS.000-1 8BVI0440HCSS.000-1
24 V Out			
Amount	2		
Output voltage DC bus voltage 260 ... 315 VDC DC bus voltage 315 ... 900 VDC	25 VDC * (DC bus voltage / 315) 24 VDC ±6%		
Fuse protection	500 mA (slow-blow) electronic, automatic reset		
Operational conditions			
Ambient temperature during operation Max. ambient temperature [18)]	5 to 40°C +55°C		
Relative humidity during operation	5 to 85%, non-condensing		
Installation at altitudes above sea level Maximum installation altitude [19)]	0 to 500 m 4,000 m		
Degree of pollution according to EN 60664-1	2 (non-conductive material)		
Overvoltage cat. according to IEC 60364-4-443:1999	III		
EN 60529 protection	IP20		
Storage and transport conditions			
Storage temperature	-25 to +55°C		
Relative humidity during storage	5 to 95%, non-condensing		
Transport temperature	-25 to +70°C		
Relative humidity during transport	Max. 95% at +40°C		
Mechanical characteristics			
Dimensions [20)] Width Height Depth Wall mounting Cold-plate Feed-through mounting	 106.5 mm 317 mm 263 mm 212 mm 209 mm		
Weight Wall mounting Cold-plate Feed-through mounting	 Approx. 5.2 kg Approx. 4.2 kg Approx. 4.2 kg		

Table 54: Technical data - Safe inverter modules, double-width, 16kW ... 32kW (single-axis modules) (cont.)

1) Valid in the following conditions: Nominal DC bus voltage 750 VDC, nominal switching frequency 5 kHz, 40°C ambient temperature, installation altitudes < 500 m above sea level.
2) I_M ... Current on the motor connection [A].
3) The power consumption $P_{24\ V\ Out}$ corresponds to the power that is output on the module's X2 / +24 V Out 1 and X2 / +24 V Out 2 connections (max. 10 W).
4) The power consumption $P_{Fan8B0M...}$ corresponds to the portion of the power that is used by the fan modules in the mounting plate / by the 8B0M0040HFF0.000-1 fan module and can be found in the technical data for the respective 8B0M... mounting plate.
5) Valid for the following conditions: Nominal DC bus voltage 750 VDC, minimum permissible coolant flow volume (3 l/min). The nominal switching frequency values for the respective ACOPOSmulti inverter module are marked in bold.
6) The temperature specifications are based on the ambient temperature.
7) The temperature specifications are based on the return temperature of the cold plate mounting plate.

8) 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.
9) 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.
10) 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.
11) **Information:**

    When using two motor cables that are connected in parallel, the maximum permissible motor cable lengths are reduced by half.

    The total length of all motor cables per backplane module is limited.
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) The EnDat encoder must be wired using a cable with a single shield and twisted pair signal lines.
15) Only EnDat 2.2 safety encoders can be connected!
16) SLOT 1 of the ACOPOSmulti module is occupied by the encoder interface.
17) The maximum encoder cable length l_{max} can be calculated as follows (the maximum permissible encoder length of 100 m must not be exceeded):

$$l_{max} = \frac{7,9}{I_G} \cdot A \cdot \frac{1}{2 \cdot \rho}$$

    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)

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) 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). Additional requirements are to be arranged with B&R.
20) The dimensions refer to 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.

3. Installation

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

4. Sizing

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

5. Wiring

5.1 General information

5.1.1 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/EG 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 switching cabinet or the system must be constructed appropriately.
2) To prevent the effects of disturbances, the following lines must be properly shielded:
   - motor lines
   - encoder cables
   - control lines
   - 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.

Overview

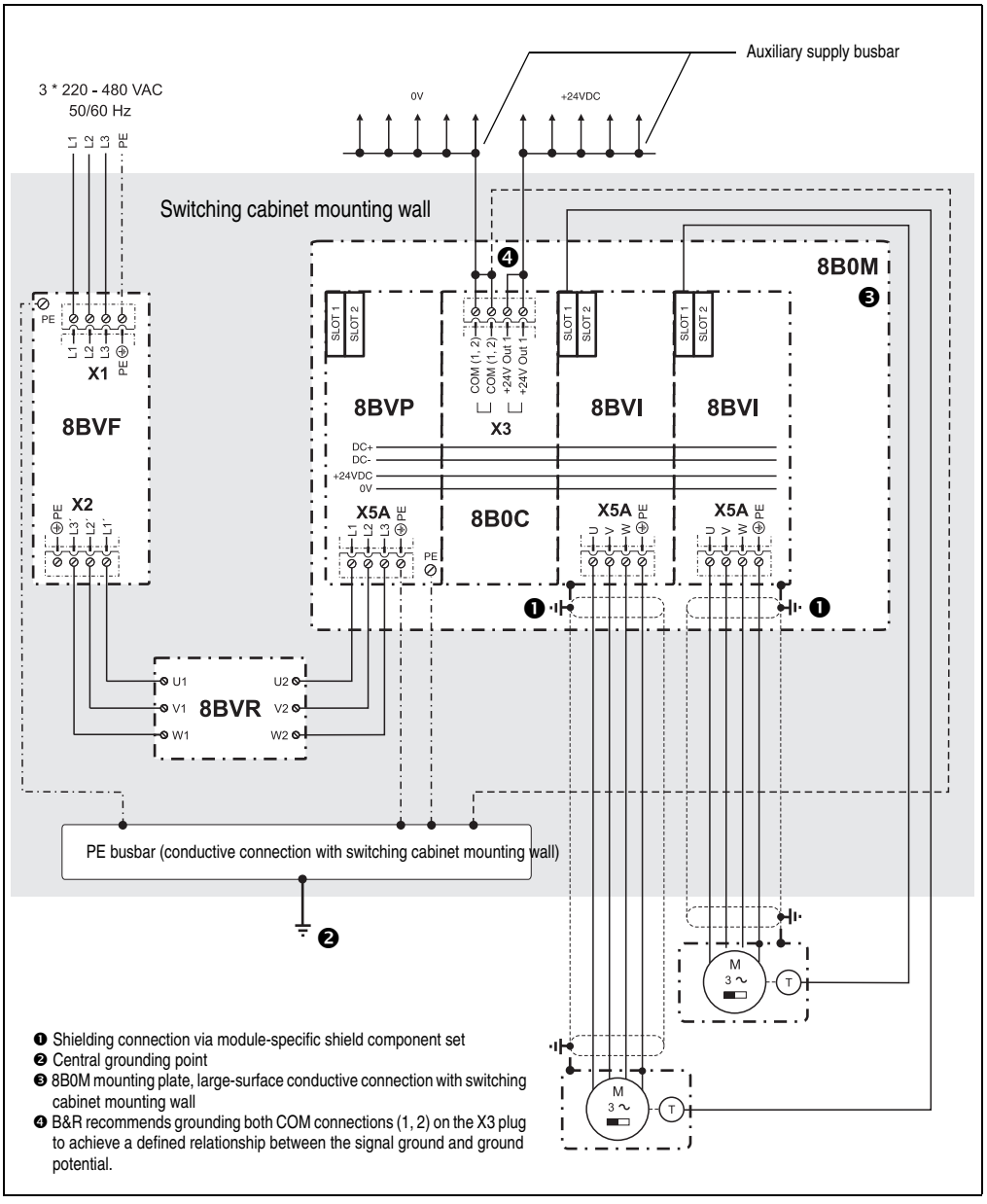


Figure 13: Overview of ground/shield for ACOPOSmulti drive system

Connection diagrams for ground and shield connections

8BVI inverter modules with SafeMC

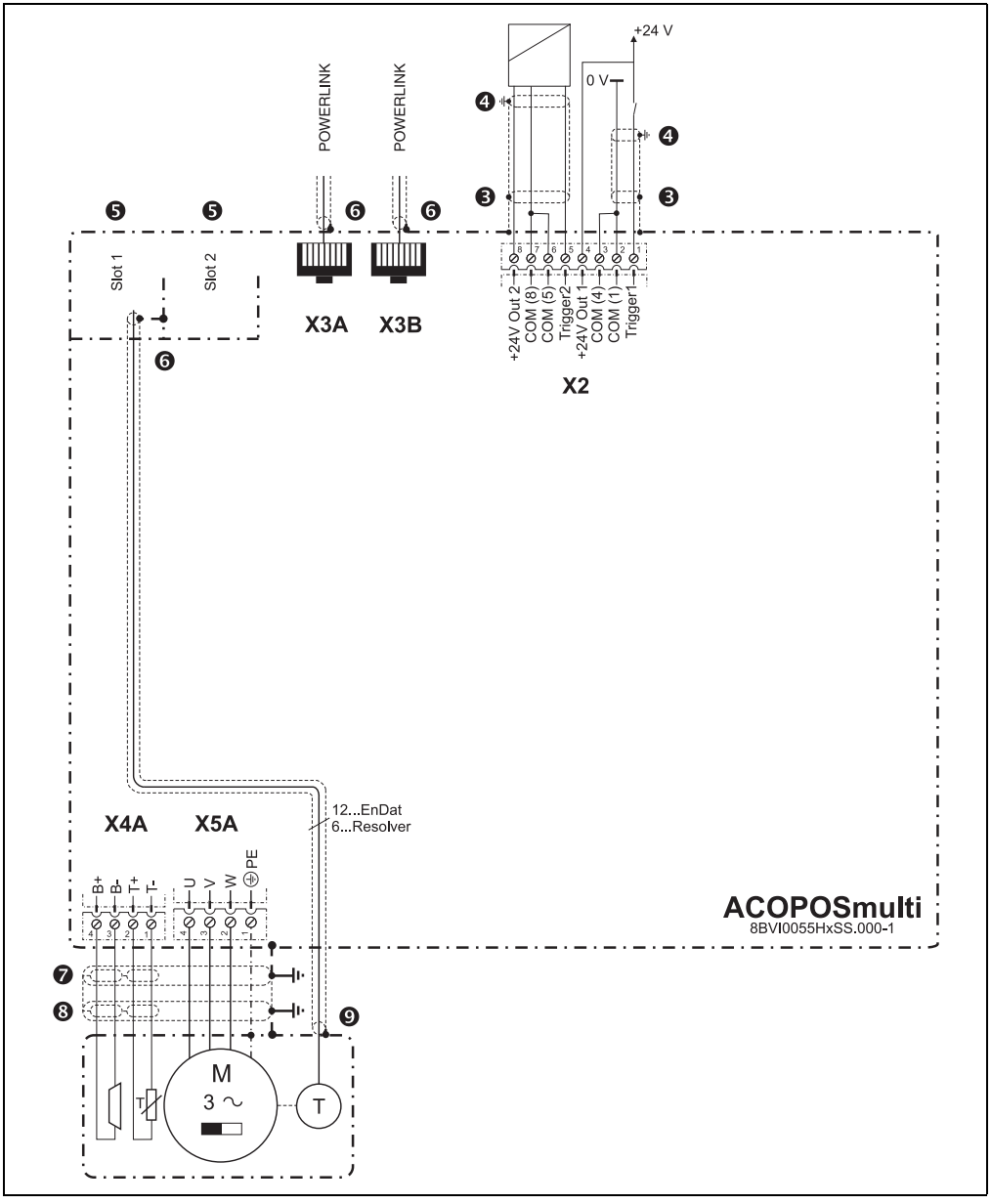


Figure 14: Ground connections and shield connections for 8BVI inverter modules

❸ Both trigger inputs are only filtered internally with approx. 50 µs. Make sure the cable shield is grounded properly. The optional shield set 8SCS002.0000-00 can be used with this.

❹ The cable shield must be attached to the shield connector.

❺ 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.

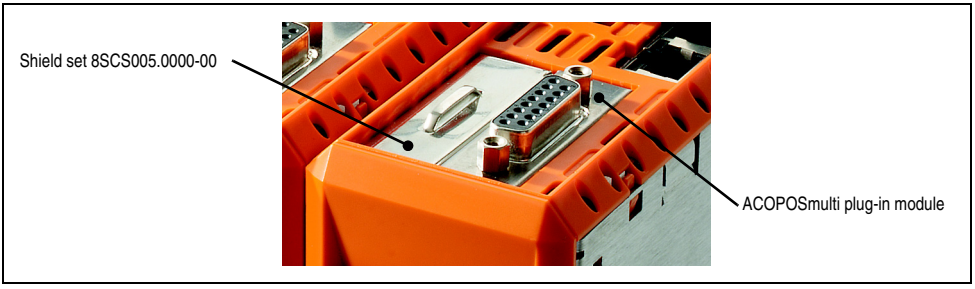


Figure 15: Use of the shield set 8SCS005.0000-00

❻ 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.

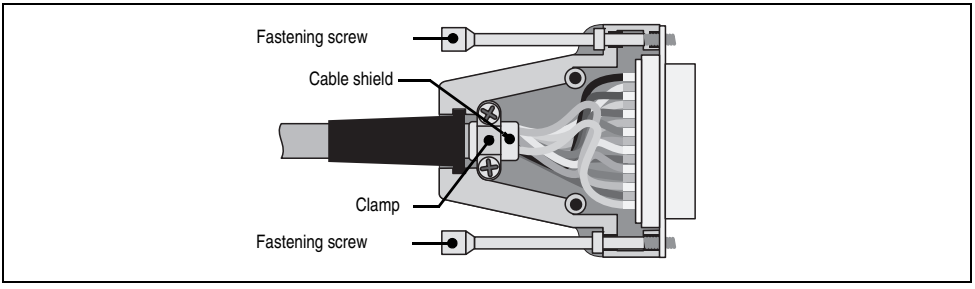


Figure 16: Cable shielding in DSUB housing

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. Both sides should be properly grounded near the connector. The optional shield set 8SCS002.0000-00, available from B&R, can be used on the ACOPOSmulti module.

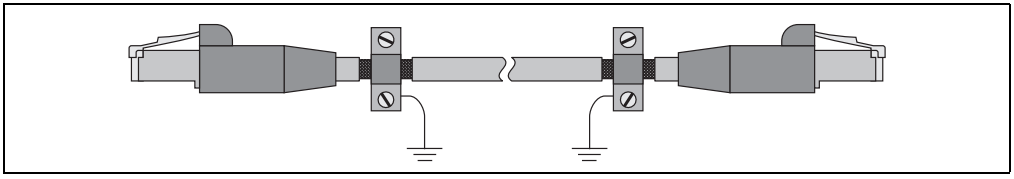


Figure 17: Grounding the POWERLINK cable shielding

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!

❼ The cable shield can be connected with the ACOPOSmulti module housing using the optional shield sets available from B&R.

❽ On the motor side, the cable shield for the motor line is connected to the motor housing using the motor plug and connected to ground via the machine.

❾ 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.

5.1.2 Isolation and high-voltage test

Insulation resistance according to EN 60204

According to 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 section 18.3 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

According to 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 1000 VAC (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

1) Remove the motor cable from the X5A / X5B connection of the ACOPOSmulti inverter module.
2) Perform the insulation test on the X1 power mains connection (mains side) of the ACOPOSmulti line filter.
3) Perform the insulation test on the B&R motor.

High voltage test

1) 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 ACOPOSmulti line filter.
2) 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.
3) Perform the high voltage test on the U1 / V1 / W1 connections of the ACOPOSmulti regeneration choke.
4) Remove the motor cable from the X5A / X5B connection of the ACOPOSmulti inverter module.
5) Perform the high voltage test on the B&R motor.

5.2 8BVI0014HxSS.000-1, 8BVI0028HxSS.000-1, 8BVI0055HxSS.000-1, 8BVI0110HxSS.000-1

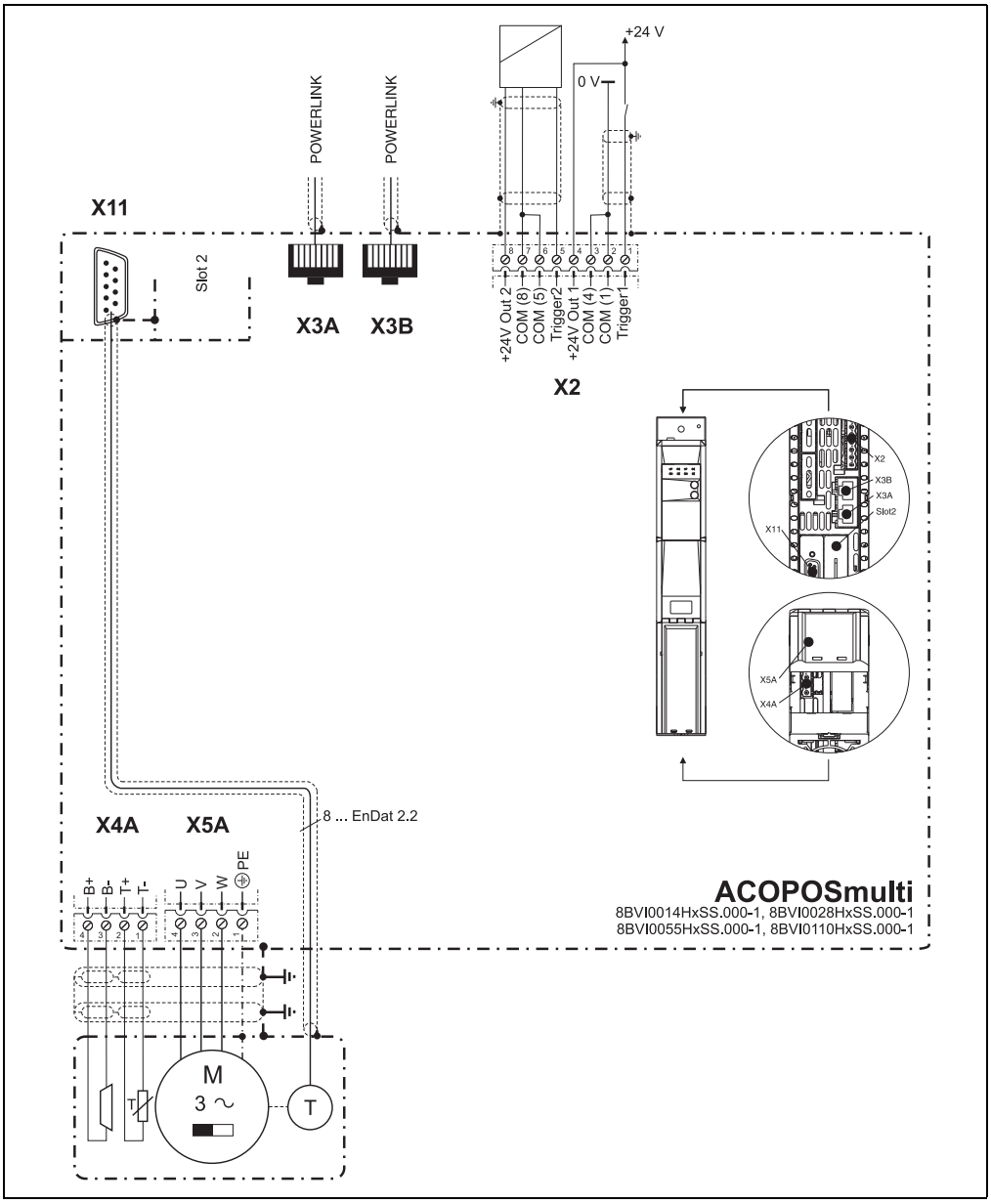


Figure 18: Overview of pin assignments
8BVI0014HxSS.000-1, 8BVI0028HxSS.000-1, 8BVI0055HxSS.000-1, 8BVI0110HxSS.000-1

5.2.1 Pin assignments - X2 plug

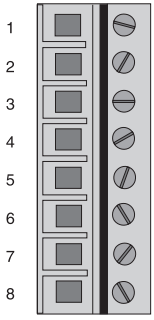
X2	Pin	Name	Function
	1	Trigger1	Trigger 1
	2	COM (1)	Trigger 1 0 V
	3	COM (4)	+24 V output 1 0 V
	4	+24 V Out 1	+24 V output 1
	5	Trigger2	Trigger 2
	6	COM (5)	Trigger 2 0 V
	7	COM (8)	+24 V output 2 0 V
	8	+24 V Out 2	+24 V output 2

Table 55: Pin assignments - X2 plug
8BVI0014HxSS.000-1, 8BVI0028HxSS.000-1, 8BVI0055HxSS.000-1, 8BVI0110HxSS.000-1

5.2.2 Pin assignments - X3A, X3B plugs

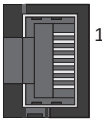
X3A, X3B	Pin	Name	Function
	1	RXD	Receive signal
	2	RXD\	Receive signal inverted
	3	TXD	Transmit signal
	4	Shield	Shield
	5	Shield	Shield
	6	TXD\	Transmit signal inverted
	7	Shield	Shield
	8	Shield	Shield

Table 56: Pin assignments - X3A, X3B plugs
8BVI0014HxSS.000-1, 8BVI0028HxSS.000-1, 8BVI0055HxSS.000-1, 8BVI0110HxSS.000-1

5.2.3 Pin assignments - X4A plug

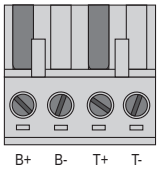
X4A	Name	Function
	T-	Axis 1: Temperature sensor -
	T+	Axis 1: Temperature sensor +
	B- 1)	Axis 1: Brake -
	B+ 1)	Axis 1: Brake +

Table 57: Pin assignments - X4A plug
8BVI0014HxSS.000-1, 8BVI0028HxSS.000-1, 8BVI0055HxSS.000-1, 8BVI0110HxSS.000-1

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!

Danger!

The SBC output

- **cannot be wired to multiple modules!**
- **cannot be wired as open emitter!**
- **cannot 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 500µs.
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 according to 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!

5.2.4 Pin assignments - X5A plug

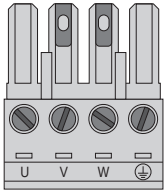
X5A	Name	Function
	PE	Axis 1: Protective ground conductor
	W	Axis 1: Motor connection W
	V	Axis 1: Motor connection V
	U	Axis 1: Motor connection U

Table 58: Pin assignments - X5A plug
8BVI0014HxSS.000-1, 8BVI0028HxSS.000-1, 8BVI0055HxSS.000-1, 8BVI0110HxSS.000-1

5.2.5 Pin assignments - SafeMC module X11 (slot 1)

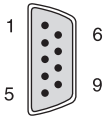
Figure	X11	Pin	Name	Function
		1	U+	Encoder supply +12.5 V
		2	---	---
		3	---	---
		4	D	Data input
		5	T	Clock output
		6	COM (1)	Encoder supply 0 V
		7	---	---
		8	D\	Data input inverted
		9	T\	Clock output inverted

Table 59: Pin assignments - SafeMC module X11 (slot 1)
8BVI0014HxSS.000-1, 8BVI0028HxSS.000-1, 8BVI0055HxSS.000-1, 8BVI0110HxSS.000-1

5.2.6 Input/output circuit diagram

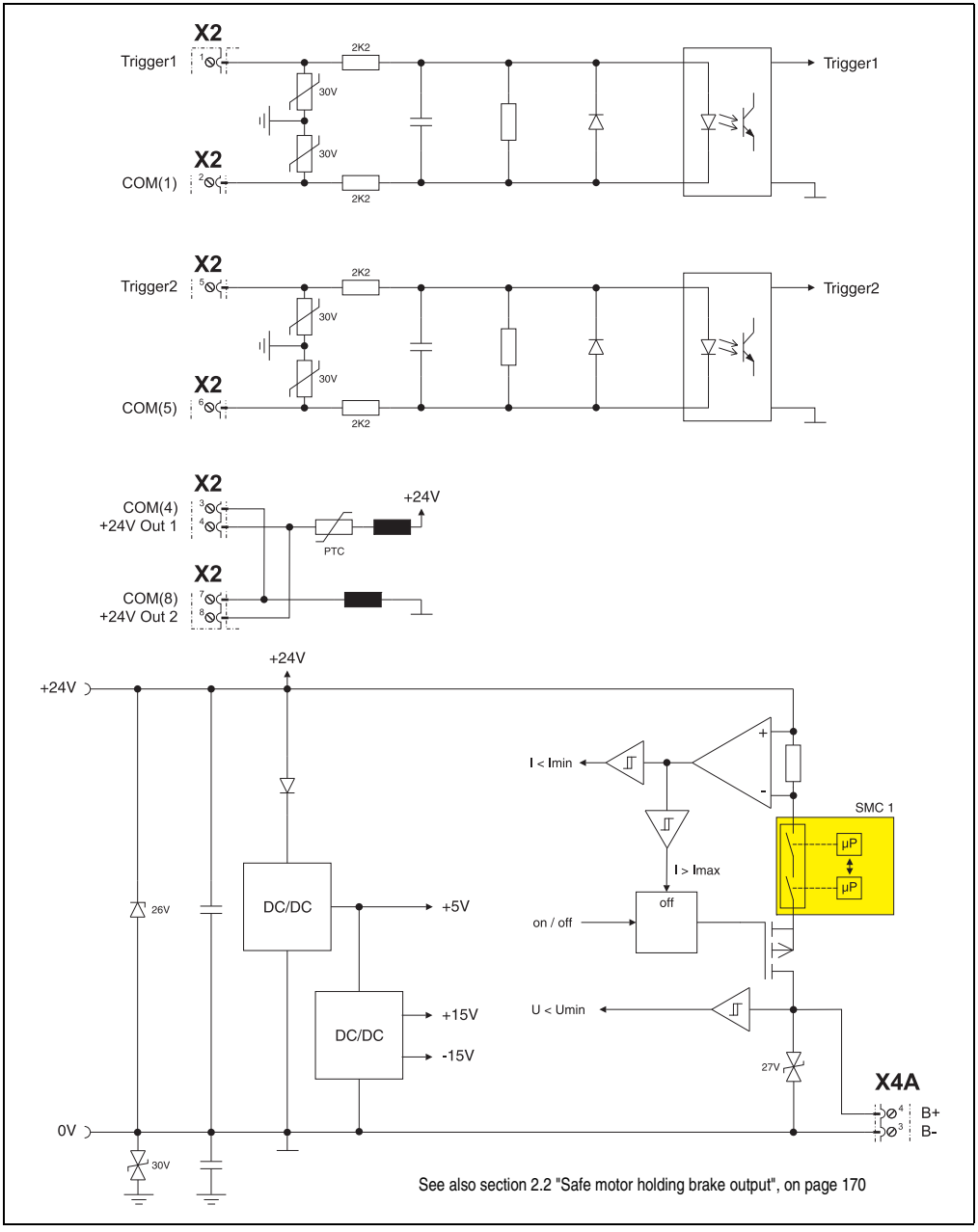


Figure 19: Input/output circuit diagram
8BVI0014HxS0.000-1, 8BVI0028HxS0.000-1, 8BVI0055HxS0.000-1, 8BVI0110HxS0.000-1

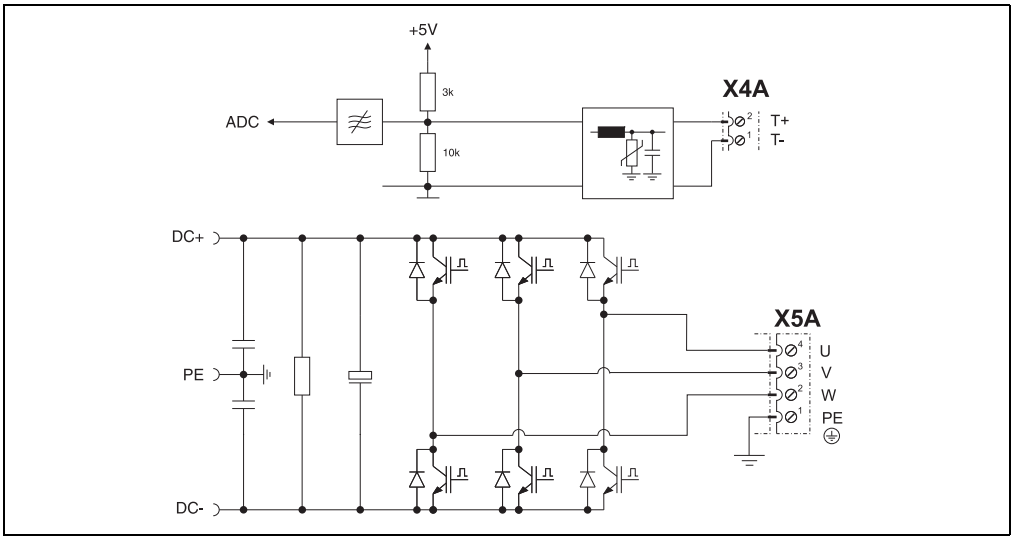


Figure 19: Input/output circuit diagram
8BVI0014HxS0.000-1, 8BVI0028HxS0.000-1, 8BVI0055HxS0.000-1, 8BVI0110HxS0.000-1 (cont.)

5.3 8BVI0014HxDS.000-1, 8BVI0028HxDS.000-1, 8BVI0055HxDS.000-1

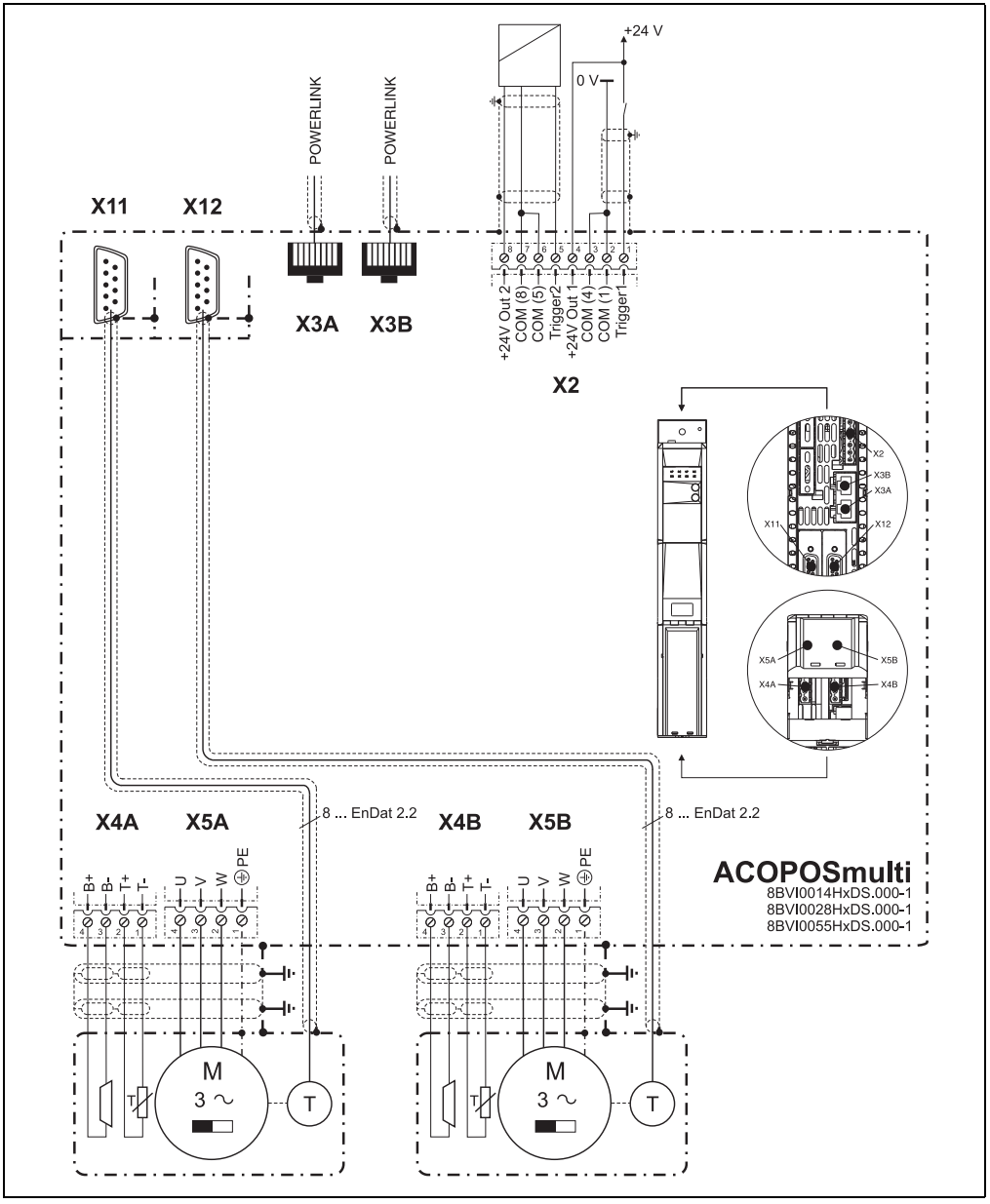


Figure 20: Overview of pin assignments
8BVI0014HxDS.000-1, 8BVI0028HxDS.000-1, 8BVI0055HxDS.000-1

5.3.1 Pin assignments - X2 plug

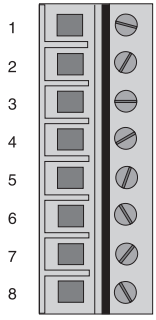
X2	Pin	Name	Function
	1	Trigger1	Trigger 1
	2	COM (1)	Trigger 1 0 V
	3	COM (4)	+24 V output 1 0 V
	4	+24 V Out 1	+24 V output 1
	5	Trigger2	Trigger 2
	6	COM (5)	Trigger 2 0 V
	7	COM (8)	+24 V output 2 0 V
	8	+24 V Out 2	+24 V output 2

Table 60: Pin assignments - X2 plug
8BVI0014HxDS.000-1, 8BVI0028HxDS.000-1, 8BVI0055HxDS.000-1

5.3.2 Pin assignments - X3A, X3B plugs

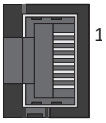
X3A, X3B	Pin	Name	Function
	1	RXD	Receive signal
	2	RXD\	Receive signal inverted
	3	TXD	Transmit signal
	4	Shield	Shield
	5	Shield	Shield
	6	TXD\	Transmit signal inverted
	7	Shield	Shield
	8	Shield	Shield

Table 61: Pin assignments - X3A, X3B plugs
8BVI0014HxDS.000-1, 8BVI0028HxDS.000-1, 8BVI0055HxDS.000-1

5.3.3 Pin assignments - X4A plug

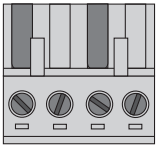
X4A	Name	Function
	T-	Axis 1: Temperature sensor -
	T+	Axis 1: Temperature sensor +
	B- 1)	Axis 1: Brake -
	B+ 1)	Axis 1: Brake +

Table 62: Pin assignments - X4A plug
8BVI0014HxDS.000-1, 8BVI0028HxDS.000-1, 8BVI0055HxDS.000-1

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

- **cannot be wired to multiple modules!**
- **cannot be wired as open emitter!**
- **cannot 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 500µs.
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 according to 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!

5.3.4 Pin assignments - X4B plug

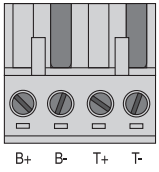
X4b	Name	Function
	T-	Axis 2: Temperature sensor -
	T+	Axis 2: Temperature sensor +
	B- 1)	Axis 2: Brake -
	B+ 1)	Axis 2: Brake +

Table 63: Pin assignments - X4B plug
8BVI0014HxDS.000-1, 8BVI0028HxDS.000-1, 8BVI0055HxDS.000-1

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

- **cannot be wired to multiple modules!**
- **cannot be wired as open emitter!**
- **cannot 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 500µs.
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 according to 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!

5.3.5 Pin assignments - X5A plug

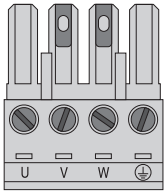
X5A	Name	Function
	PE	Axis 1: Protective ground conductor
	W	Axis 1: Motor connection W
	V	Axis 1: Motor connection V
	U	Axis 1: Motor connection U

Table 64: Pin assignments - X5A plug
8BVI0014HxDS.000-1, 8BVI0028HxDS.000-1, 8BVI0055HxDS.000-1

5.3.6 Pin assignments - X5B plug

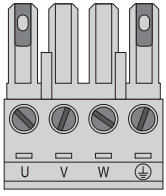
X5B	Name	Function
	PE	Axis 2: Protective ground conductor
	W	Axis 2: Motor connection W
	V	Axis 2: Motor connection V
	U	Axis 2: Motor connection U

Table 65: Pin assignments - X5B plug
8BVI0014HxDS.000-1, 8BVI0028HxDS.000-1, 8BVI0055HxDS.000-1

5.3.7 Pin assignments - SafeMC module X11 (slot 1)

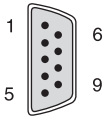
Figure	X11	Pin	Name	Function
		1	U+	Encoder supply +12.5 V
		2	---	---
		3	---	---
		4	D	Data input
		5	T	Clock output
		6	COM (1)	Encoder supply 0 V
		7	---	---
		8	D\	Data input inverted
		9	T\	Clock output inverted

Table 66: Pin assignments - SafeMC module X11 (slot 1)
8BVI0014HxDS.000-1, 8BVI0028HxDS.000-1, 8BVI0055HxDS.000-1

5.3.8 Pin assignments - SafeMC module X12 (slot 2)

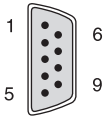
Figure	X11	Pin	Name	Function
		1	U+	Encoder supply +12.5 V
		2	---	---
		3	---	---
		4	D	Data input
		5	T	Clock output
		6	COM (1)	Encoder supply 0 V
		7	---	---
		8	D\	Data input inverted
		9	T\	Clock output inverted

Table 67: Pin assignments - SafeMC module X12 (slot 2)
8BVI0014HxDS.000-1, 8BVI0028HxDS.000-1, 8BVI0055HxDS.000-1

5.3.9 Input/output circuit diagram

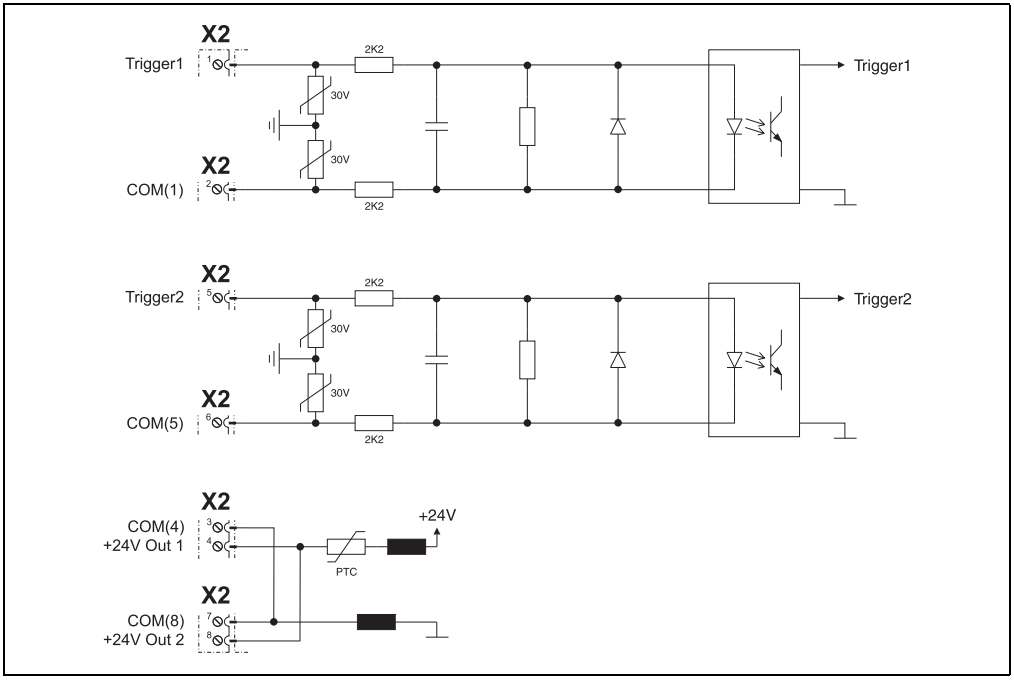


Figure 21: Input/output circuit diagram 8BVI0014HxDS.000-1, 8BVI0028HxDS.000-1, 8BVI0055HxDS.000-1

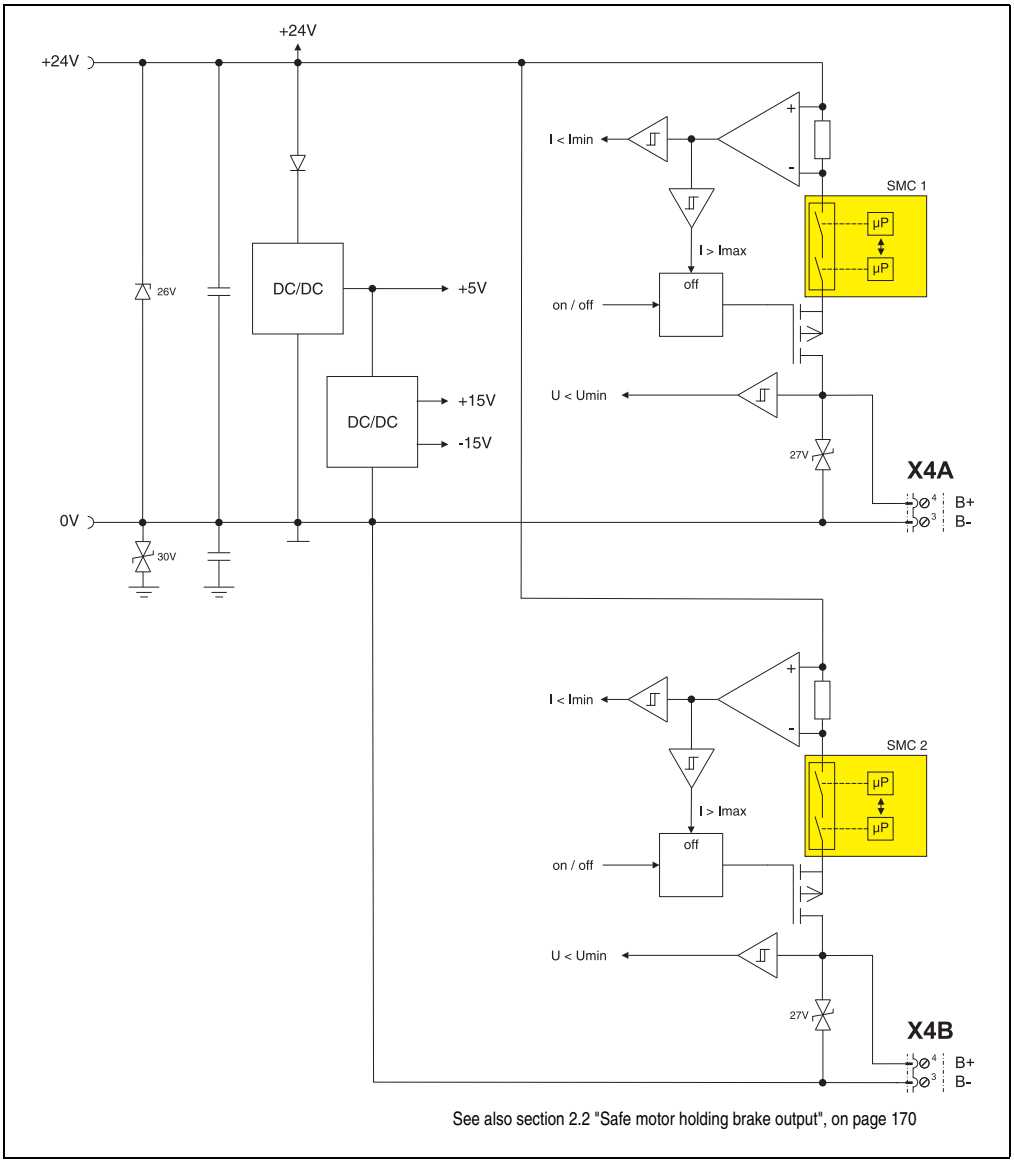


Figure 21: Input/output circuit diagram 8BVI0014HxDS.000-1, 8BVI0028HxDS.000-1, 8BVI0055HxDS.000-1

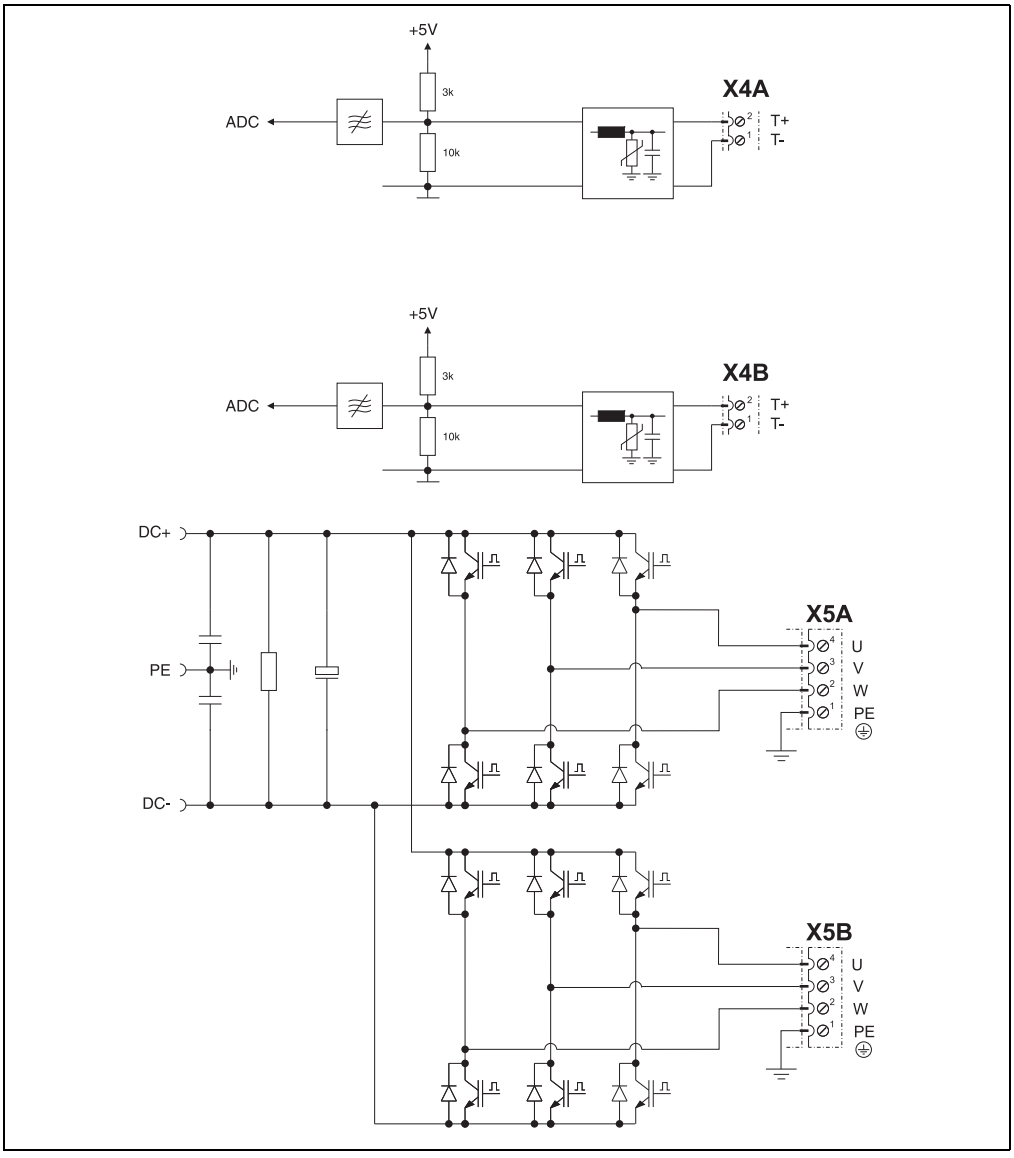


Figure 21: Input/output circuit diagram 8BVI0014HxDS.000-1, 8BVI0028HxDS.000-1, 8BVI0055HxDS.000-1

5.4 8BVI0220HxSS.000-1, 8BVI0330HxSS.000-1, 8BVI0440HxSS.000-1

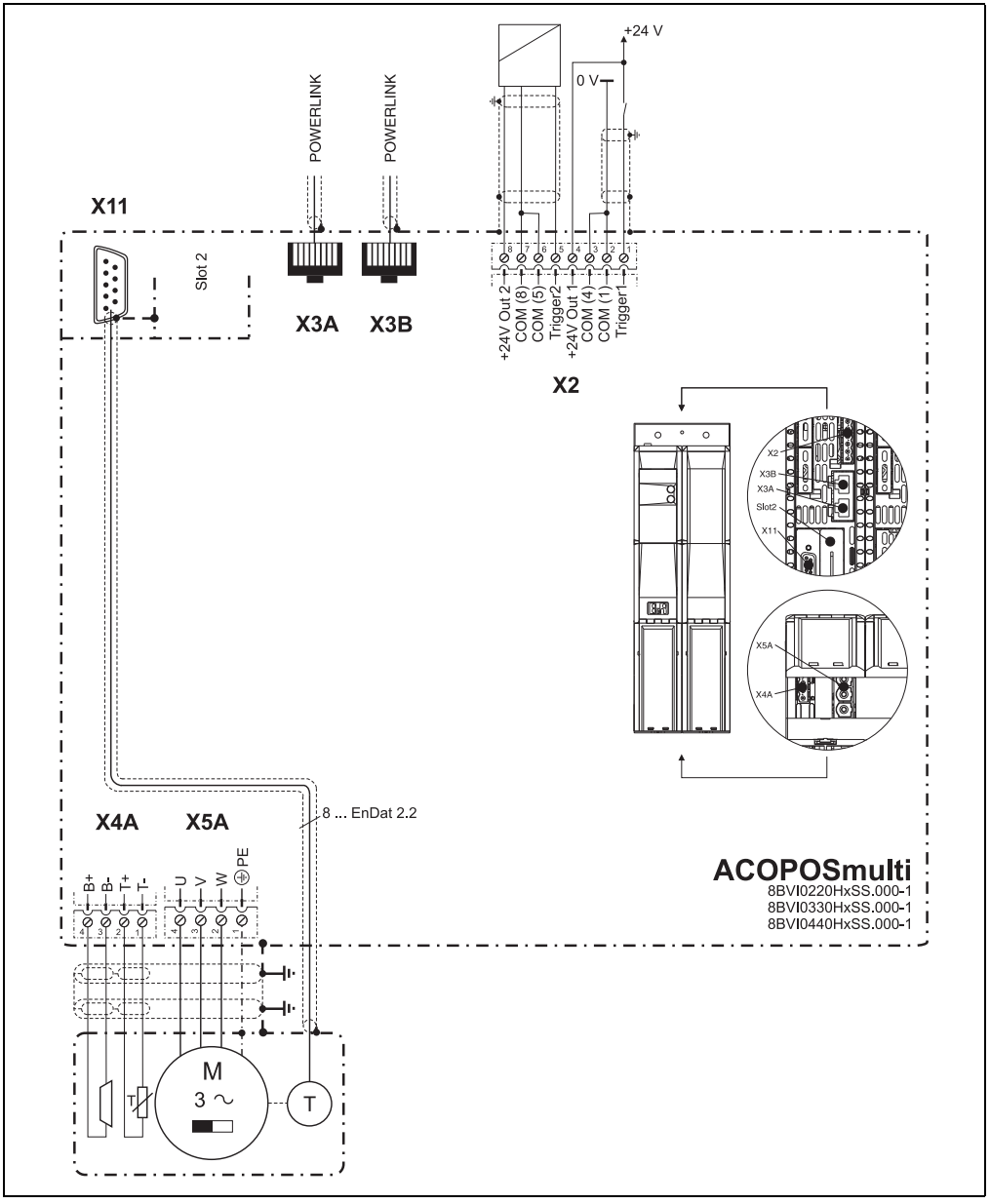


Figure 22: Overview of pin assignments
8BVI0220HxSS.000-1, 8BVI0330HxSS.000-1, 8BVI0440HxSS.000-1

5.4.1 Pin assignments - X2 plug

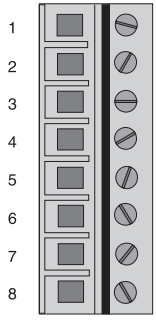
X2	Pin	Name	Function
	1	Trigger1	Trigger 1
	2	COM (1)	Trigger 1 0 V
	3	COM (4)	+24 V output 1 0 V
	4	+24 V Out 1	+24 V output 1
	5	Trigger2	Trigger 2
	6	COM (5)	Trigger 2 0 V
	7	COM (8)	+24 V output 2 0 V
	8	+24 V Out 2	+24 V output 2

Table 68: Pin assignments - X2 plug
8BVI0220HxSS.000-1, 8BVI0330HxSS.000-1, 8BVI0440HxSS.000-1

5.4.2 Pin assignments - X3A, X3B plugs

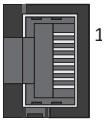
X3A, X3B	Pin	Name	Function
	1	RXD	Receive signal
	2	RXD\	Receive signal inverted
	3	TXD	Transmit signal
	4	Shield	Shield
	5	Shield	Shield
	6	TXD\	Transmit signal inverted
	7	Shield	Shield
	8	Shield	Shield

Table 69: Pin assignments - X3A, X3B plugs
8BVI0220HxSS.000-1, 8BVI0330HxSS.000-1, 8BVI0440HxSS.000-1

5.4.3 Pin assignments - X4A plug

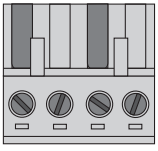
X4A	Name	Function
	T-	Axis 1: Temperature sensor -
	T+	Axis 1: Temperature sensor +
	B- 1)	Axis 1: Brake -
	B+ 1)	Axis 1: Brake +

Table 70: Pin assignments - X4A plug
8BVI0220HxSS.000-1, 8BVI0330HxSS.000-1, 8BVI0440HxSS.000-1

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!

Danger!

The SBC output

- **cannot be wired to multiple modules!**
- **cannot be wired as open emitter!**
- **cannot 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 500µs.
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 according to 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!

5.4.4 Pin assignments - X5A plug

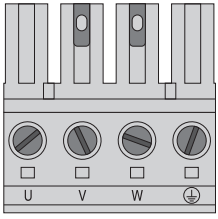
X5A	Name	Function
	PE	Axis 1: Protective ground conductor
	W	Axis 1: Motor connection W
	V	Axis 1: Motor connection V
	U	Axis 1: Motor connection U

Table 71: Pin assignments - X5A plug
8BVI0220HxSS.000-1, 8BVI0330HxSS.000-1, 8BVI0440HxSS.000-1

Information:

An additional PE conductor does not have to be connected to the threaded bolts located beside the X5A plug. The PE connection on the X5A plug is required and sufficient.

5.4.5 Pin assignments - SafeMC module X11 (slot 1)

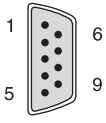
Figure	X11	Pin	Name	Function
		1	U+	Encoder supply +12.5 V
		2	---	---
		3	---	---
		4	D	Data input
		5	T	Clock output
		6	COM (1)	Encoder supply 0 V
		7	---	---
		8	D\	Data input inverted
		9	T\	Clock output inverted

Table 72: Pin assignments - SafeMC module X11 (slot 1)
8BVI0220HxSS.000-1, 8BVI0330HxSS.000-1, 8BVI0440HxSS.000-1

5.4.6 Input/output circuit diagram

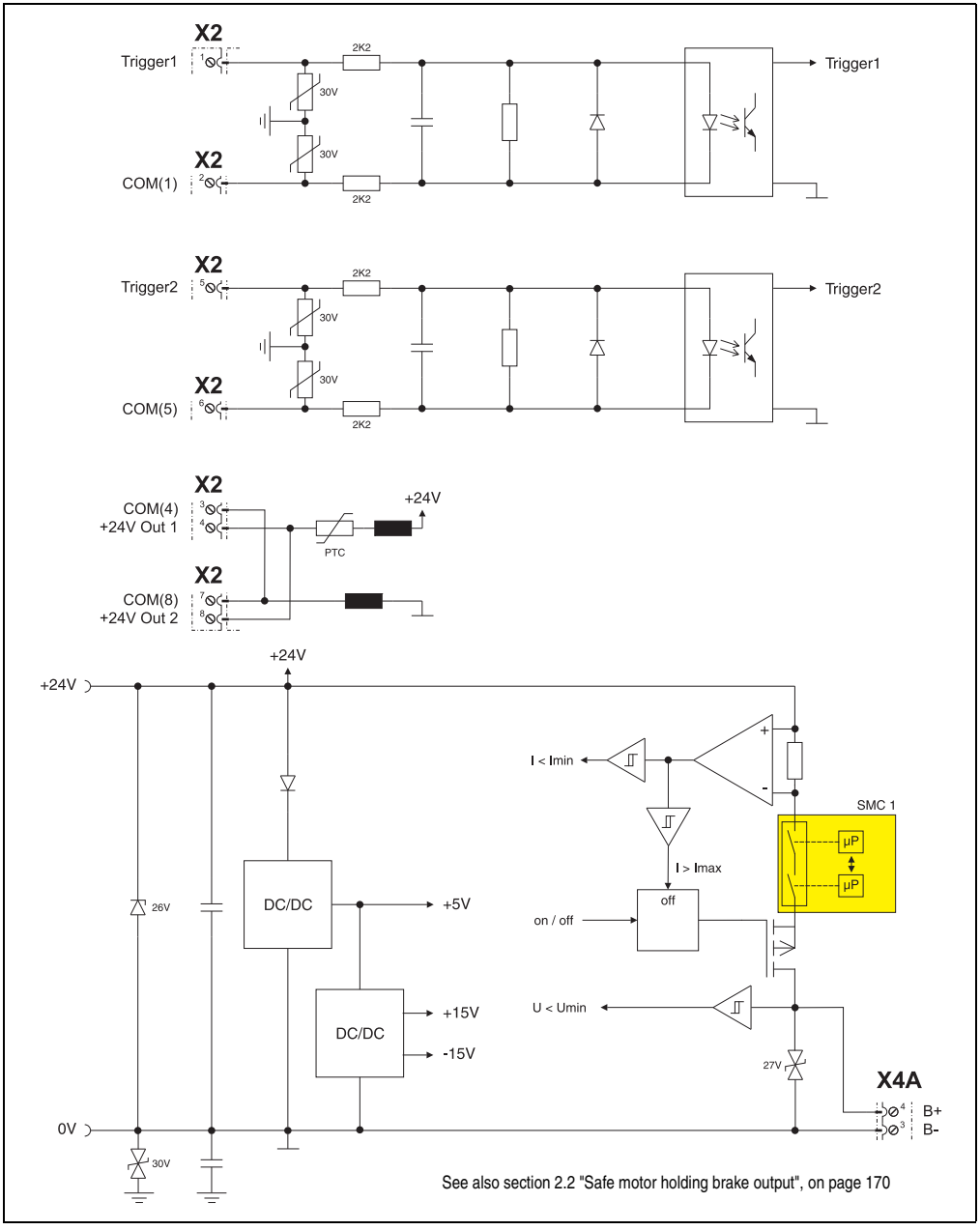


Figure 23: Input/output circuit diagram
8BVI0220HxSS.000-1, 8BVI0330HxSS.000-1, 8BVI0440HxSS.000-1

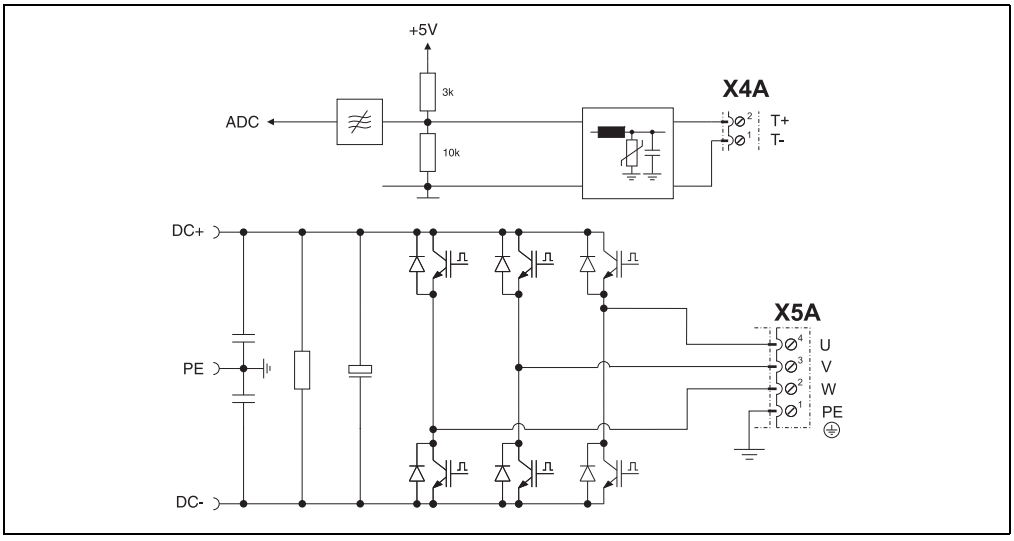


Figure 23: Input/output circuit diagram
8BVI0220HxSS.000-1, 8BVI0330HxSS.000-1, 8BVI0440HxSS.000-1 (cont.)

Chapter 6 • 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, flight control systems, flight safety, the control of mass transportation systems, medical life support systems and the control of weapons systems.

1.2 The safe power transmission

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

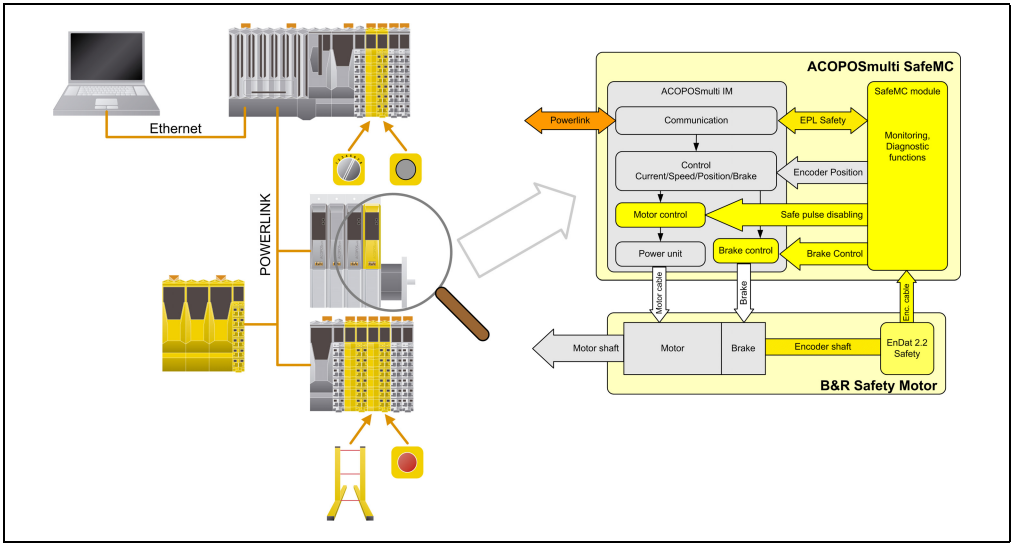


Figure 24: The safe power transmission

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 station and one safe station.
On the other hand, one two-axis module contains two SafeMC modules and is therefore equal to one POWERLINK node and two safe nodes!

The actual control takes place as before – via the functional 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.

There are two differences between the motor and the standard motor:

- Type of encoder being used
  An EnDat2.2 functional safety encoder is absolutely necessary when using ACOPOSmulti with SafeMC! With standard EnDat2.2 encoders, only the functions STO, SBC, and SS1 are available for time-monitoring!
- Installing the position 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.

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°/2p (for B&R standard motors, p=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 ACOPOSmulti 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.

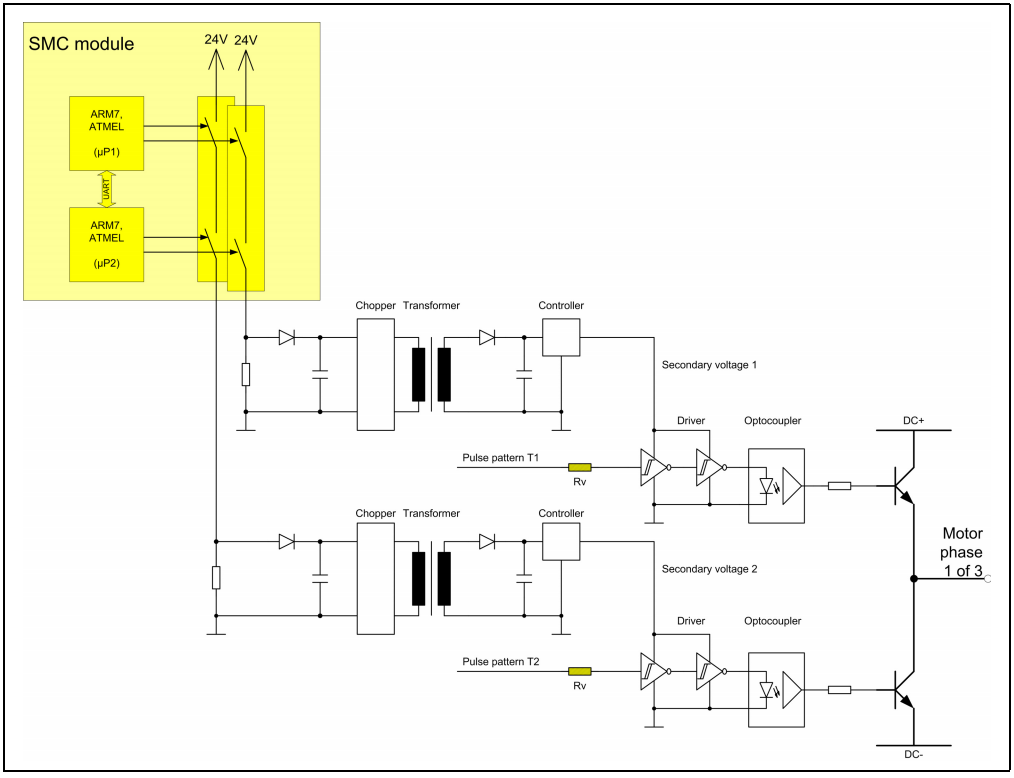


Figure 25: Control of safe pulse disabling

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

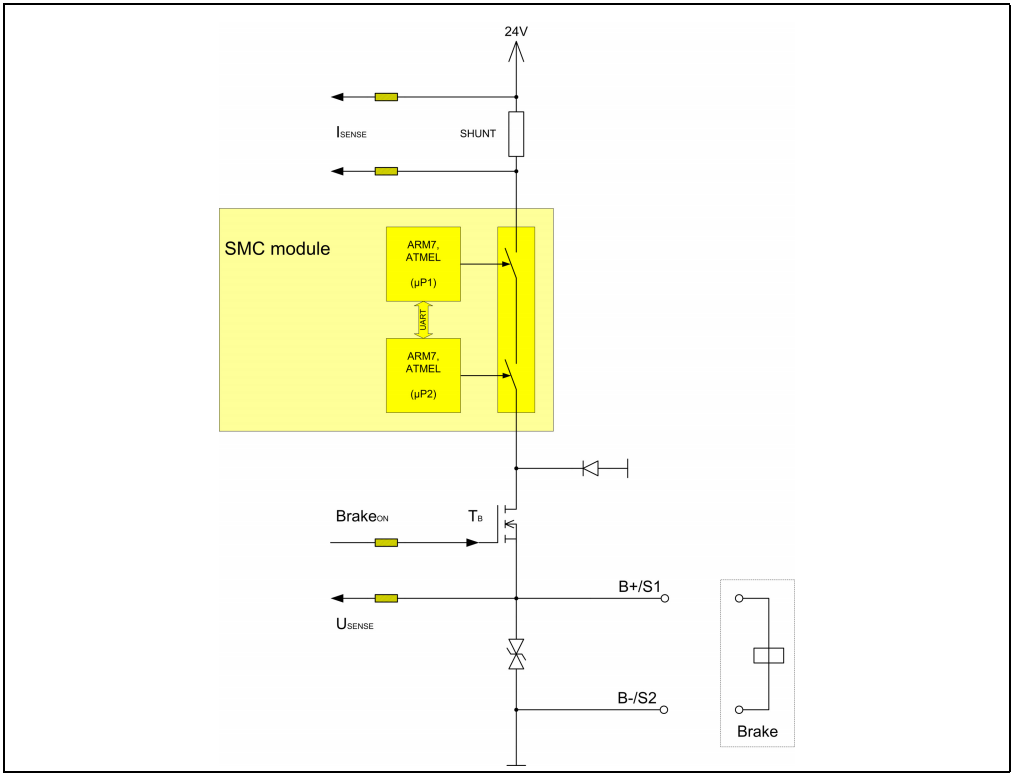


Figure 26: Connection of safe motor holding brake output

A wiring error that causes the output B+ to be shorted to 24 V, causes the actuator to remain turned on despite the acknowledgeable functional fail safe state being activated.

Error description	Effect	Safety function in accordance with category 4 / SIL 3 / PL e 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 73: 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 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

- **cannot be wired to multiple modules!**
- **cannot be wired as open emitter!**
- **cannot 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 500µs.
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.

Information:

The calculation of the safety-related characteristic values for the individual safety functions uses the values specified by Heidenhain for the EnDat 2.2 functional safety encoder.
Therefore, this does not have to be accounted for again when calculating a complete safety chain!

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. Heidenhein provides respective specifications for this that must be followed when installing the encoder. The motor manufacturer must ensure that these specifications are adhered to.

Danger!

To reach safety level SIL 2 for the safety functions that require a 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 and limit violations early-on!

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.

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.

Danger!

Some safety-related measurement devices are restricted to use in the ´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".

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)
  → 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.

Safety function	Criteria	Characteristic value
Safe Torque Off (STO) **Safe Stop 1 (SS1), time-monitored**	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 dangerous Failure per Hour)	< 5*10-11
	PFD (Probability of dangerous Failure on Demand)	< 9*10-06 at a proof test interval of 20 years
	PT (Proof Test interval)	max. 20 years
	DC (Diagnostic Coverage)	> 90%
	MTTFd (Mean Time To Failure - dangerous)	> 142
Safe Torque Off (STO) single-channel	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 dangerous Failure per Hour)	< 8*10-10
	PFD (Probability of dangerous Failure on Demand)	< 2*10-04 at a proof test interval of 20 years
	PT (Proof Test interval)	max. 20 years
	DC (Diagnostic Coverage)	> 90%
	MTTFd (Mean Time To Failure - dangerous)	> 174
Safe Brake Control (SBC)	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 dangerous Failure per Hour)	< 5*10-11
	PFD (Probability of dangerous Failure on Demand)	< 9*10-06 at a proof test interval of 20 years
	PT (Proof Test interval)	max. 20 years
	DC (Diagnostic Coverage)	> 90%
	MTTFd (Mean Time To Failure - dangerous)	> 147
Safe Operating Stop (SOS) [1] **Safe Stop 1 (SS1)** [1] **Safe stop 2 (SS2)** [1] **Safely Limited Speed (SLS)** [1] **Safe Direction (SDI)** [1] **Safely Limited Increments (SLI)** [1] **Safe Maximum Speed (SMS)** [1]	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 dangerous Failure per Hour)	< 5*10-09
	PFD (Probability of dangerous Failure on Demand)	< 8*10-04 at a proof test interval of 20 years
	PT (Proof Test interval)	max. 20 years
	DC (Diagnostic Coverage)	> 90%
	MTTFd (Mean Time To Failure - dangerous)	> 129

Table 74: Safety characteristics

1) The safety characteristics also include the values of the functional safety EnDat2.2 encoder.

4. Integrated safety functions

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!

The following safety functions are supported by the SafeMC module:

Safety function	EN ISO 13849 - 1	EN 61508 / EN 62061	Safe encoder evaluation required?
Safe Torque Off (STO)	PI e	SIL 3	No
Safe Torque Off One Channel (STO1)	PI d	SIL 2	No
Safe Operation Stop (SOS)	PI d	SIL 2	Yes
Safe Stop 1 (SS1)	PL e (time monitored) PI d	SIL 3 (time monitored) SIL 2	No Yes
Safe stop 2 (SS2)	PI d	SIL 2	Yes
Safely Limited Speed (SLS)	PI d	SIL 2	Yes
Safe Maximum Speed (SMS)	PI d	SIL 2	Yes
Safe Direction (SDI)	PI d	SIL 2	Yes
Safely Limited Increment (SLI)	PI d	SIL 2	Yes
Safe Brake Control (SBC)	PI e	SIL 3	No

Table 75: 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 functional application.

If there is a hardware defect, then the module must be replaced. Because the SafeMC module is built into the ACOPOSmulti inverter module, the entire inverter module must be replaced in the event of error!

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!

Information:

Fail Safe state is indicated by constant illumination of the SE LEDs! Defective modules must be replaced immediately. It is your responsibility to ensure that all necessary repairs are made if an error occurs because subsequent errors could create a dangerous situation!

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 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 Chapter 5 "Safe response time", on page 28 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.)

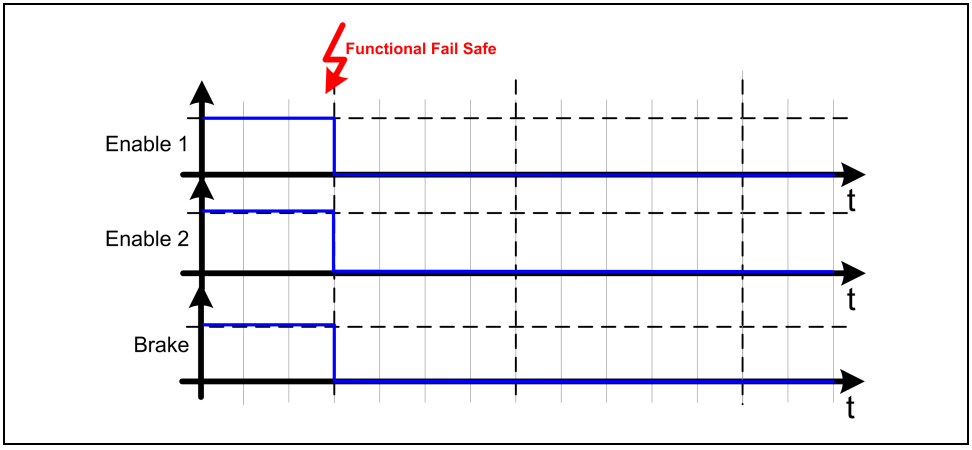
The following parameters are provided in SafeDESIGNER for configuring the Functional Fail Safe state:

Parameter	Description		Default value	Units
Behavior of Functional Fail Safe	In the Functional Fail Safe state, STO and SBC is activated immediately or STO1 and then STO and SBC after a delay		STO	---
	Parameter 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.		
Delay for STO in Functional Fail Safe	Delay time between STO1 and SBC in the Functional Fail Safe state. Delay time between STO1 and STO in the Functional Fail Safe state (only if "Delay time until the brake engages = 0").		0	[µs]
Delay time until the brake engages	**Delay time until the brake engages (only if "Behavior of Functional Fail Safe = STO1 and STO with time delay")** The second Enable channel (STO) is activated after a delay of this amount of time - in addition to "Delay for STO in Functional Fail Safe".		0	[µs]
Channel selection for One Channel STO (STO1)	Selection of HighSide or LowSide IGBT in the OneChannelSTO function		HighSide	---
	Parameter value	**Description**		
	HighSide	The high side IGBTs are actuated with the function STO1.		
	LowSide	The low side IGBTs are actuated with the function STO1.		

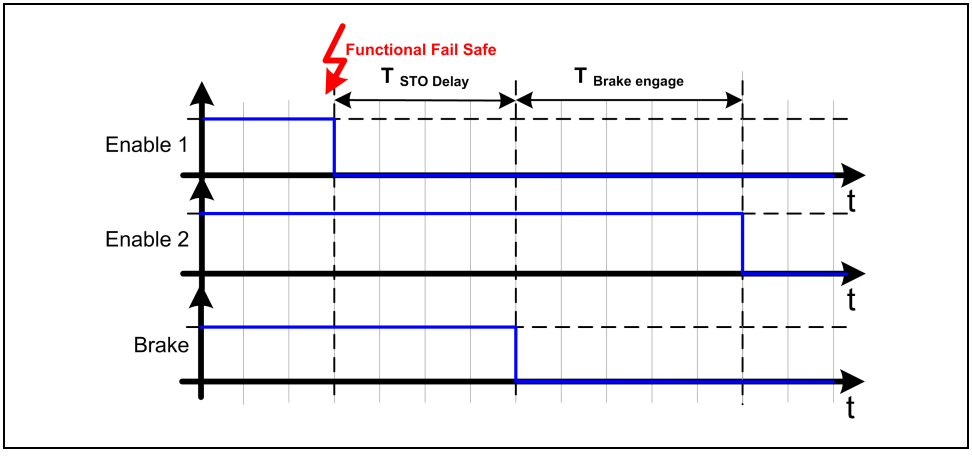
Table 76: Functional Fail Safe state parameters

Behavior of the Functional Fail Safe state must be configured as follows:

1) **"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 0V.



2) **"Behavior of Functional Fail Safe" = "STO1 and STO with time delay"**
Either the low or high side of the pulse disabling is switched to 0V immediately after the error is detected. The safe motor holding brake output is set to 0 V after the configured time "Delay 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.



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 0V 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!

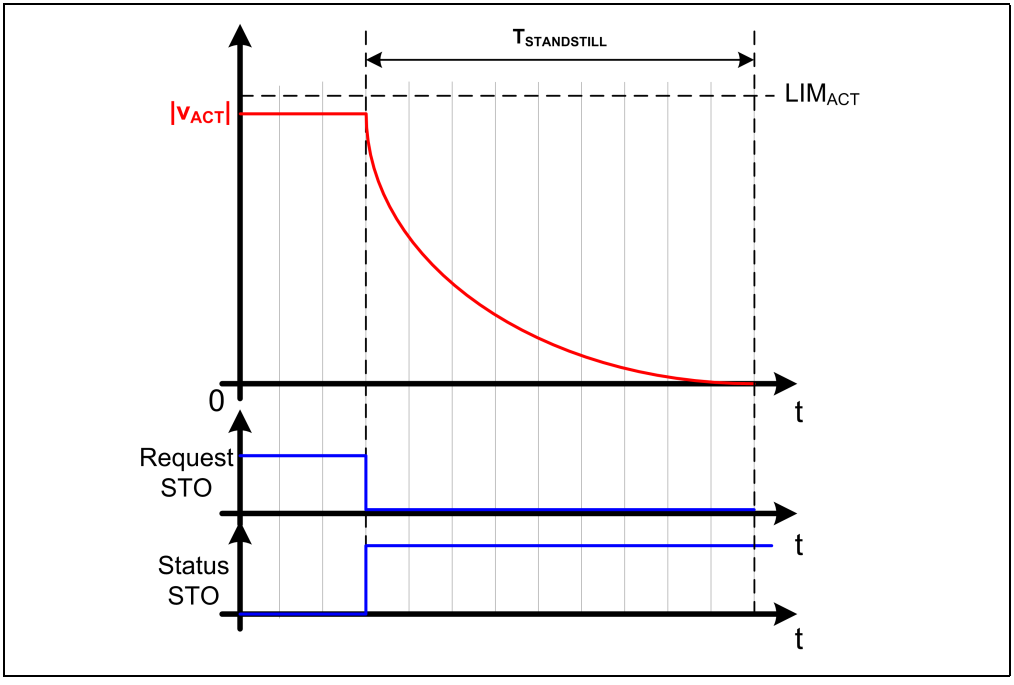


Figure 27: Safe Torque Off

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 $T_{STANDSTILL}$ movement and time depends on the properties of the machine and must always be considered when dimensioning the safety equipment.
The maximum possible (worst case) movement must be assumed.

The maximum possible speed is determined by the current operating mode. If there is no active safety function, the maximum speed that is physically possible for the motor must be assumed.

Danger!

If the SMS or SLS 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 reaction 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 Safe Torque Off, single-channel (STO1)

The safety function STO1 works in the same way as STO with the sole difference 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	Description		Default value	Units
Channel selection for One Channel STO (STO1)	Selection of HighSide or LowSide IGBT in the OneChannelSTO function		HighSide	---
	Parameter value	**Description**		
	HighSide	The high side IGBTs are actuated with the function STO1.		
	LowSide	The low side IGBTs are actuated with the function STO1.		

Table 77: 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 (see section 2.2 "Safe motor holding brake output", on page 170).

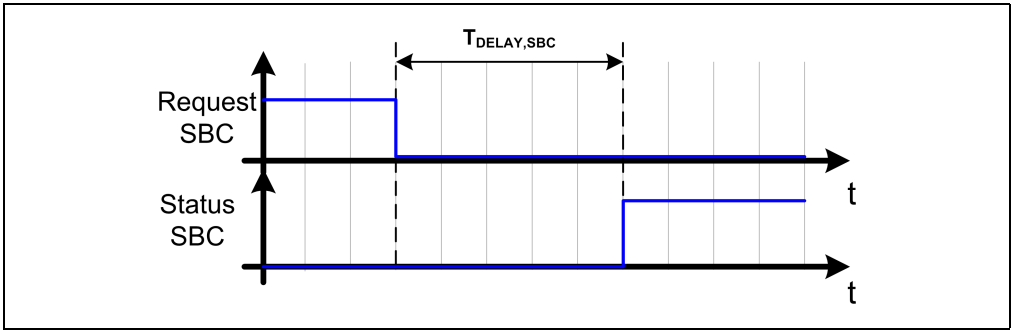


Figure 28: Safe Brake Control

Only the actuation of the motor holding brake output through the SafeMC module is safely evaluated with SIL 3.

The braking procedure will not be monitored for safety by the SMC 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 time $T_{DELAY, SBC}$ can be configured using the following parameters in SafeDESIGNER:

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

Table 78: 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!

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.
This means that an EnDat 2.2 Functional Safety encoder must be used!
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!

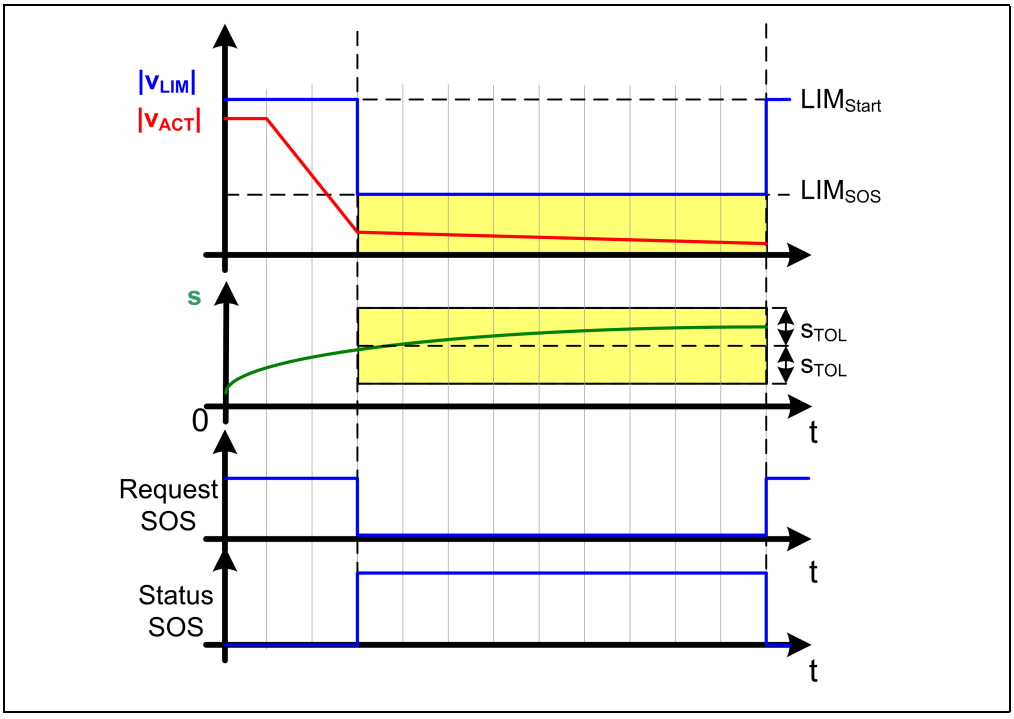


Figure 29: Safe Operating Stop

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

Table 79: 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. The Functional Fail Safe state behaves according to the configuration as described in chapter 4.2 "Functional Fail Safe state", on page 176.

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.

Danger!

In cases involving external forces, 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)!

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!

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 activated.

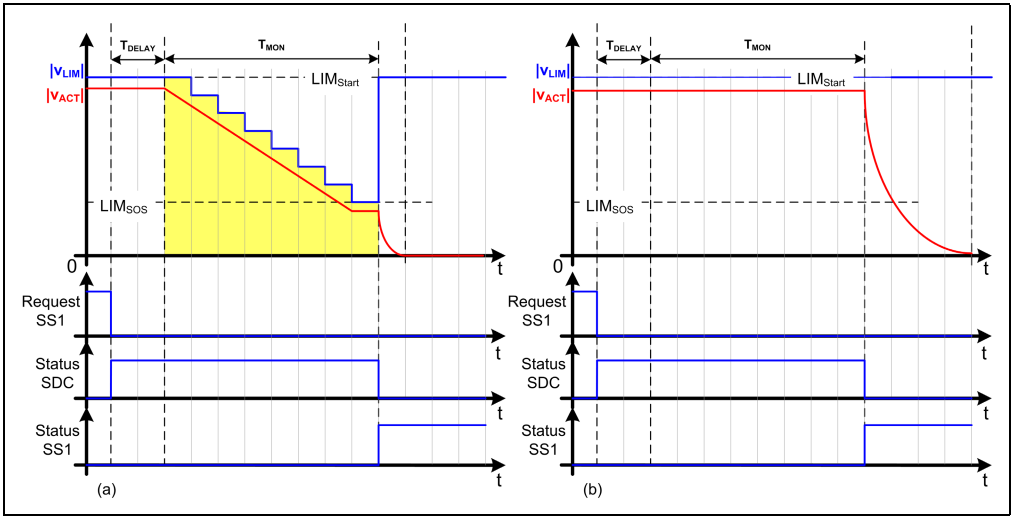


Figure 30: Safe stop 1

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

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.

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

Parameter	Description		Default value	Units
Deceleration ramp	Slope of the deceleration ramp to be monitored		2147483647	[units/s²]
Ramp monitoring for SS1	Activates ramp monitoring (in addition to the time) when the SS1 function is requested		Acitvated	---
	Parameter value	**Description**		
	Acitvated	When changing to the safe state of the SS1 function, a deceleration ramp is also monitored, in addition to the configurable time		
	Deactivated	When changing to the safe state of the SS1 function, only a configurable time is monitored		
Early Limit Monitoring	Monitoring of the deceleration ramp is prematurely terminated if the target limit is exceeded "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.		Deacitvated	---
	Parameter value	**Description**		
	Acitvated	"Early Limit Monitoring" is active!		
	Deactivated	"Early Limit Monitoring" is not active!		
Speed Tolerance (units /s)	Speed tolerance for standstill monitoring		0	units/s
Ramp Monitoring Time for SS1 (µs)	Deceleration monitoring time for SS1		0	[µs]
Delay time to start ramp monitoring (µs)	Delay time between request of ramp monitoring and start of monitoring		0	[µs]
Early Limit Monitoring timer	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	[µs]

Table 80: SS1 safety function parameters

Depending on the request for the safety function and its configuration, either only the deceleration time T_{MON} - see figure 30 "Safe stop 1" (b) - or also the deceleration ramp - see figure 30 "Safe stop 1" (a) - can be monitored.

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 beings 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.
The Functional Fail Safe state behaves according to the configuration as described in chapter 4.2 "Functional Fail Safe state", on page 176.

Information:

If ramp monitoring is configured for the safety function SS1, then the speed must be safely evaluated. This means that an EnDat 2.2 Functional Safety encoder must be used!
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!

When 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

"Rampmonitoring 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 functional 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 limit 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!
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 a 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 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 reaction 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 maintained at standstill by the functional application.
This standstill is monitored, similar to SOS, by the SafeMC module according to the configured standstill tolerance window LIM_{SOS} (parameter "*Speed Tolerance (units /s)*") and s_{TOL} (parameter "*Position Tolerance (units)*").

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.
This means that an EnDat 2.2 Functional Safety encoder must be used!
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!

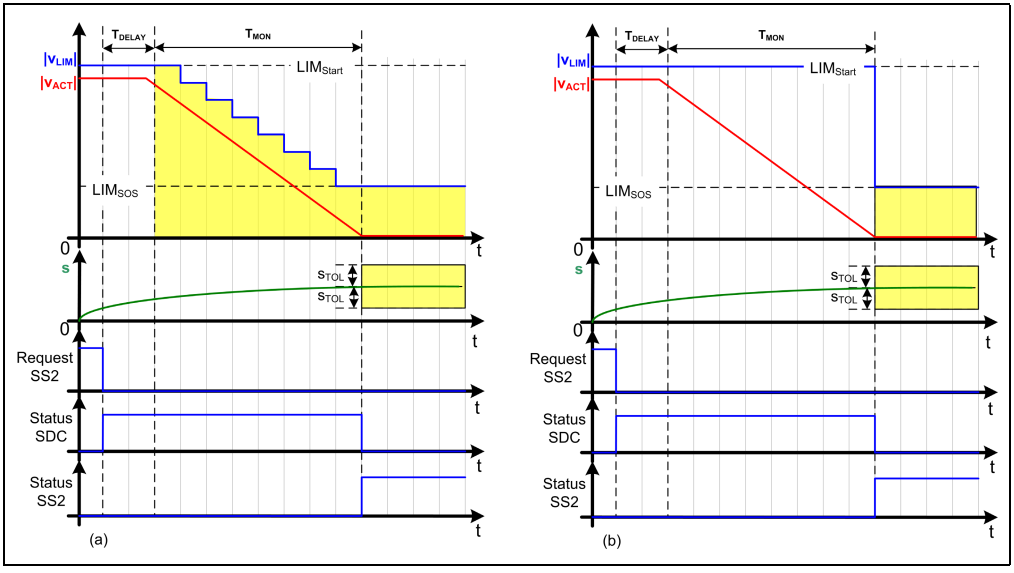


Figure 31: Safe stop 2

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.

Danger!

In cases involving external forces, 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)!

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	Description		Default value	Units
Deceleration ramp	Slope of the deceleration ramp to be monitored		2147483647	[units/s²]
Ramp monitoring for SS2	Activates ramp monitoring (in addition to the time) when the SS2 function is activated		Acitvated	---
	Parameter value	**Description**		
	Acitvated	When changing to the safe state of the SS2 function, a deceleration ramp is also monitored, in addition to the configurable time		
	Deactivated	When changing to the safe state of the SS2 function, only a configurable time is monitored		
Early Limit Monitoring	Monitoring of the deceleration ramp is prematurely terminated if the target limit is exceeded "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.		Deacitvated	---
	Parameter value	**Description**		
	Acitvated	"Early Limit Monitoring" is active!		
	Deactivated	"Early Limit Monitoring" is not active!		
Speed Tolerance (units /s)	Speed tolerance for standstill monitoring		0	units/s

Table 81: SS2 safety function parameters

Parameter	Description	Default value	Units
Position Tolerance (units)	Position tolerance for standstill and direction monitoring	0	units
Ramp Monitoring Time for SS2 (µs)	Deceleration monitoring time for SS2	0	[µs]
Delay time to start ramp monitoring (µs)	Delay time between request of ramp monitoring and start of monitoring	0	[µs]
Early Limit Monitoring timer	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	[µs]

Table 81: SS2 safety function parameters

Similar to SS1, either only the deceleration time T_{MON} - see figure 31 "Safe stop 2" (b) - or also the deceleration ramp - see figure 31 "Safe stop 2" (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 beings 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.
The Functional Fail Safe state behaves according to the configuration as described in chapter 4.2 "Functional Fail Safe state", on page 176.

Danger!

When 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 time 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!

When 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 time 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 (parameter "*Safe Speedlimit 1, 2, 3, 4 for SLS (units/s)*"). All limits can also be monitored in parallel.

Each of these 4 speed limits is implemented as a separate function. This means that the function block has 4 SLS inputs and 4 SLS outputs.
If a request is made to monitor multiple speed limits at the same time, then the lowest limit value will always be monitored.

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

Information:

The safety function SLS requires safe encoder evaluation of the speed.
This means that an EnDat 2.2 Functional Safety encoder must be used!
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!

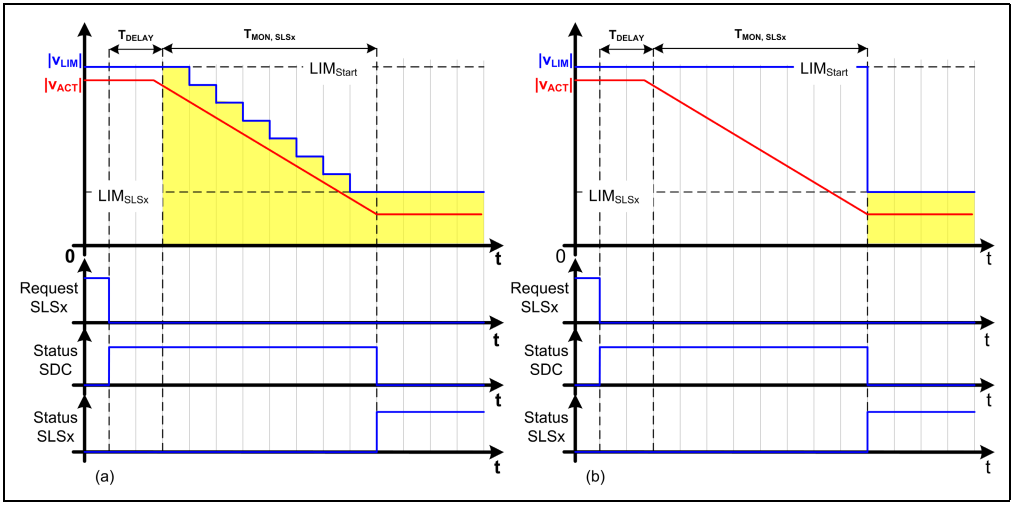


Figure 32: Safely Limited Speed

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.

Danger!

In cases involving external forces, 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)!

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.

If the delay time Tmon, SLS (parameter "*Ramp Monitoring Time for SLS1, 2, 3,4 (µs)*") is set to zero, then the speed limit (parameter "*Safe Speedlimit 1, 2, 3, 4 for SLS (units/s)*") will be monitored immediately after the safety function is requested.

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	Description		Default value	Units
Deceleration ramp	Slope of the deceleration ramp to be monitored		2147483647	[units/s²]
Ramp monitoring for SLS	Activates ramp monitoring (in addition to the time) when the SLS function is activated		Acitvated	---
	Parameter value	**Description**		
	Acitvated	When changing to the safe state of the SLS function, a deceleration ramp is also monitored, in addition to the configurable time		
	Deactivated	When changing to the safe state of the SLS function, only a configurable time is monitored		

Table 82: SLS safety function parameters

Parameter	Description		Default value	Units
Early Limit Monitoring	Monitoring of the deceleration ramp is prematurely terminated if the target limit is exceeded "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.		Deacitvated	---
	Parameter value	**Description**		
	Acitvated	"Early Limit Monitoring" is active!		
	Deactivated	"Early Limit Monitoring" is not active!		
Safe Speedlimit 1 for SLS (units/s)	Speed Limit 1 for SLS		0	units/s
Safe Speedlimit 2 for SLS (units/s)	Speed Limit 2 for SLS		0	units/s
Safe Speedlimit 3 for SLS (units/s)	Speed Limit 3 for SLS		0	units/s
Safe Speedlimit 4 for SLS (units/s)	Speed Limit 4 for SLS		0	units/s
Ramp Monitoring Time for SLS1(µs)	Deceleration monitoring time for SLS1		0	[µs]
Ramp Monitoring Time for SLS2(µs)	Deceleration monitoring time for SLS2		0	[µs]
Ramp Monitoring Time for SLS3(µs)	Deceleration monitoring time for SLS3		0	[µs]
Ramp Monitoring Time for SLS4(µs)	Deceleration monitoring time for SLS4		0	[µs]
Delay time to start ramp monitoring (µs)	Delay time between request of ramp monitoring and start of monitoring		0	[µs]
Early Limit Monitoring timer	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	[µs]

Table 82: 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 32 "Safely Limited Speed" (b) - or both the deceleration time and the deceleration ramp - see figure 32 "Safely Limited Speed" (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 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 beings 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 standstill speed limit for at least the amount of time defined by "*Early Limit Monitoring timer*" during deceleration ramp monitoring.

Danger!

When the monitored ramp or the enabled safe speed is exceeded, the 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 safely 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 time 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!

When 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 safely 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 time 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.
This means that an EnDat 2.2 Functional Safety encoder must be used!
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	Description		Default value	Units
Safe Maximum Speed	Activates the SMS safety function by configuration		Used	---
	Parameter value	**Description**		
	Used	SMS is activated		
	Unused	SMS is deactivated		
Maximum Speed (units/s)	Speed limit of the maximum speed		0	units/s

Table 83: SMS safety function parameters

Danger!

When 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 time must be tested accordingly!

4.11 Safely Limited Increments (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. This means that an EnDat 2.2 Functional Safety encoder must be used!
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!

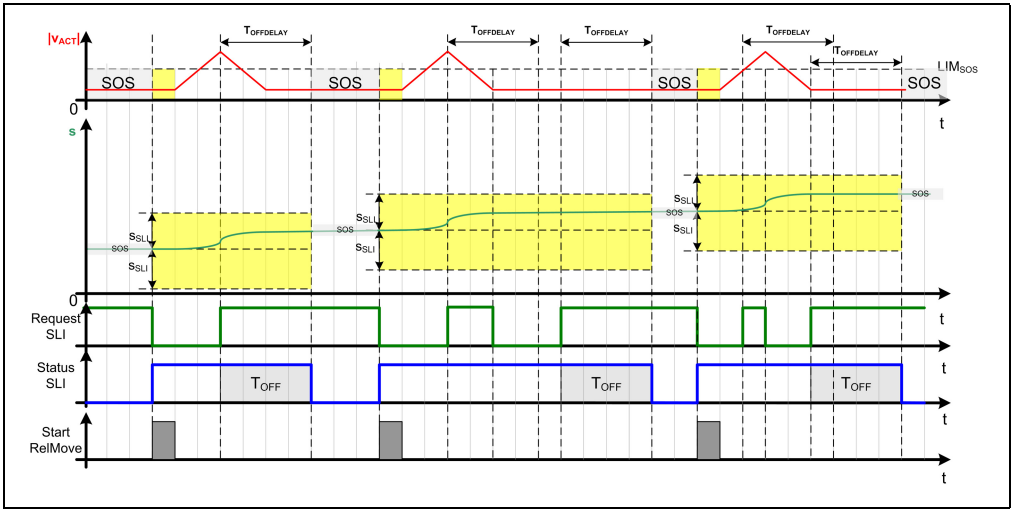


Figure 33: Safely Limited Increments

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, SLS or SLI.

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	Description	Default value	Units
Speed Tolerance (units /s)	Speed tolerance for standstill monitoring	0	units/s
Safe Increments (units)	Maximum moveable increments when SLI is active	0	units/s
SLI Off Delay (µs)	Switch off delay of SLI	0	units/s

Table 84: 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 for the speed standstill tolerance (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.

Danger!

In cases involving external forces, 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)!

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 time must be tested accordingly!

4.12 Safe Direction (SDI)

The SDI safety function monitors the defined direction of movement.

The positive and negative direction can be monitored using the two inputs provided on the function block.

Information:

The safety function SDI requires safe encoder evaluation of the position.
This means that an EnDat 2.2 Functional Safety encoder must be used!
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!

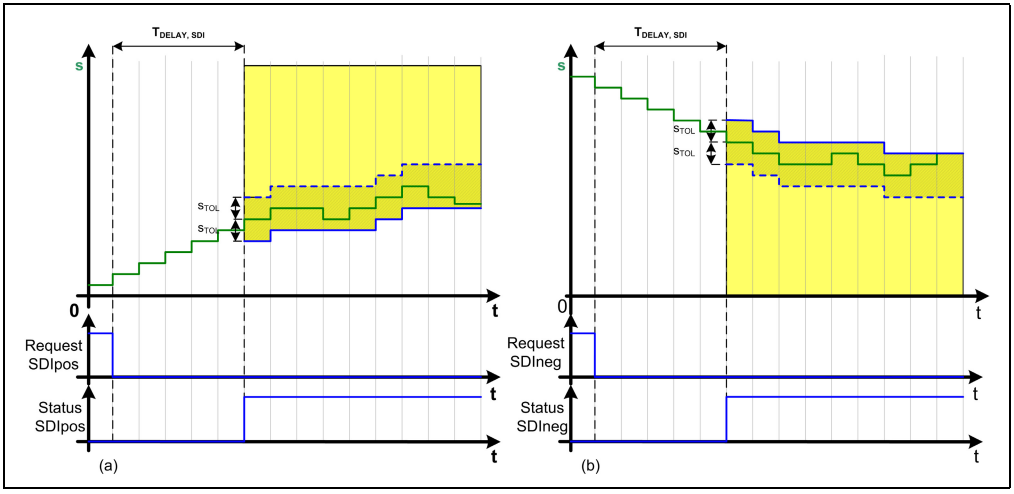


Figure 34: Safe Direction

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	Description	Default value	Units
Position Tolerance (units)	Position tolerance for standstill and direction monitoring	0	units
Delay time to start SDI(µs)	Delay time between request of SDI and activation of the safety function	0	[µs]

Table 85: 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.

Danger!

In cases involving external forces, 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)!

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 time must be tested accordingly!

5. Status LEDs

See chapter 2 "Technical data", section 2.2 "Indicators", on page 100.

6. Register description - SafeMC

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

Group: Function model

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

Table 86: SafeMC parameter I/O configuration: Function model

Group: General

Parameter	Description		Default value	Units
Module supervised	System behavior when a module is missing.		On	---
	Parameter value	**Description**		
	On	Missing module causes service mode to be activated		
	Off	Missing module is ignored		
Module information	This parameter activates / deactivates the module/specific information in IO mapping: • SerialNumber • ModuleID • Hardware variant • Firmware version		On	---
SafeLOGIC ID	For applications with multiple SafeLOGIC devices, this parameter specifies the module's affiliation to SafeLOGIC. • Permissible values: 1 - 1024		assigned automatically	---
SafeMODULE ID	Unique safety address for the module • Permissible values: 1 - 1024		assigned automatically	---

Table 87: SafeMC parameter I/O configuration: General

6.2 SafeDESIGNER parameters

Group: Basic

Parameter	Description		Default value	Units
Min_required_FW_Rev	This parameter is reserved future function expansions.		Basic release	---
Optional	The module can be optionally configured using this parameter. Optional modules do not have to be present, i.e. in case these modules are absent, it is not signaled by the SafeLOGIC. However, this parameter does not influence the module signal or status data.		No	---
	Parameter value	**Description**		
	No	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 (SafeModuleOk = 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.		
	Yes	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 if 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.		
	Start-up	This module is optional, decisions are made regarding further behavior of the module 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.		
External_UDID	This parameter enables the option on the module of determining the expected UDID externally from the CPU.		No	---
	Parameter value	**Description**		
	Yes-CAUTION	The UDID is determined by the CPU. SafeLOGIC must be restarted when the UDID is changed.		
	No	The UDID is determined by a Teach In procedure during startup.		

Table 88: SafeMC parameter group: Basic

Danger!

In case the "External_UDID = Yes-CAUTION" function is used, incorrect specifications from the CPU can lead to safety-critical situations.
Execute an FMEA in order to detect this situation and ensure safety using additional safety measures.

Group: Safety_Response_Time (also see section 5.6 "Parameters for safe response time in the SafeDESIGNER", on page 32)

Parameter	Description		Default value	Units
Manual_Configuration	This parameter allows individual, manual configuration of the safe response time for the module. Generally, the parameters for safe response time are set the same for all stations involved in the application. This is why these parameters are configured in the SafeDESIGNER by the SafeLOGIC. For application situations in which individual safety functions require optimum response time behavior, the parameters for safe response time can be configured individually for this on the affected module.		No	---
	Parameter value	**Description**		
	Yes	The data from the module's group "Safety_Response_Time" is used for calculating the safe response time for the signals of the module.		
	No	The parameters for safe response time are drawn from the "Safety_Response_Time" in the SafeLOGIC.		
Synchronous_Network_Only	This parameter determines the synchronization properties of the underlying network.		Yes	---
	Parameter 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.		
	No	No requirement for synchronization of the networks.		
Max_X2X_CycleTime_us	This parameter corresponds with the maximum duration of communication between the SafeMC module and the POWERLINK interface. • Permissible values: 200 - 30000 µs		1600	µs
Max_Powerlink_CycleTime_us	This parameter specifies the maximum POWERLINK cycle time used to calculate the safe response time. • Permissible values: 200 - 30000 µs		5000	µs
Max_CPU_CrossLinkTask_CycleTime_us	This parameter specifies the maximum cycle time for the copier task in the CPU used to calculate the safe response time. A value of 0 means that no copy task was included for the response time. • Permissible values: 0 - 30000 µs		5000	µs
Min_X2X_CycleTime_us	This parameter corresponds with the minimum duration of communication between the SafeMC module and the POWERLINK interface. • Permissible values: 200 - 30000 µs		600	µs

Table 89: SafeMC group: Safety_Response_Time

Parameter	Description	Default value	Units
Min_Powerlink_CycleTime_us	This parameter specifies the minimum POWERLINK cycle time used to calculate the safe response time. • Permissible values: 200 - 30000 µs	200	µs
Min_CPU_CrossLinkTask_CycleTime_us	This parameter specifies the minimum cycle time for the copy task in the CPU used to calculate the safe response time. A value of "0" means that configurations without copier tasks are also included for the response time. • Permissible values: 0 - 30000 µs	0	µs
Worst_Case_Response_Time_us	This parameter specifies the limit value for monitoring the safe response time. • Permissible values: 3000 - 50000 µs	50000	µs

Table 89: SafeMC group: Safety_Response_Time (cont.)

Group: Encoder Unit System

Parameter	Description		Default value	Units
Number of encoder revolutions	Unit scale: x-revolutions Any unit (e.g. 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.		1	---
Units per number of encoder revolutions [units]	Unit scale: Units per x revolutions Any unit (e.g. 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.		1000	[units]
Counting direction	Counting direction of the position or speed		Default	---
	Parameter value	**Description**		
	Default	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		
Maximum speed to normalize the speed range [units]	Maximum speed to which the displayed speed should be normalized		32767	[units]

Table 90: SafeMC group: Encoder Unit System

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

Parameter	Description	Default value	Units
Deceleration ramp	Slope of the deceleration ramp to be monitored	2147483647	[units/s²]

Table 91: SafeMC group: Safety deceleration ramp

Group: General settings

Parameter	Description		Default value	Units
Safe Maximum Speed	Activates the SMS safety function by configuration.		Used	---
	Parameter value	**Description**		
	Used	SMS is activated		
	Unused	SMS is deactivated		
Automatic Reset at Startup	Activates automatic reset of the function block at startup		Unused	---
	Parameter value	**Description**		
	Used	After starting up, the module automatically changes to the state, "Operational" (start reset). The Reset input does not have to be actuated!		
	Unused	After startup, the module gets stuck in an Init state, until a positive edge is detected on the Reset input.		
Channel selection for One Channel STO (STO1)	Selection of HighSide or LowSide IGBT in the OneChannelSTO function		HighSide	---
	Parameter value	**Description**		
	HighSide	The high side IGBTs are actuated with the function STO1.		
	LowSide	The low side IGBTs are actuated with the function STO1.		
Ramp monitoring for SS1	Activates ramp monitoring (in addition to the time) when the SS1 function is activated		Activated	---
	Parameter value	**Description**		
	Activated	When changing to the safe state of the SS1 function, a deceleration ramp is also monitored, in addition to the configurable time		
	Deactivated	When changing to the safe state of the SS1 function, only a configurable time is monitored		
Ramp monitoring for SS2	Activates ramp monitoring (in addition to the time) when the SS2 function is activated		Activated	---
	Parameter value	**Description**		
	Activated	When changing to the safe state of the SS2 function, a deceleration ramp is also monitored, in addition to the configurable time		
	Deactivated	When changing to the safe state of the SS2 function, only a configurable time is monitored		

Table 92: SafeMC group: General settings

Parameter	Description		Default value	Units
Ramp monitoring for SLS	Activates ramp monitoring (in addition to the time) when the SLS function is activated		Activated	---
	Parameter value	**Description**		
	Activated	When changing to the safe state of the SLS function, a deceleration ramp is also monitored, in addition to the configurable time		
	Deactivated	When changing to the safe state of the SLS function, only a configurable time is monitored		
Early Limit Monitoring	Monitoring of the deceleration ramp is prematurely terminated if the target limit is exceeded "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.		Deactivated	---
	Parameter value	**Description**		
	Activated	"Early Limit Monitoring" is active!		
	Deactivated	"Early Limit Monitoring" is not active!		

Table 92: SafeMC group: General settings (cont.)

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 with regard to safety. Additional measures must be implemented to ensure correct, safety-related functionality.

Group: Encoder Monitoring

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

Table 93: SafeMC 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

Parameter	Description		Default value	Units
Behavior of Functional Fail Safe	In the Functional Fail Safe state, STO and SBC is activated immediately or STO1 and then STO and SBC after a delay		STO	---
	Parameter 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.		
Delay for STO in Functional Fail Safe	Delay between STO1 and STO (and SBC) in the Functional Fail Safe state		0	[µs]
Delay time until the brake engages	**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	[µs]

Table 94: SafeMC group: Behavior of Functional Fail Safe

Group: Safety Speed Limits

Parameter	Description	Default value	Units
Maximum Speed (units/s)	Speed limit of the maximum speed	0	units/s
Safe Speedlimit 1 for SLS (units/s)	Speed Limit 1 for SLS	0	units/s
Safe Speedlimit 2 for SLS (units/s)	Speed Limit 2 for SLS	0	units/s
Safe Speedlimit 3 for SLS (units/s)	Speed Limit 3 for SLS	0	units/s
Safe Speedlimit 4 for SLS (units/s)	Speed Limit 4 for SLS	0	units/s

Table 95: SafeMC 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 (see chapter "Signal processing in the safe B&R SafeMC module", on page 30) 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.

Group: Safety Standstill and Direction Tolerances

Parameter	Description	Default value	Units
Speed Tolerance (units /s)	Speed tolerance for standstill monitoring	0	units/s
Position Tolerance (units)	Position tolerance for standstill and direction monitoring	0	units

Table 96: SafeMC group: Safety Standstill and Direction Tolerances

Information:

The following application rule must be observed:

LIMSOS ≤ LIMSLS4 ≤ LIMSLS3 ≤ LIMSLS2 ≤ LIMSLS1 ≤ LIMSMS ≤ 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!

Danger!

The respectively monitored speed limit must be set in such a manner so that, with consideration for the error response time (see chapter "Signal processing in the safe B&R SafeMC module", on page 30) and the resulting movement in the worst case scenario, a dangerous movement cannot occur in the event of error.

The dangerous movement must be determined by a risk analysis.

Group: Safely Limited Increment

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

Table 97: SafeMC 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 (see chapter "Signal processing in the safe B&R SafeMC module", on page 30) and the resulting movement in the worst case scenario, a dangerous movement cannot occur in the event of error.

The dangerous movement must be determined by a risk analysis.

Group: Safety Ramp Monitoring Times

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

Table 98: SafeMC group: Safety Ramp Monitoring Times

Group: Safety Additional Parameters

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

Table 99: SafeMC 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

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

Table 100: SafeMC 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!

6.3 Channel list

Channel name	Access via Automation Studio	Access via SafeDESIGNER	Data type	Description
ModulIOK	Read	---	BOOL	Indicates if the module is OK
SerialNumber	Read	---	UDINT	Module serial number
ModuleID	Read	---	UINT	Module ID
HardwareVariant	Read	---	UINT	HW variants
FirmwareVersion	Read	---	UINT	Firmware version of the module
UDID_low	(Read) [1)]	---	UDINT	UDID, lower 4 bytes
UDID_high	(Read) [1)]	---	UINT	UDID, upper 2 bytes
SafetyFWversion1	(Read) [1)]	---	UINT	Firmware version safety processor 1
SafetyFWversion2	(Read) [1)]	---	UINT	Firmware version safety processor 2
Diag1_Temp	(Read) [1)]	---	UINT	Module temperature in °C
SafeModuleOK	-	Read	SAFEBOOL	Indicates if the safe communication channel is OK
SafetyActiveSTO	Read	(Read) [2)]	SAFEBOOL	STO safety function status (TRUE = safe state)
SafetyActiveSBC	Read	(Read) [2)]	SAFEBOOL	SBC safety function status (TRUE = safe state)
SafetyActiveSOS	Read	(Read) [2)]	SAFEBOOL	SOS safety function status (TRUE = safe state)
SafetyActiveSS1	Read	(Read) [2)]	SAFEBOOL	SS1 safety function status (TRUE = safe state)
SafetyActiveSS2	Read	(Read) [2)]	SAFEBOOL	SS2 safety function status (TRUE = safe state)
SafetyActiveSLS1	Read	(Read) [2)]	SAFEBOOL	SLS1 safety function status (TRUE = safe state)
SafetyActiveSLS2	Read	(Read) [2)]	SAFEBOOL	SLS2 safety function status (TRUE = safe state)
SafetyActiveSLS3	Read	(Read) [2)]	SAFEBOOL	SLS3 safety function status (TRUE = safe state)
SafetyActiveSLS4	Read	(Read) [2)]	SAFEBOOL	SLS4 safety function status (TRUE = safe state)
SafetyActiveSTO1	Read	(Read) [2)]	SAFEBOOL	STO1 safety function status (TRUE = safe state)
SafetyActiveSDIpos	Read	(Read) [2)]	SAFEBOOL	SDIpos safety function status (TRUE = safe state)
SafetyActiveSLI	Read	(Read) [2)]	SAFEBOOL	SLI safety function status (TRUE = safe state)
SafetyActiveSDIneg	Read	(Read) [2)]	SAFEBOOL	SDIneg safety function status (TRUE = safe state)
StatusSetPosAlive	Read	-	SAFEBOOL	Status of set position "Alive Testing" (TRUE = valid)
AllReqFuncAct	Read	(Read) [2)]	SAFEBOOL	Staus of the requested safety functions (TRUE = all of the requested safety functions are active)

Table 101: SafeMC channel list

Channel name	Access via Automation Studio	Access via SafeDESIGNER	Data type	Description
SafetyActiveSDC	Read	(Read) [2]	SAFEBOOL	Status of the delay monitor (TRUE = delay monitoring is active)
Operational	Read	-	SAFEBOOL	Status of the function block (TRUE = function block is in the state "Operational", "Safe", or "Wait for Confirmation")
NotErrENC	Read	(Read) [3]	SAFEBOOL	Status of the safe encoder (FALSE = pending encoder error)
NotErrFUNC	Read	(Read) [2]	SAFEBOOL	SafeMC module status (FALSE = SafeMC module is in the error state Functional Fail Safe)
ScaledSpeed	Read	(Read) [3]	SAFEINT	Safe scaled speed
RequestSTO	(Read) [4]	(Write) [5]	SAFEBOOL	Select / deselect the safety function "Safe Torque Off", STO
RequestSBC	(Read) [4]	(Write) [5]	SAFEBOOL	Selects / deselects the safety function "Safe Brake Control", SBC
RequestSOS	(Read) [4]	(Write) [5]	SAFEBOOL	Selects / deselects the safety function "Safe Operating Stop", SOS.
RequestSS1	(Read) [4]	(Write) [5]	SAFEBOOL	Selects / deselects the safety function "Safe Stop 1", SS1.
RequestSS2	(Read) [4]	(Write) [5]	SAFEBOOL	Selects / deselects the safety function "Safe Stop 2", SS2.
RequestSLS1	(Read) [4]	(Write) [5]	SAFEBOOL	Selects / deselects the safety function "Safely Limited Speed", Speed Limit 1.
RequestSLS2	(Read) [4]	(Write) [5]	SAFEBOOL	Selects / deselects the safety function "Safely Limited Speed", Speed Limit 2.
RequestSLS3	(Read) [4]	(Write) [5]	SAFEBOOL	Selects / deselects the safety function "Safely Limited Speed", Speed Limit 3.
RequestSLS4	(Read) [4]	(Write) [5]	SAFEBOOL	Selects / deselects the safety function "Safely Limited Speed", Speed Limit 4.
RequestSTO1	(Read) [4]	(Write) [5]	SAFEBOOL	Select / deselect the safety function "Safe Torque Off, one channel", STO1
RequestSDIpos	(Read) [4]	(Write) [5]	SAFEBOOL	Selects / deselects the safety function "Safe Direction", movement allowed in the positive direction
RequestSLI	(Read) [4]	(Write) [5]	SAFEBOOL	Selects / deselects the safety function "Safely Limited Increment", SLI.
RequestSDIneg	(Read) [4]	(Write) [5]	SAFEBOOL	Selects / deselects the safety function "Safe Direction", movement allowed in the negative direction
Activate	(Read) [4]	(Write) [5]	SAFEBOOL	Enabling the function block
Reset	(Read) [4]	(Write) [5]	SAFEBOOL	Reset input for confirming the "Functional Fail Safe" state.

Table 101: SafeMC channel list (cont.)

1) This data is accessed in Automation Studio using the ASIOACC library.
2) This data is accessed indirectly via the SF_SafeMC_BR function block's outputs.
3) This data is accessed indirectly via the SF_SafeMC_Speed_BR function block's outputs.
4) This data can be accessed via NC Action or Trace.
5) This data is accessed indirectly via the SF_SafeMC_BR function block's inputs.

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 functional application must react accordingly to the request for a safety function.

To ensure proper interaction between the functional and the safe application (and thereby ensuring maximum availability of the system), the different timing of the two applications must be accounted for.

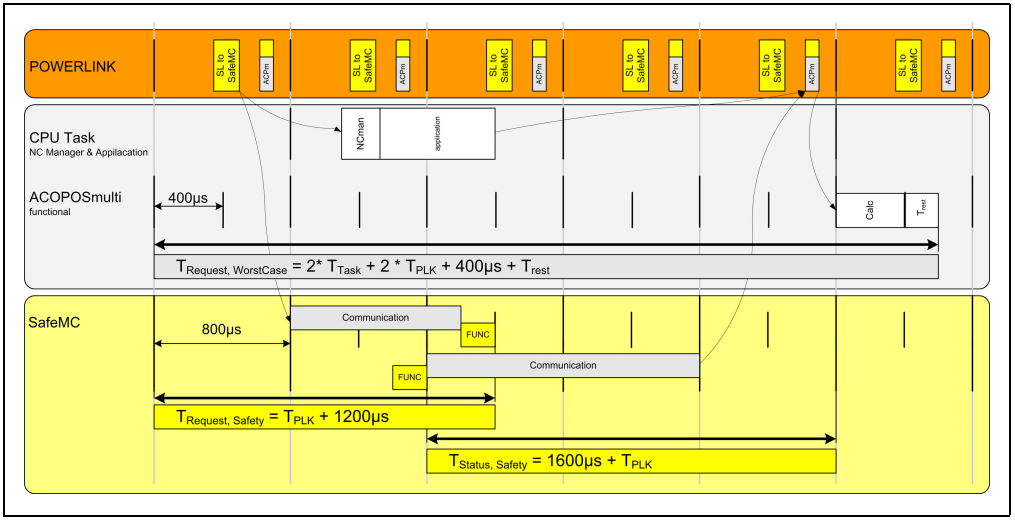


Figure 35: Inverter module timing - SafeMC module

The differing runtimes of the functional and the safe application can be accounted for using the "Delay times for requesting a safety function".

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

Table 102: Delay times for requesting a safety function

7.1 Application in SafeDESIGNER

The safety application is implemented in SafeDESIGNER. The two function blocks **SF_SafeMC_BR** and **SF_SafeMC_Speed_BR** are available for activating the SafeMC modules. The previous sections contain 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 the "SafeDESIGNER" Chapter 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!

7.2 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.

7.2.1 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.

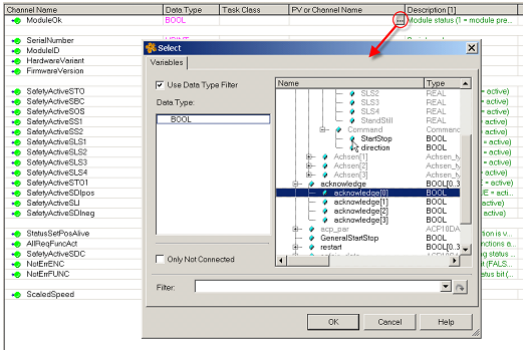


Figure 36: PV Mapping

7.2.2 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

Table 103: Parameter IDs

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, for example, 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.

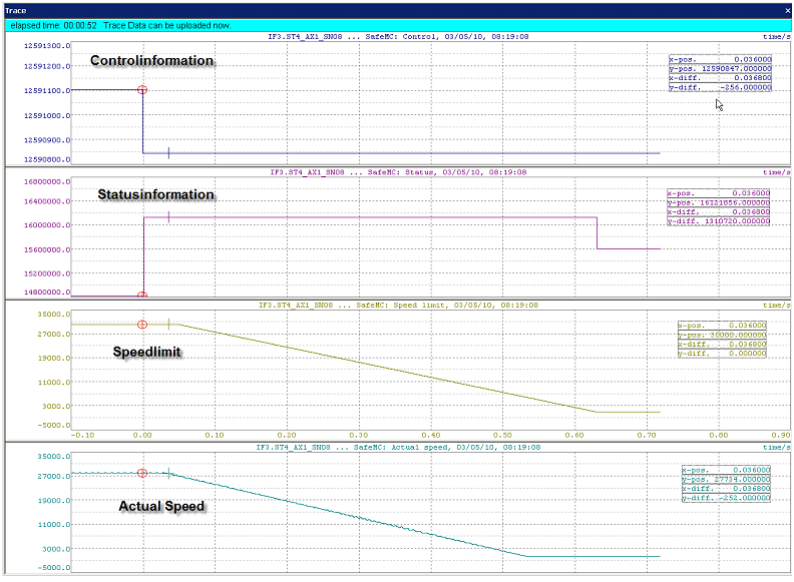


Figure 37: ACOPOSmulti trace of available SafeMC data

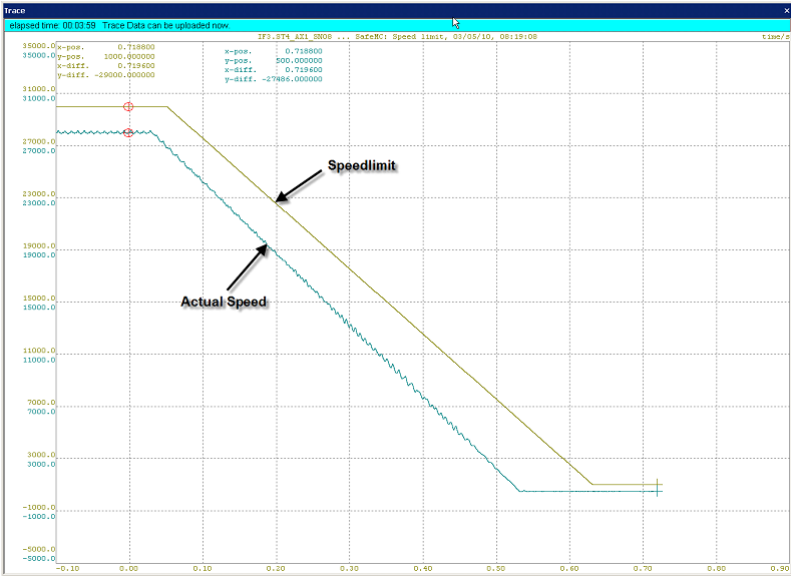


Figure 38: ACOPOSmulti Trace: Speed reserve

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 9	**Bit 9**	**Bit 10**	**Bit 11**	**Bit 12**	**Bit 13**	**Bit 14**	**Bit 15**
SLS4	STO1	SDIpos	SLI	SDIneg	Res1	Res2	Res3
Bit 16	**Bit 17**	**Bit 18**	**Bit 19**	**Bit 20**	**Bit 21**	**Bit 22**	**Bit 23**
Res4	Setposition Alive Testing	SFR	All Requested Safetyfunctions Active	SDC	Operational	NOT ERR Encoders	NOT ERR Functional

Table 104: Parameter ID 4 status bits

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 9	**Bit 9**	**Bit 10**	**Bit 11**	**Bit 12**	**Bit 13**	**Bit 14**	**Bit 15**
SLS4	STO1	SDIpos	SLI	SDIneg	Res1	Res2	Res3
Bit 16	**Bit 17**	**Bit 18**	**Bit 19**	**Bit 20**	**Bit 21**	**Bit 22**	**Bit 23**
Res4	Res5	Res6	Res7	Res8	Res9	Activate	Reset

Table 105: Parameter ID 5 control bits

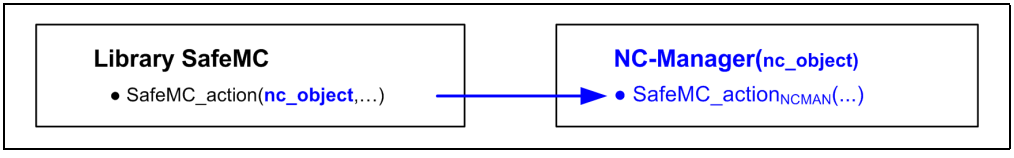
7.2.3 Function SafeMC_action()

The function **SafeMC_action()** in the **SafeMC** library makes it possible to access the SafeMC data of an ACOPOS axis, as described below.
This is particularly important because the control bits of the individual SafeMC modules can also be easily accessed!

Valid data definitions:

- **Safe OUT** Data from the SafeLOGIC to the SafeMC module
- **Safe IN** Data from the SafeMC module to the SafeLOGIC

If the global function **SafeMC_action()** that is contained in the **SafeMC** library is called, then it uses the specified NC object to call a function **SafeMC_action**$_{NCMAN}$(), which is contained in the NC manager that belongs to this NC object:



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**

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 106: 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)

Moreover, the following error codes are output for some actions, which suggests an initialization error in the SafeMC data (see below "SafeOUT/SafeIN.init_error"):

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 "init_error" values are provided by the functions plAction(plACTION_GET_DP_INFO) or plCECreate() for the "PowerInk" library. Only the following is mentioned:

20923	Data point not available (not entered in the PDO Mapping)

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 structure "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)
reserved_ctrl_b13   USINT       Reserved
reserved_ctrl_b14   USINT       Reserved
reserved_ctrl_b15   USINT       Reserved
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
```

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 structure "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     SDIpos Status bit
SafetyActiveSLI     USINT     SLI Status bit
SafetyActiveSDIneg  USINT     SDIneg Status bit
reserved_stat_b13   USINT     Reserved
reserved_stat_b14   USINT     Reserved
reserved_stat_b15   USINT     Reserved
reserved_stat_b16   USINT     Reserved
StatusSetPosAlive   USINT     Set position tested
StatusSFR           USINT     At least one safety function has been requested
AllReqFuncActv      USINT     All requested safety functions are active
SafetyActiveSDC     USINT     Delay monitoring status bit
Operational         USINT     Function block is operational
NotErrENC           USINT     Encoder error status bit
NotErrFUNC          USINT     Functional fail safe status bit

ScaledSpeed         INT       Scaled safe speed
```

Example: Access to the SafeMC data:

```
_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));
    }
}
```

the following PLCopen function blocks can also be used as an alternative to the NC action:

- SafeMC_ReadSafeIn ... Read DataSafeIN data
- SafeMC_ReadSafeOutData ... Read SafeOUT data

7.3 Validate the safety functions

Danger!

You are responsible for performing safeguard function tests. You must therefore validate the safeguards.

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	Enable/disable function	Test of 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	✔	---	✔	✔	---
SDIpos	✔	---	---	---	✔
SDIneg	✔	---	---	---	✔
SLI	✔	---	---	---	✔
SMS	---	---	---	✔	---

Table 107: Test matrix for the safety functions

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!

7.4 Maintenance scenarios

7.4.1 Commissioning

When commissioning the machine, the safety functions must always undergo thorough testing, as described in the chapter "Validate the safety functions", on page 231.

Danger!

All of the applied safety functions must be tested!
A function is considered to be used if the respective input variable is connected!

7.4.2 Replacing ACOPOSmulti with SafeMC safe inverter modules

SafeLOGIC recognizes, on its own, when safe modules have been exchanged. Following a module replacement, the entire system (SafeLOGIC, POWERLINK Safety) 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.

7.4.3 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.

7.4.4 Firmware update / Acknowledging a firmware exchange

Changes to safety-related parts of the firmware are distributed by B&R as firmware (FW) updates.
Upgrades to safety-related firmware can only be performed by qualified personnel.
A FW 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.

7.4.5 Decommissioning a system

SafeMC modules have a maximum lifespan of 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 lifespan is not permitted! The user must ensure that all SafeMC modules are removed from operation i.e. replaced by new SafeMC modules, before their lifespan expires.

Chapter 7 • Standards and certifications

1. Applicable European directives

- EMC directive 2004/108/CE
- Low-voltage directive 2006/95/CE
- Machine directive 2006/42/EG [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 108: Applicable standards for ACOPOSmulti servo drives

1) Replaced by EN ISO 13849-1.

1) This machine directive only applies to logic units for safety functions that are for the first time being placed on the market by B&R for sale or use.

The limit values specified in the following section (3 "Environmental Limits" to 6 "Other environmental limit values according to IEC 61800-2") are taken from the product standard EN 61800 (and IEC 61800) for servo drives in industrial environments (Category C3 [1]). Stricter test procedures and limit values are used during the type tests for ACOPOSmulti servo drives. Additional information is available from B&R.

1) Limit values from CISPR11, group 2, class A (second environment).

3. Environmental Limits

3.1 Mechanical conditions according to EN 61800-2

3.1.1 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 109: Mechanical conditions during operation

3.1.2 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 110: Mechanical conditions during transport

1) Only valid for components in original packaging.

2) The values in table 109 "Mechanical conditions during operation", on page 237 apply to components that are not in their original packaging.

3.2 Climate conditions according to IEC 61800-2

3.2.1 Operation

IEC 60721-3-3, class 3K3	
	EN 61800-2
Ambient temperature during operation	5 to 40°C
Relative humidity during operation	5 - 85%, non-condensing

Table 111: Climate conditions during operation

3.2.2 Bearings

IEC 60721-3-1, class 1K4	
	EN 61800-2
Storage temperature	-25 to +55°C

Table 112: Climate conditions (temperature) during storage

IEC 60721-3-1, class 1K3	
	EN 61800-2
Relative humidity during storage	5 - 95%, non-condensing

Table 113: Climate conditions (humidity) during storage

3.2.3 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 114: Climate conditions during transport

4. Requirements for immunity to disturbances (EMC)

- The applicable requirements are in accordance with EN 61800-3.
- For all modules that have certified safety functions, stricter requirements apply for section 4.3 "High frequency disturbances according to 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	The system does not reboot automatically (reset required).
FS	Functional safety - Behavior of test subject according to EN 61800-5-2, Item 6.2.5.3

Table 115: Evaluation criteria (performance criteria) for immunity to disturbances

4.2 Low frequency disturbances according to EN 61800-3

The following limit values are applicable for industrial environments (category C3). [1)]

4.2.1 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 116: 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 117: Limit values for commutation notches / voltage distortions

1) Limit values from CISPR11, group 2, class A (second environment).

4.2.2 Voltage changes, deviations, dips and short-term interruptions

IEC 61000-2-4, class 3		
	EN 61800-3	**Performance criteria**
Voltage changes and deviations	± 10%	A
Voltage changes and deviations (< 1 min)	+ 10% to - 15%	

Table 118: Limit values for voltage changes and deviations

IEC 61000-2-1		
	EN 61800-3	**Performance criteria**
Voltage dips and short-term interruptions	10% to 100%	C

Table 119: Limit values for voltage dips and short-term interruptions

4.2.3 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 120: Limit values for asymmetric voltages and frequency changes

4.3 High frequency disturbances according to EN 61800-3

These immunity tests are valid for industry (category C3). [1)]

4.3.1 Electrostatic discharge

Tests according to EN 61000-4-2				
	EN 61800-3		**Increased immunity to disturbances**	
	Requirement	**PC**	**Requirement** [1)]	**PC**
Contact discharge to powder-coated and bare metal housing parts	4 kV	B	6 kV	FS
Discharge through the air to plastic housing parts	8 kV		15 kV	

Table 121: Limits for electrical 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.

1) Limit values from CISPR11, group 2, class A (second environment).

4.3.2 Electromagnetic fields

Tests according to EN 61000-4-3				
	EN 61800-3		Increased immunity to disturbances	
	Requirement	PC	Requirement	PC
Housing, completely wired	80 MHz - 1 GHz, 10 V/m, 80% amplitude modulation at 1 kHz	A	80 MHz to 1 GHz ... 20 V/m, 1.4 to 2 GHz ... 10 V/m, 2 GHz to 2.7 GHz ... 3 V/m, 80% amplitude modulation at 1 kHz	FS

Table 122: Limits for electromagnetic fields

4.3.3 Burst

Tests according to EN 61000-4-4				
	EN 61800-3		Increased immunity to disturbances	
	Requirement	PC	Requirement [1]	PC
Power connection	2 kV, 1 min, direct coupling	B	4 kV, direct coupling	FS
Lines for measurement and control functions in the process environment	2 kV, 1 min		4 kV	
Signal interfaces, other lines	1 kV, 1 min		2 kV	

Table 123: 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.

4.3.4 Surge

Tests according to EN 61000-4-5				
	EN 61800-3		Increased immunity to disturbances	
	Requirement	PC	Requirement [1]	PC
Power connection	1 kV (2 Ω) [2], DM, symmetrical 2 kV (12 Ω) [2], CM, unsymmetrical	B	2 kV (2 Ω) [2], DM, symmetrical 4 kV (12 Ω) [2], CM, unsymmetrical	FS

Table 124: 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 EN 61000-4-5 because it is not defined in EN 61800-3.

4.3.5 High frequency conducted disturbances

Tests according to EN 61000-4-6				
	EN 61800-3		Increased immunity to disturbances	
	Requirement	PC	Requirement	PC
Power connection	0.15 - 80 MHz, 10 V, 80% amplitude modulation at 1 kHz	A	0.15 - 80 MHz, 20 V, 80% amplitude modulation at 1 kHz	FS
Lines for measurement and control functions in the process environment				
Signal interfaces, other lines				

Table 125: Limits for conducted disturbances (radio frequency)

5. Requirements for emissions (EMC)

5.1 High frequency emissions according to EN 61800-3

These emission tests are valid for industry (category C3). 1)

5.1.1 Conducted emissions on the power connections

Tests according to EN 55011			
Continuous current on motor	**Frequency range [MHz]**	**Quasi-peak value**	**Average**
I ≤ 100 A	0.15 ≤ f < 0.5	100 dB (µV)	90 dB (µV)
	0.5 ≤ f < 5	86 dB (µV)	76 dB (µV)
	5 ≤ f < 30	90 dB (µV) Decreases with the logarithm of the frequency 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 126: Limits for conducted emissions on the power connections

5.1.2 Electromagnetic emissions

Tests according to EN 55011	
Frequency range [MHz]	**Quasi-peak value**
30 ≤ f ≤ 230	40 dB (µV/m), measured at distance of 30 m 1)
230 < f ≤ 1000	50 dB (µV/m), measured at distance of 30 m 1)

Table 127: Limit values for electro-magnetic emissions

1) The limit values were increased by 10 dB (µV/m) when measuring from distances of 10 m.

1) Limit values from CISPR11, group 2, class A (second environment).

6. Other environmental limit values according to IEC 61800-2

	EN 61800-2
Degree of pollution according to IEC 61800-2, 4.1.2.1.	2 (non-conductive material)
Overvoltage cat. according to IEC 60364-4-443:1999	III
Protection according to IEC 60529	IP20
Reduction of the continuous current at installation altitudes over 500 m above sea level	10% per 1,000 m
Maximum installation altitude	4,000 m [1)]

Table 128: Additional environmental limits

1) Additional requirements are to be arranged with B&R.

7. International certifications

B&R products and services comply with applicable standards. They are 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 give special consideration to 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 certification of your machines and systems in these areas.
Europe	All harmonized EN standards for the applicable directives are met.
Russian Federation	GOST-R certification is available for the export of all B&R ACOPOS servo drives to the Russian Federation.
Functional Safety Type Approved TÜVRheinland FS	All important B&R servo drives have the FS - Functional Safety - certification mark from TÜV Rheinland.

Table 129: International Certifications

8. Standards & definitions for safety techniques

Stop Functions according to 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, 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 130: Overview of stop function categories

The necessary stop functions must be determined based on a risk evaluation 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 is not permitted to cause a dangerous state.

Emergency stops according to IEC 60204-1/2006 (electrical equipment for machines, part 1: general requirements)

The following requirements are valid for emergency stops in addition to the requirements for the 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 necessary stop function must be determined based on a risk evaluation for the machine.

For emergency stop function in stop category 0, only hard wired, electromechanical equipment can be used. Additionally, the function is not permitted to depend on electronic switching logic (hardware or software) or the transfer of commands via a communication network or data connection. [1)]

When using a category 1 stop function for the 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) according to EN ISO 13849-1 (Safety of machinery – Safety-related parts of control systems, Part 1: General design principles)

1) In accordance to the national foreword for the valid German version of EN 60204-1/2006, it is determined that electronic equipment (and also especially for emergency stop systems) can be used regardless of the stop category, if e.g. it provides the same safety using the standards EN ISO 13849-1 and/or IEC 61508 as required by EN 60204-1.

The safety related parts of control systems must meet one or more of the requirements for five defined Performance Levels. The Performance Levels define the required behavior of safety related controller parts regarding 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 parts 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 safety function to fail.**
b	1	Safety related parts must be designed and built so that only reliable components and safety principles are used. (e. g. preventing short circuits by using sufficient distances, reducing the probability of errors caused by using oversized components, defining the failure route - bias current fail-safe, etc.)	**Caution!** **An error can cause the safety function to fail.**
c	1	Safety related parts must be designed so that their safety functions are checked in suitable intervals by the machine controller. (e. g. automatic or manual check during start-up)	**Caution!** **An error between checks can cause the safety function to fail. If the safety function fails, it will be recognized during the check.**
d	2	Safety related parts must be designed so that individual errors do not cause the safety function to fail. Individual errors should - if possible - be recognized the next time (or before) the safety function is required.	**Caution!** **The safety function remains active when an error occurs. Some, but not all errors are recognized. A buildup of errors can cause the safety function to fail.**
e	3	Safety related parts must be designed so that individual errors do not cause the safety function to fail. 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 function to fail.	**Information:** **The safety function remains active when an error occurs. Errors are recognized in time to prevent the safety function from failing.**

Table 131: Overview of Performance Levels (PL)

The suitable performance level must be selected separately for each drive system (or for each axis) based on a risk evaluation. This risk evaluation is a part of the total risk evaluation for the machine.

The following risk graph (according to EN ISO 13849-1, Appendix A) provides a simplified procedure for risk evaluation:

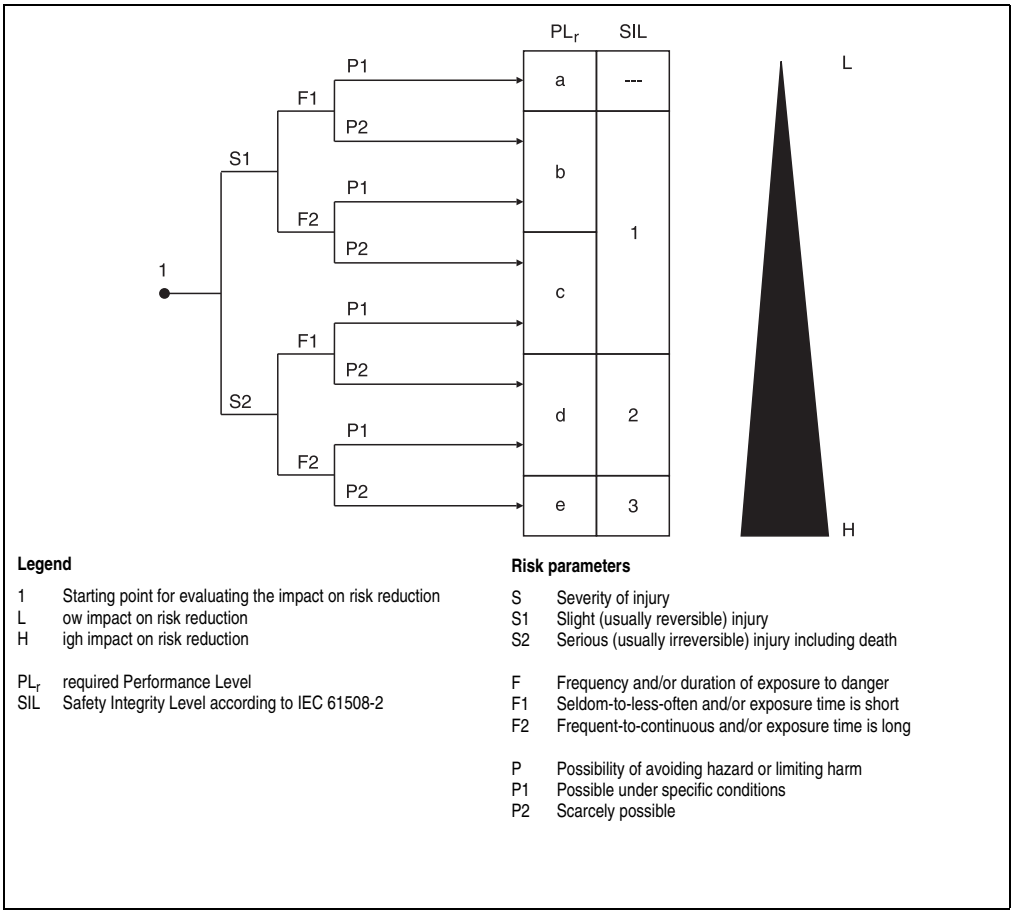


Figure 39: Risk graph for determining the PL_r for each safety function in accordance with EN ISO 13849-1, Appendix A

Begin at the starting point shown and follow the risk parameters S, F and P to the performance level to be used.

Restart inhibit according to EN 1037/04.96 (Safety of machinery - prevention of unexpected start-up)

Keeping a machine in an idle state when people are working in the danger zone is one of the most important requirements for safe operation of machines.

Starting refers to the transition of a machine or its parts from an idle state to moving state. Any start is unexpected if it is caused by:

- A start command sent because of a controller failure or because of external influences on the controller.
- A start 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 starting of machines or parts of machines, power should be removed and dissipated. If this is not practical (e. g. frequent, short work in danger zone), other measures must be taken:

- Measures to prevent random start commands.
- Measures to prevent that random start commands cause unexpected starting.
- Measures to automatically stop dangerous parts of the machine before a dangerous situation can be caused by unexpected starting.

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