X20(c)SC2212

Information:

B&R makes every effort to keep data sheets as current as possible. From a safety point of view, however, the current version of the data sheet must always be used.

The certified, currently valid data sheet can be downloaded from the B&R website www.br-automation.com.

Organization of notices

Safety notices

Contain **only** information that warns of dangerous functions or situations.

Signal word	Description
Danger!	Failure to observe these safety guidelines and notices will result in death, severe injury or substantial damage to property.
Warning!	Failure to observe these safety guidelines and notices can result in death, severe injury or substantial damage to property.
Caution!	Failure to observe these safety guidelines and notices can result in minor injury or damage to property.
Notice!	Failure to observe these safety guidelines and notices can result in damage to property.

Table 1: Organization of safety notices

General notices

Contain **useful** information for users and instructions for avoiding malfunctions.

Signal word	Description
Information:	Useful information, application tips and instructions for avoiding malfunctions.

Table 2: Organization of general notices

1 General information

The modules are equipped with 6 safe digital inputs and 2 safe digital outputs. They are designed for a nominal voltage of 24 VDC.

The modules can be used to read in digital signals and control actuators in safety-related applications up to PL e or SIL 3.

The modules are equipped with filters that are individually configurable for switch-on and switch-off behavior. The modules also provide pulse signals for diagnosing the sensor line.

The outputs are designed using semiconductor technology so that the safety-related characteristics do not depend on the number of switching cycles. The "high-side high-side" variant (output type B) is required for actuators with reference potential (e.g. enable inputs on frequency inverters). It is important to observe the special notices for the wiring in this case. Safe digital output modules are equipped with protection against automatic restart in the event of network errors.

These modules are designed for X20 16-pin terminal blocks.

- 6 safe digital inputs, sink circuit
- 6 pulse outputs
- Software input filter configurable for each channel
- 2 safe digital outputs, output type B with 0.5 A, source circuit
- Integrated output protection

1.1 Function

Safe digital inputs

The module is equipped with safe digital input channels. It can be flexibly used for a wide range of tasks involving the reading of digital signals in safety-related applications up to PL e or SIL 3.

The module is equipped with filters that are individually configurable for switch-on and switch-off behavior. Switch-on filters are used to filter out signal disturbances. Switch-off filters are used to smooth testing gaps in external signal sources – i.e. OSSD signals – so that unintended cutoffs can be avoided.

The input signals of signal pairs (channels 1 and 2, 3 and 4, etc.) are monitored in the module for simultaneity. The maximum permitted discrepancy of inputs of a signal pair is configurable. Here, the signals of dual-channel evaluation directly represent the safe signal of a 2-channel sensor, such as from an E-stop button or safety light curtain.

The module provides pulse signals for diagnosing the sensor line. By default, each pulse signal provides a unique pulse pattern derived from the module's serial number and pulse channel number. This allows any pulse signals to be combined in one signal cable and still cover any cross fault combinations in the cable. The pulse check can also be disabled to connect electronic sensors with separate line monitoring (OSSD signals).

Safe digital outputs

The module is equipped with safe digital output channels. It can be flexibly used for controlling actuators in safety-related applications up to PL e or SIL 3.

The outputs are designed using semiconductor technology so that the safety-related characteristics do not depend on the number of operating cycles. In order to handle all situations involving actuators, there are basically 2 different types of outputs: the high-side - low-side variant (type A) and the high-side - high-side variant (type B). Type A outputs have safety-related advantages since the actuator can be cut off in its connection cable in all error scenarios. Type A outputs are limited to actuators without ground potential (e.g. relays, valves). For actuators with ground potential (e.g. enable inputs on frequency inverters), type B outputs are required. It is important to observe the special notices for the cabling in this case.

Safe digital output channels provide protection against automatic restart when network errors occur. Function blocks needed to fulfill additional requirements regarding protection against automatic restart are available in SafeDESIGNER. The outputs can also be controlled by the standard application. The combination of safety-related control and standard control is arranged such that the execution of a cutoff request always has top priority. For diagnostic purposes, the outputs are designed to be read back.

Depending on the product, the safe digital output channels are equipped with current measurement for detecting open circuits. This function can also be used to monitor muting lamps, for example.

The testing of the semiconductors that is necessary from a safety point of view results in what are known as OSSD low phases in many products. The effect of this is that when an output is active (high state), a switch-off situation (low state) occurs for a very brief amount of time. The test can be cut off if this behavior leads to problems in the application. Observe the associated safety-related notices!

openSAFETY

This module uses the protective mechanisms of openSAFETY when transferring data to the various bus systems. Because the data is encapsulated in the openSAFETY container in a fail-safe manner, the components on the network that are involved in the transfer do not require any additional safety-related features. At this point, only the safety-related characteristic values specified for openSAFETY in the technical data are to be consulted. The data in the openSAFETY container undergoes safety-related processing only when received by the remote station; for this reason, only this component is involved from a safety point of view. Read access to the data in the openSAFETY container for applications without safety-related characteristics is permitted at any point in the network without affecting the safety-related characteristics of openSAFETY.

open SAFETY

1.2 Coated modules

Coated modules are X20 modules with a protective coating for the electronics component. This coating protects X20c modules from condensation.
The modules' electronics are fully compatible with the corresponding X20 modules.

> **Information:**
>
> **For simplification purposes, only images and module IDs of uncoated modules are used in this data sheet.**

The coating has been certified according to the following standards:

- Condensation: BMW GS 95011-4, 2x 1 cycle
- Corrosive gas: EN 60068-2-60, Method 4, exposure 21 days

Contrary to the specifications for X20 system modules without safety certification and despite the tests performed, X20 safety modules are **NOT suited for applications with corrosive gases (EN 60068-2-60)!**

2 Overview

Module	X20SC2212
Safe digital inputs	
Number of inputs	6
Nominal voltage	24 VDC
Input filter Hardware Software	 ≤150 µs Configurable between 0 and 500 ms
Input circuit	Sink
Pulse outputs	
Design	Push-Pull
Switching voltage	I/O power supply minus residual voltage
Safe digital outputs	
Number of outputs	2
Nominal voltage	24 VDC
Nominal output current	0.5 A
Total nominal current	1 A
Output protection	Thermal short circuit shutdown, integrated protection for switching inductive loads

Table 3: Digital mixed modules

3 Order data

Model number	Short description	Figure
	Digital mixed modules	
X20SC2212	X20 safe digital mixed module, 6 safe digital inputs, configurable input filter, 6 pulse outputs, 24 VDC, 2 safe type B1 digital outputs, 24 VDC, 0.5 A, OSSD <500 µs	
X20cSC2212	X20 safe digital mixed module, coated, 6 safe digital inputs, configurable input filter, 6 pulse outputs, 24 VDC, 2 safe type B1 digital outputs, 24 VDC, 0.5 A, OSSD <500 µs	
	Required accessories	
	Bus modules	
X20BM33	X20 bus module, for X20 SafeIO modules, internal I/O power supply continuous	
X20BM36	X20 bus module, for X20 SafeIO modules, with node number switch, internal I/O power supply continuous	
X20cBM33	X20 bus module, coated, for X20 SafeIO modules, internal I/O power supply continuous	
	Terminal blocks	
X20TB5F	X20 terminal block, 16-pin, safety-keyed	

Table 4: X20SC2212, X20cSC2212 - Order data

4 Technical data

Model number	X20SC2212	X20cSC2212
Short description		
I/O module	6 safe digital inputs, 6 pulse outputs, 24 VDC, 2 safe type B1 digital outputs, 24 VDC, 0.5 A, OSSD <500 µs	
General information		
B&R ID code	0xBDA5	0xDD9D
System requirements		
Automation Studio	3.0.81.15 or later	4.0.16 or later
Automation Runtime	3.00 or later	V3.08 or later
SafeDESIGNER	2.70 or later	3.1.0 or later
Safety Release	1.2 or later	1.7 or later
Status indicators	I/O function per channel, operating state, module status	
Diagnostics		
Module run/error	Yes, using status LED and software	
Outputs	Yes, using status LED and software	
Inputs	Yes, using status LED and software	
Blackout mode		
Scope	Module	
Function	Module function	
Standalone mode	No	
Max. I/O cycle time	1 ms	
Power consumption		
Bus	0.25 W	
Internal I/O	1.4 W	
Electrical isolation		
Channel - Bus	Yes	
Channel - Channel	No	
Certifications		
CE	Yes	
KC	Yes	-
EAC	Yes	
UL	cULus E115267 Industrial control equipment	
HazLoc	cCSAus 244665 Process control equipment for hazardous locations Class I, Division 2, Groups ABCD, T5	
ATEX	Zone 2, II 3G Ex nA nC IIA T5 Gc IP20, Ta (see X20 user's manual) FTZÚ 09 ATEX 0083X	
DNV GL	Temperature: **A** (0 - 45°C) Humidity: **B** (up to 100%) Vibration: **A** (0.7 g) EMC: **B** (bridge and open deck)	
Functional safety	cULus FSPC E361559 Energy and industrial systems Certified for functional safety ANSI UL 1998:2013	
Functional safety	IEC 61508:2010, SIL 3 EN 62061:2013, SIL 3 EN ISO 13849-1:2015, Cat. 4 / PL e IEC 61511:2004, SIL 3	
Functional safety	EN 50156-1:2004	
Safety characteristics		
EN ISO 13849-1:2015		
MTTFD	2500 years	
Mission time	Max. 20 years	
IEC 61508:2010, IEC 61511:2004, EN 62061:2013		
PFH / PFH_d		
Module	$<1*10^{-10}$	
openSAFETY wired	Negligible	
openSAFETY wireless	$<1*10^{-14}$ * Number of openSAFETY packets per hour	
PFD	$<2*10^{-5}$	
Proof test interval (PT)	20 years	

Table 5: X20SC2212, X20cSC2212 - Technical data

Model number	X20SC2212	X20cSC2212
Safe digital inputs		
EN ISO 13849-1:2015		
Category	Cat. 3 when using individual input channels, Cat. 4 when using input channel pairs (e.g. SI1 and SI2) or more than 2 input channels [1]	
PL	PL e	
DC	>94%	
IEC 61508:2010, IEC 61511:2004, EN 62061:2013		
SIL CL	SIL 3	
SFF	>90%	
Safe digital outputs		
EN ISO 13849-1:2015		
Category	Cat. 3 if parameter "Disable OSSD = Yes-ATTENTION", Cat. 4 if parameter "Disable OSSD = No" [1]	
PL	PL d if parameter "Disable OSSD = Yes-ATTENTION", PL e if parameter "Disable OSSD = No" [1]	
DC	>60% if parameter "Disable OSSD = Yes-ATTENTION", >94% if parameter "Disable OSSD = No" [1]	
IEC 61508:2010, IEC 61511:2004, EN 62061:2013		
SIL CL	SIL 2 if parameter "Disable OSSD = Yes-ATTENTION", SIL 3 if parameter "Disable OSSD = No" [1]	
SFF	>60% if parameter "Disable OSSD = Yes-ATTENTION", >90% if parameter "Disable OSSD = No" [1]	
I/O power supply		
Nominal voltage	24 VDC	
Voltage range	24 VDC -15% / +20%	
Integrated protection	Reverse polarity protection	
Safe digital inputs		
Nominal voltage	24 VDC	
Input characteristics per EN 61131-2	Type 1	
Input filter		
Hardware	≤150 µs	
Software	Configurable between 0 and 500 ms	
Input circuit	Sink	
Input voltage	24 VDC -15% / +20%	
Input current at 24 VDC	Max. 3.28 mA	
Input resistance	Min. 7.33 kΩ	
Error detection time	100 ms	
Isolation voltage between channel and bus	500 V_{eff}	
Switching threshold		
Low	<5 VDC	
High	>15 VDC	
Line length between pulse output and input	Max. 60 m with unshielded line Max. 400 m with shielded line	
Safe digital outputs		
Variant	FET, 2x positive switching, type B1, output level readable	
Nominal voltage	24 VDC	
Nominal output current	0.5 A	
Total nominal current	1 A	
Output protection	Thermal short-circuit shutdown, integrated protection for switching inductive loads [2]	
Braking voltage when switching off inductive loads	Max. 45 VDC	
Error detection time	1 s	
Isolation voltage between channel and bus	500 V_{eff}	
Peak short-circuit current	Max. 12 A	
Leakage current when switched off	<500 µA	
Residual voltage	≤300 mVDC at nominal current	
Switching voltage	I/O power supply minus residual voltage	
Max. switching frequency	1000 Hz	
Test pulse length	Max. 500 µs	
Max. capacitive load	100 nF	
Current on loss of ground		
I_{OUT}	<1 mA	
I_{GND}	<180 mA	
Pulse outputs		
Variant	Push-Pull	
Nominal output current	20 mA	
Output protection	Shutdown of individual channels in the event of overload or short circuit [2]	
Peak short-circuit current	25 A for 15 µs	
Short-circuit current	100 mA_{eff}	
Leakage current when switched off	0.1 mA	
Residual voltage	3 VDC	

Table 5: X20SC2212, X20cSC2212 - Technical data

Model number	X20SC2212	X20cSC2212
Switching voltage	I/O power supply minus residual voltage	
Total nominal current	120 mA	
Operating conditions		
Mounting orientation		
Horizontal	Yes	
Vertical	Yes	
Installation elevation above sea level	0 to 2000 m, no limitation	
Degree of protection per EN 60529	IP20	
Ambient conditions		
Temperature		
Operation		
Horizontal mounting orientation	0 to 60°C	-40 to 60°C 3)
Vertical mounting orientation	0 to 50°C	-40 to 50°C 4)
Derating	See section "Derating".	
Storage	-40 to 85°C	
Transport	-40 to 85°C	
Relative humidity		
Operation	5 to 95%, non-condensing	Up to 100%, condensing
Storage	5 to 95%, non-condensing	
Transport	5 to 95%, non-condensing	
Mechanical properties		
Note	Order 1x safety-keyed terminal block separately. Order 1x safety-keyed bus module separately.	
Spacing	$25^{+0.2}$ mm	

Table 5: X20SC2212, X20cSC2212 - Technical data

1) The related danger warnings in the technical data sheet must also be observed.
2) The protective function is provided for max. 30 minutes for a continuous short circuit.
3) Up to hardware upgrade <1.10.1.0 and hardware revision <E0: -25 to 60°C
4) Up to hardware upgrade <1.10.1.0 and hardware revision <E0: -25 to 50°C

Danger!

Operation outside the technical data is not permitted and can result in dangerous states.

Information:

For detailed information about installation, see chapter "Installation notes for X20 modules" on page 50.

Derating

The derating curve refers to standard operation and can be shifted to the right by the specified derating bonus if in a horizontal mounting orientation.

Module	X20SC2212
Derating bonus	
At 24 VDC	+5°C
Dummy module on the left	+2.5°C
Dummy module on the right	+0°C
Dummy module on the left and right	+5°C
With double PFH / PFH_d	+0°C

Table 6: Derating bonus

Inputs

The number of inputs that should be used at the same time depends on the operating temperature and the mounting orientation. The resulting amount can be looked up in the following table.

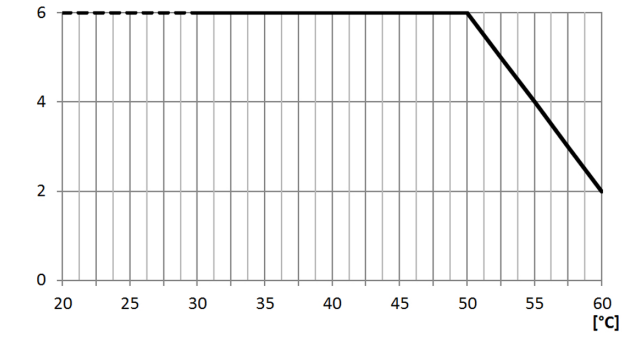
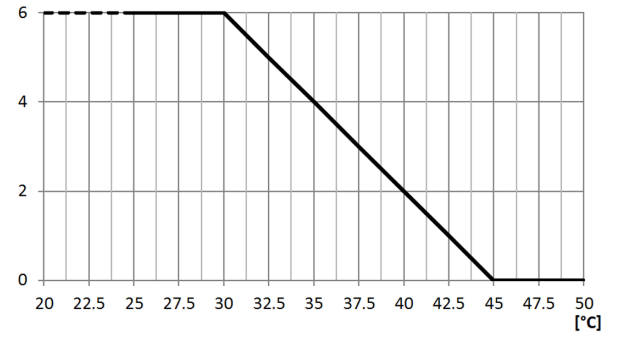
Horizontal (0 to 60°C, coated: -40 to 60°C)	Vertical (0 to 50°C, coated: -40 to 50°C)
	

Table 7: Derating in relation to operating temperature and mounting orientation

Outputs

The maximum total nominal current depends on the operating temperature and the mounting orientation. The resulting total nominal current can be found in the following table.

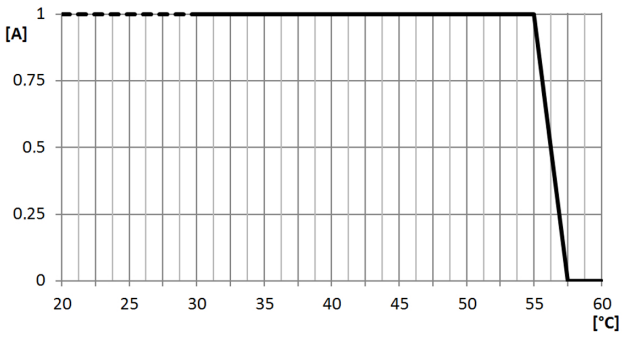
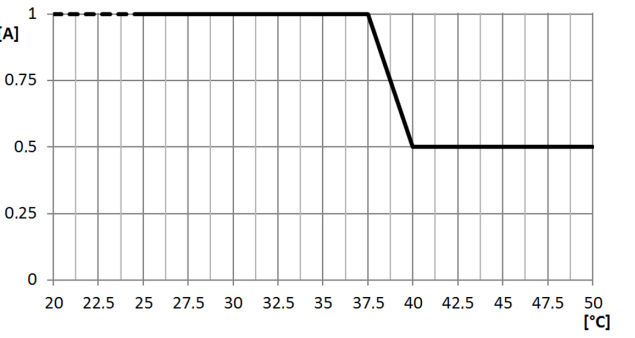
Horizontal (0 to 60°C, coated: -40 to 60°C)	Vertical (0 to 50°C, coated: -40 to 50°C)
	

Table 8: Derating in relation to operating temperature and mounting orientation

Information:

Regardless of the values specified in the derating curve, the module cannot be operated above the values specified in the technical data.

5 LED status indicators

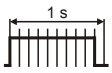
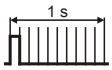
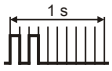
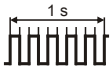
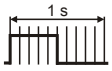
Figure	LED	Color	Status	Description
	r	Green	Off	No power to module
			Single flash	Reset mode
			Double flash	Updating firmware
			Blinking	PREOPERATIONAL mode
			On	RUN mode
	e	Red	Off	No power to module or everything OK
			Pulsating	Boot loader mode
			Triple flash	Updating safety-related firmware
			On	Error or I/O component not provided with voltage
	e + r	Red on / green single flash		Invalid firmware
	1 to 6	Input state of the corresponding digital input		
		Red	On	Warning/Error on an input channel
			Blinking	Error in dual-channel evaluation (synchronous blinking of 2 affected channels)
			All on	Error on all channels, connection to the SafeLOGIC controller not OK or booting not yet completed
		Green	On	Input set
	1 to 2	Output status of the corresponding digital output		
		Red	On	Warning/Error on an output channel
			All on	Error on all channels, connection to the SafeLOGIC controller not OK or booting not yet completed
		Orange	On	Output set
	SE	Red	Off	RUN mode or I/O component not provided with voltage
				Boot phase, missing X2X Link or defective processor
				Safety PREOPERATIONAL state Modules that are not used in the SafeDESIGNER application remain in the PREOPERATIONAL state.
				Safe communication channel not OK
				The firmware for this module is a non-certified pilot customer version.
				Boot phase, faulty firmware
			On	Safety state active for the entire module (= "FailSafe" state)
		The "SE" LEDs separately indicate the status of safety processor 1 ("S" LED) and safety processor 2 ("E" LED).		

Table 9: Status display

Danger!

Constantly lit "SE" LEDs indicate a defective module that must be replaced immediately.
It is your responsibility to ensure that all necessary repair measures are initiated after an error occurs since subsequent errors can result in a hazard!

6 Pinout

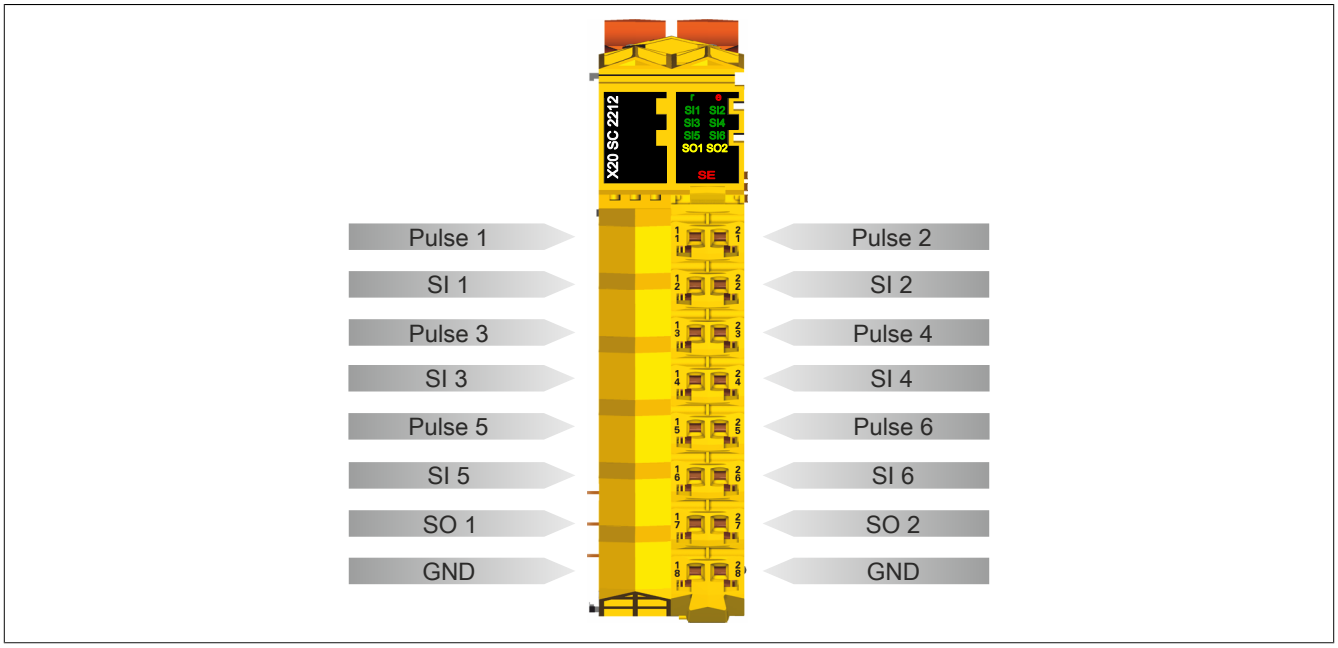


Figure 1: X20SC2212 - Pinout

7 Connection examples

The typical connection examples in this section only represent a selection of the different wiring methods. The user must take error detection into account in each case.

Information:

For details about connection examples (such as circuit examples, compatibility class, max. number of supported channels, terminal assignments, etc.), see chapter Connection examples of the "Integrated safety technology" user's manual (MASAFETY-ENG).

7.1 Module behavior when GND connection is lost

In this section and all of its subsections, the term "connection element" is to be understood as follows for the respective system (X20, X67):

- X20: e.g. terminal block
- X67: e.g. M12, M8

A loss of GND on the module may cause current to flow from the module via the output or the GND connection of the connection element.

If power supplies, actuators or GND connections are grounded, the user must ensure that no grounding wires or any associated potential short circuits or open circuits will cause any additional impermissible GND connections.

The two currents I_{OUT} and I_{GND} are module-specific and must be taken from the technical data.

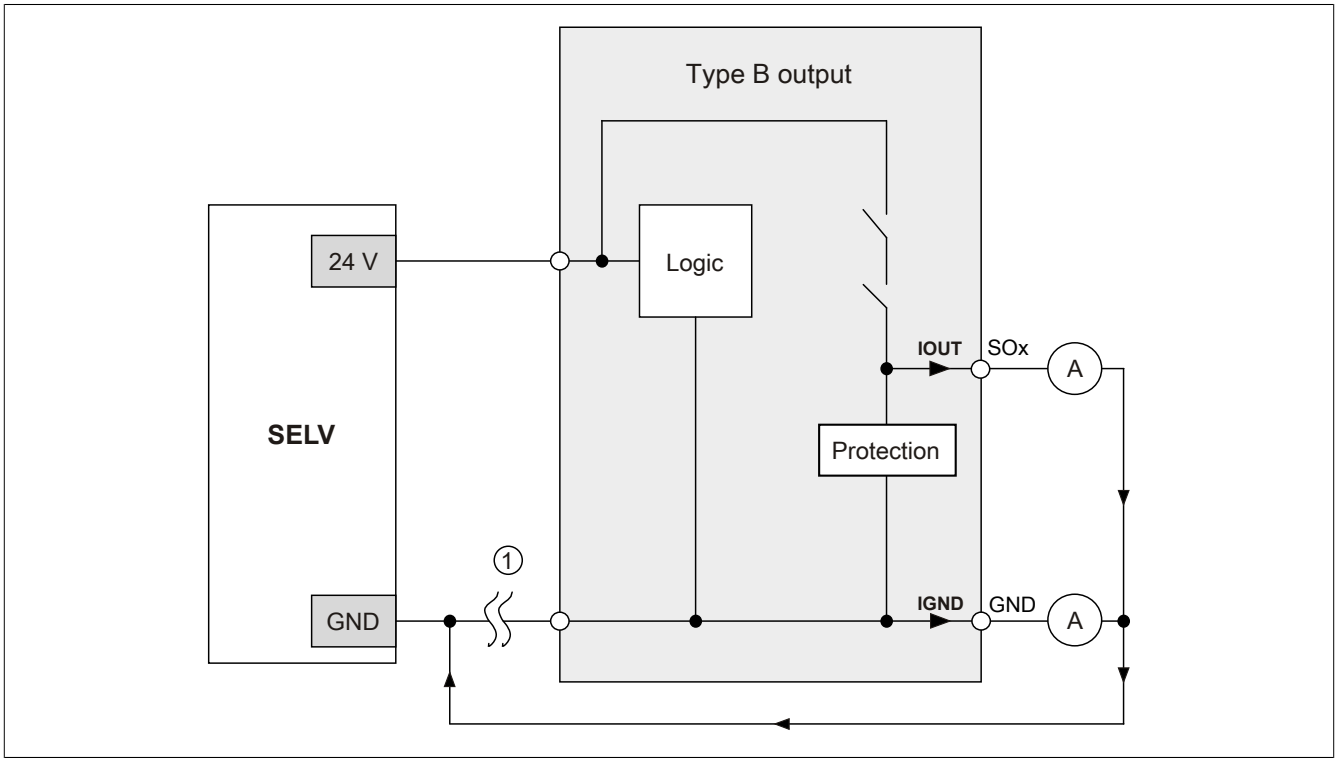


Figure 2: Module behavior when GND connection is lost

Danger!

The user is responsible for preventing any safety problems that could occur as a result of the I_{OUT} and I_{GND} currents specified in the technical data and the selected method of installation.

7.1.1 GND feedback to connection element, no external GND

If the module is used in the following wiring mode, then a loss of GND will not cause any problems because current is not able to flow via I_{OUT} or I_{GND}.

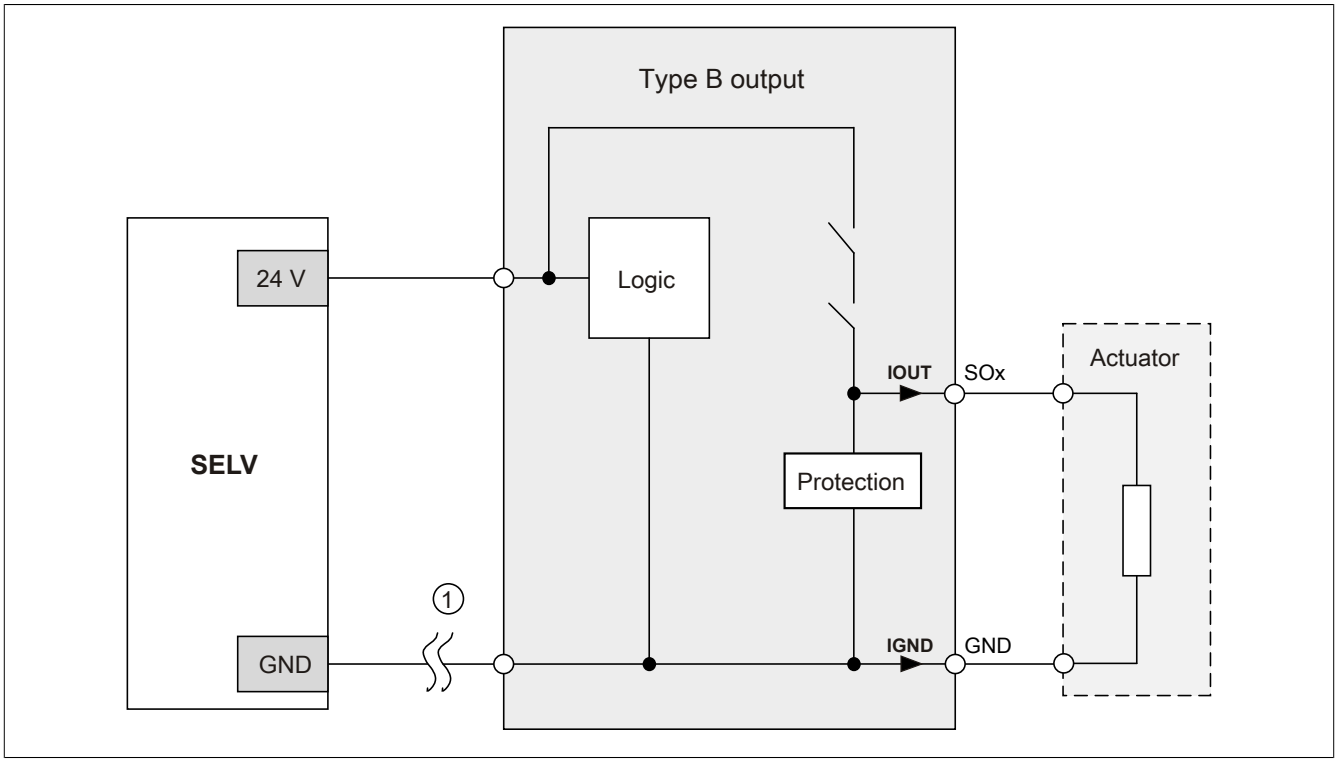


Figure 3: GND feedback to connection element

Danger!

Other wiring methods

If another wiring method is used, the user must ensure that a safety-critical state cannot occur if there are 2 external faults (open circuit, etc.). In addition, the current specifications for I_{OUT} and I_{GND} must be taken into consideration in the event that the GND connection is lost.

7.1.2 Using external GND without GND from connection element

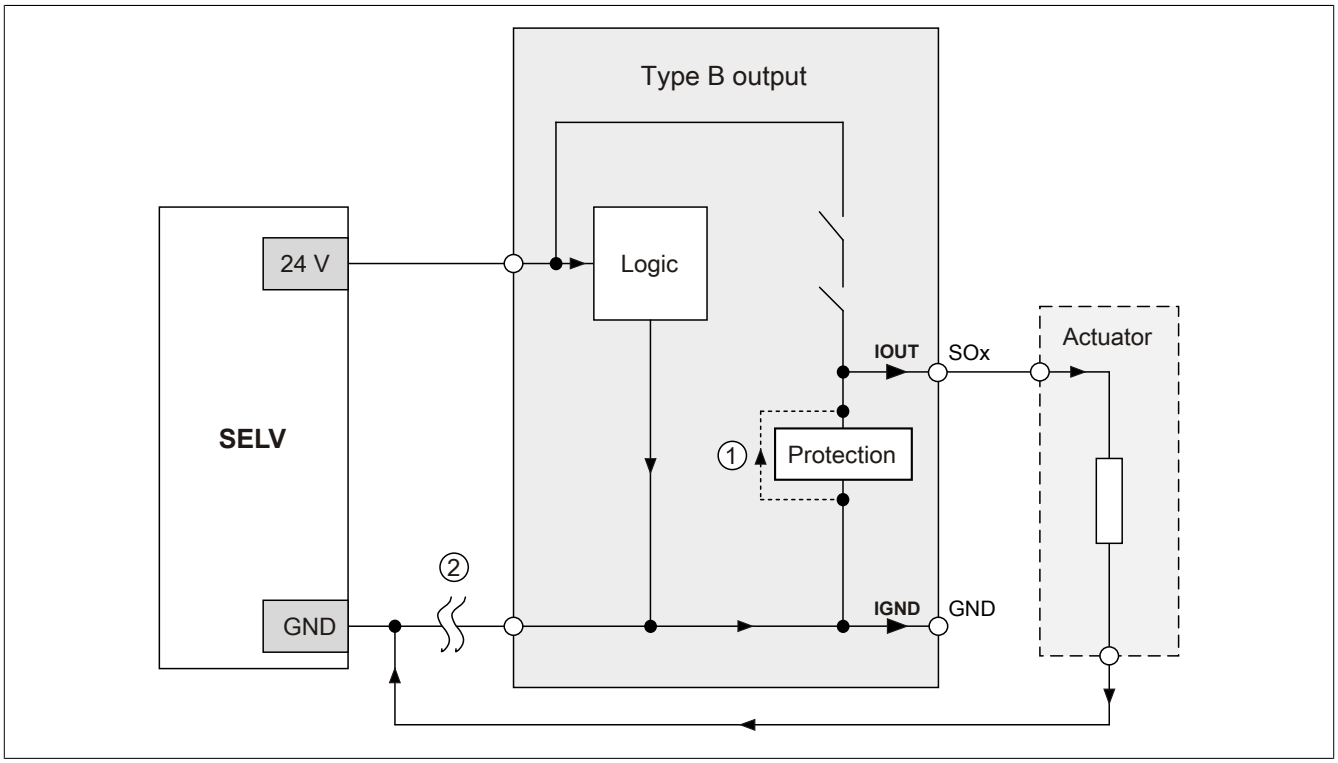


Figure 4: External GND only

Fault sequence:

- Fault ① (defective protective component):
  A component connected to GND on the output short circuits or behaves like an ohmic resistor. This fault is not always detected.
- Fault ② (open circuit on module GND):
  The module loses its direct connection to GND and current begins to flow through the defective protective component → I_{OUT} → actuator.
  As a result, current above the maximum value permitted by the module is supplied to the actuator.

Danger!

This type of installation can cause hazardous situations and is therefore NOT permitted.

7.1.3 Using external GND and GND from connection element

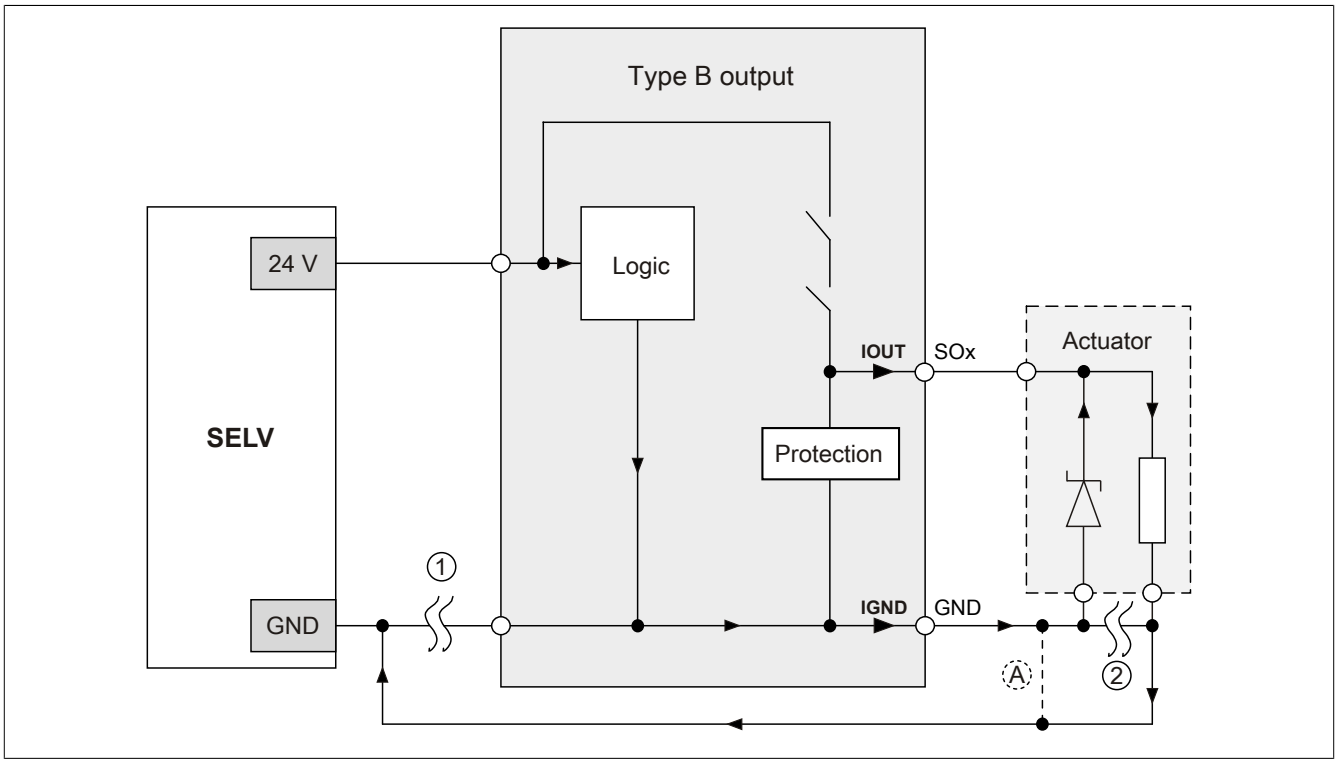


Figure 5: Possible connection error

Fault sequence:

- Fault ① (open circuit on module GND):
  No error is detected and the module continues to operate normally due to the additional external GND connection.
- Fault ② (open circuit on actuator's protective circuit):
  The module loses its direct connection to GND and current begins to flow through I_{GND} → damping diode → actuator.
  As a result, current above the maximum value permitted by the module is supplied to the actuator.

Danger!

This type of installation can cause hazardous situations and is therefore NOT permitted.

Possible remedies

This wiring method could be made possible, for example, by using two wires to complete the connection that experienced the open circuit fault in ② → see connection Ⓐ.

Information:

The diode in the actuator shown in the "Possible connection error" image is intended only to illustrate the error and is not mandatory.

7.2 Connecting single-channel sensors with contacts

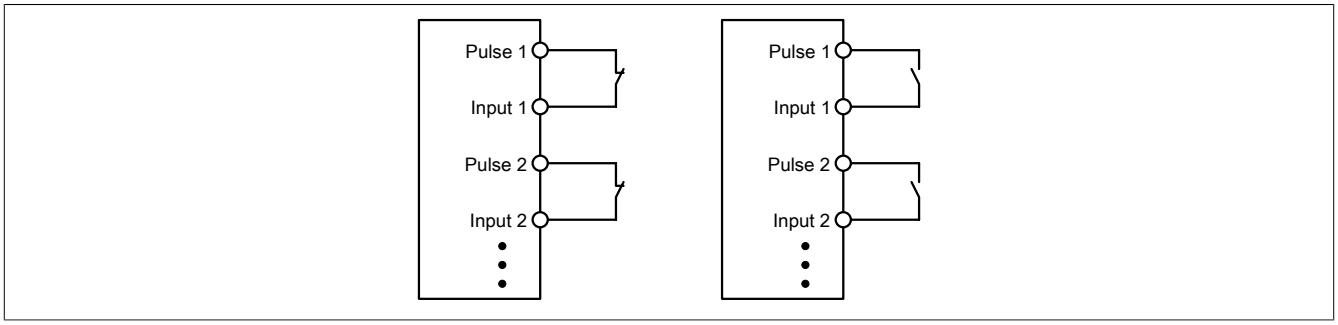


Figure 6: Connecting single-channel sensors with contacts

Single-channel sensors with contacts are the simplest connection.

With this connection, the module satisfies Category 3 requirements in accordance with EN ISO 13849-1:2015. Be aware that this statement applies only to the module and not to the wiring shown. You are responsible for wiring the sensor according to the required category.

7.3 Connecting two-channel sensors with contacts

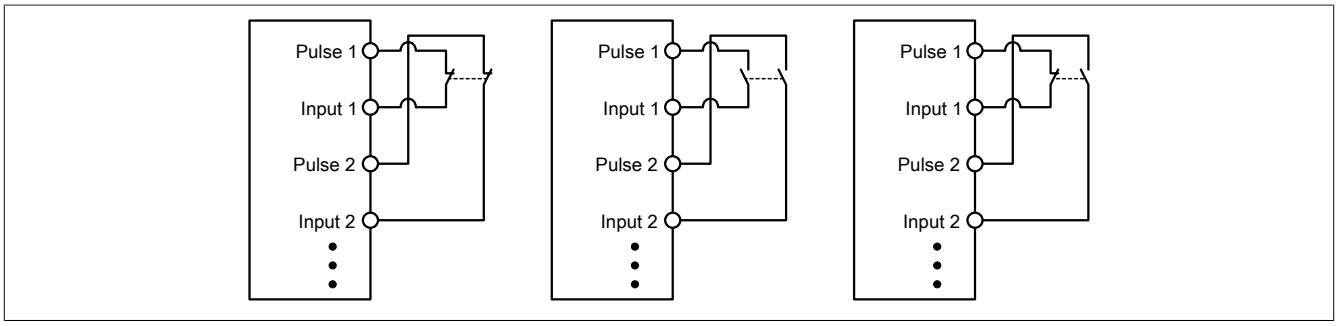


Figure 7: Connecting two-channel sensors with contacts

Sensors with contacts can be connected directly to a safe digital input module via two channels. Dual-channel evaluation is handled directly by the module.

With this connection, the module satisfies Category 4 requirements in accordance with EN ISO 13849-1:2015. Be aware that this statement applies only to the module and not to the wiring shown. You are responsible for wiring the sensor according to the required category.

7.4 Connecting multi-channel sensors with contacts

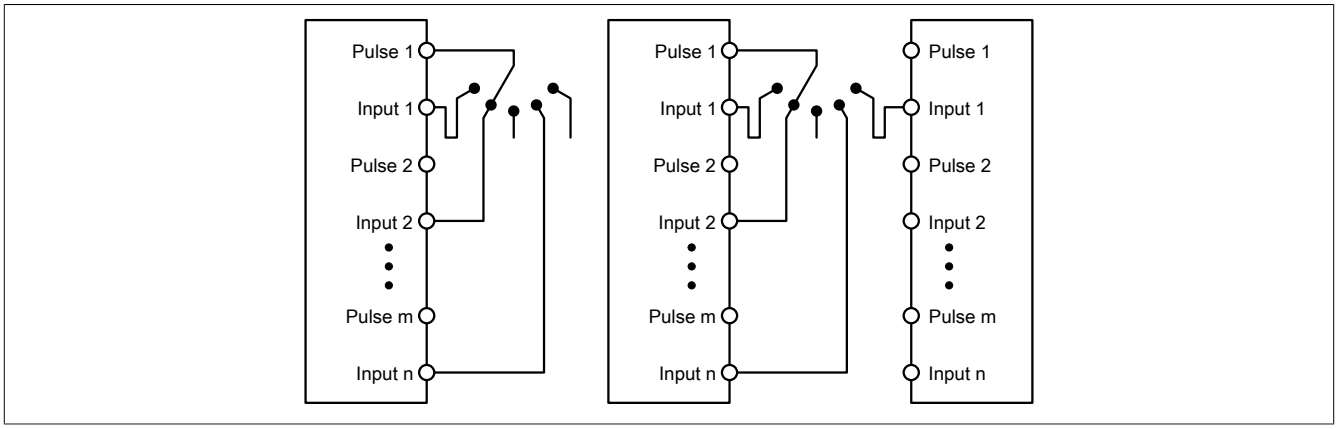


Figure 8: Connecting multi-channel sensors with contacts

Multi-channel switches (mode selector switches, switching devices with "shift key" capability) can be connected to multiple safe digital input modules.

If signals are evaluated internally in the module (see image to the left), the same pulse must be configured for all of the inputs being used. If signals are evaluated across all modules (see image to the right), all of the inputs must be configured to use an external pulse. In this type of application, pulse evaluation with the "default" pulse is not suitable; therefore, a separate pulse signal with approx. 4 ms low-phase is available.

In this case, multi-channel evaluation must be handled in the safety application (PLCopen function block "SF_ModeSelector"). The category achieved per EN ISO 13849-1:2015 in this way depends on the error models of the switching element (e.g. mode selector switch) and must be examined in combination with the error detection present in the PLCopen function block.

7.5 Connecting electronic sensors

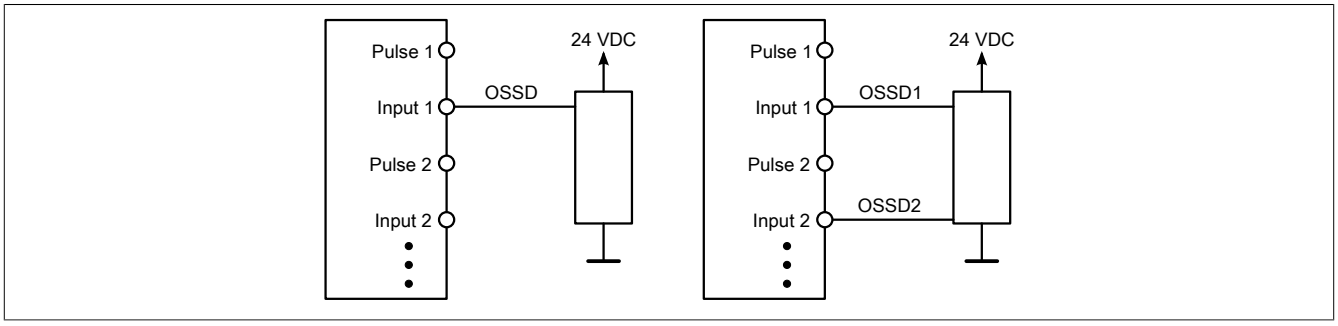


Figure 9: Connecting electronic sensors

Electronic sensors (light curtains, laser scanners, inductive sensors, etc.) can be connected directly to safe digital input modules. The switching thresholds of the input channels must be taken into account for these types of applications.

With single-channel wiring (see image on the left), the module satisfies Category 3 requirements in accordance with EN ISO 13849-1:2015. With two-channel wiring (see image on the right), the module satisfies Category 4 requirements in accordance with EN ISO 13849-1:2015. Be aware that this statement applies only to the module and not the wiring or connected electronic sensor. You are responsible for wiring the sensor in accordance with the required category and within the specifications set forth by the manufacturer of the electronic sensor.

7.6 Using the same pulse signals

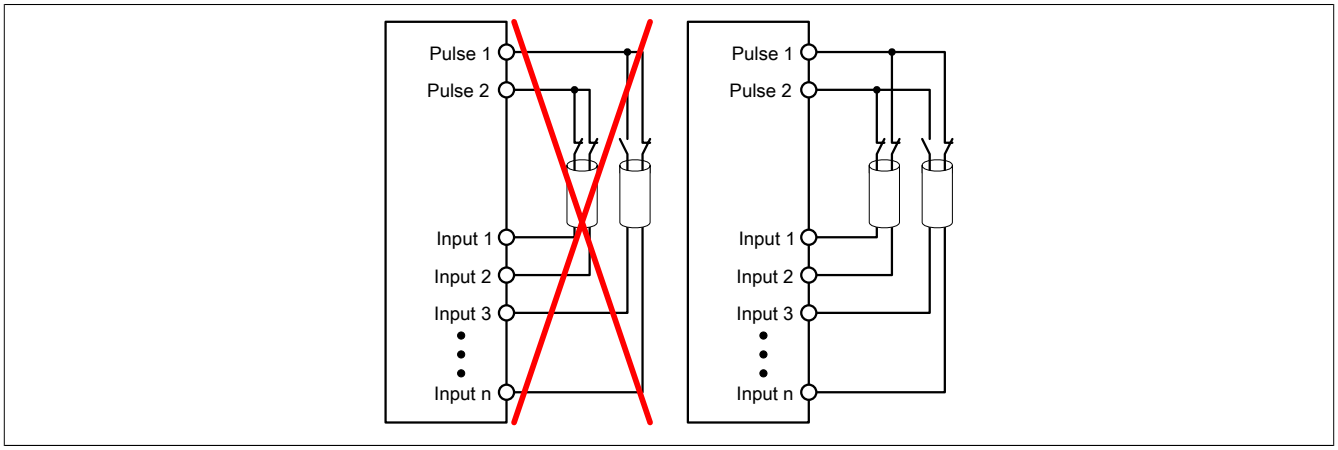


Figure 10: Using the same pulse signals

When using the same pulse signals for different inputs, they must be isolated from one another. Otherwise, damage to the cables may cause errors that are not detected by the module.

Danger!

If the same pulse signals are routed in the same cable, damage to the cable can cause cross faults between the signals to occur that are not detected by the module. This can result in dangerous situations.

For this reason, signal lines with the same pulse signal should be routed in different cables, or you should implement other error prevention measures in accordance with EN ISO 13849-2:2012.

Danger!

It is especially important to check the wiring when using the same pulse signal for two inputs that are located next to each other on the terminal. Pay special attention to ensure that poor wiring has not resulted in the two inputs being connected together.

7.7 Connecting safety-oriented actuators for Type B outputs

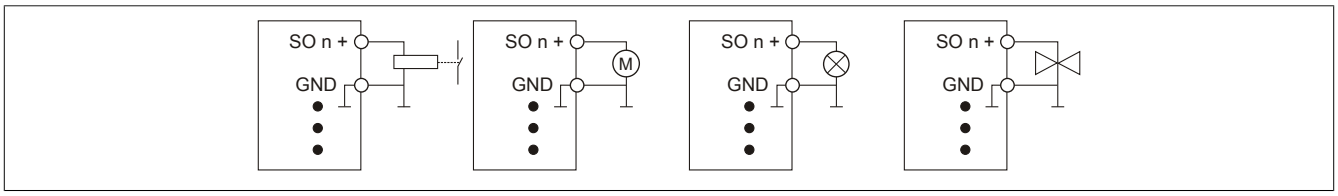


Figure 11: Connecting safety-oriented actuators for Type B outputs

Safety actuators (contactors, motors, muting lamps, valves) that are compatible with module performance data can be connected directly.

With this connection, the module satisfies Category 4 requirements in accordance with EN ISO 13849-1:2015. Be aware that this statement applies only to the module and not to the wiring shown. You are responsible for wiring the actuator in accordance with the required category and the characteristics of actuator.

If the actuators contain an inverse diode or electronic components, then the special instructions in section "Module behavior when GND connection is lost" must be followed.

8 Error detection

8.1 Internal module errors

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

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

Errors that occur within the module are detected according to the requirements of the standards listed in the certificate and within the minimum safety response time specified in the technical data. After this occurs, the module enters a safe state.

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

BOOT mode on a module is clearly indicated by a slowly blinking SE LED (2 Hz or 1 Hz).

The error detection time specified in the technical data is relevant only for detecting external errors (i.e. wiring errors) in single-channel structures.

Danger!

Operating the safety module in BOOT mode is not permitted.

Danger!

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

8.2 Wiring errors

The wiring errors described in section "Error detection" are indicated by the red channel LED according to the application.

If a module detects an error, then:

- The channel LED is lit constantly red.
- Status signal (e.g. (Safe)ChannelOK, (Safe)InputOK, (Safe)OutputOK, etc.) is set to (SAFE)FALSE.
- Signal "SafeDigitalInputxx" or "SafeDigitalOutputxx" is set to SAFEFALSE.
- An entry is generated in the logbook.

Danger!

Recognizable errors (see the following chapters) are detected by the module within the error detection time. Errors not recognized by the module (or not recognized on time) that can lead to safety-critical states must be detected using additional measures.

Danger!

It is your responsibility to ensure that all necessary repair measures are initiated after an error occurs since subsequent errors can result in a hazard!

8.2.1 Type B output channels

Danger!

As illustrated in the following circuit examples, the connected actuators can be connected to GND on the load side. Connecting actuators on just one side without a GND supply is not permitted, however. This would cause a series connection of the actuators in the event of an open circuit, which could then cause a hazardous module error.

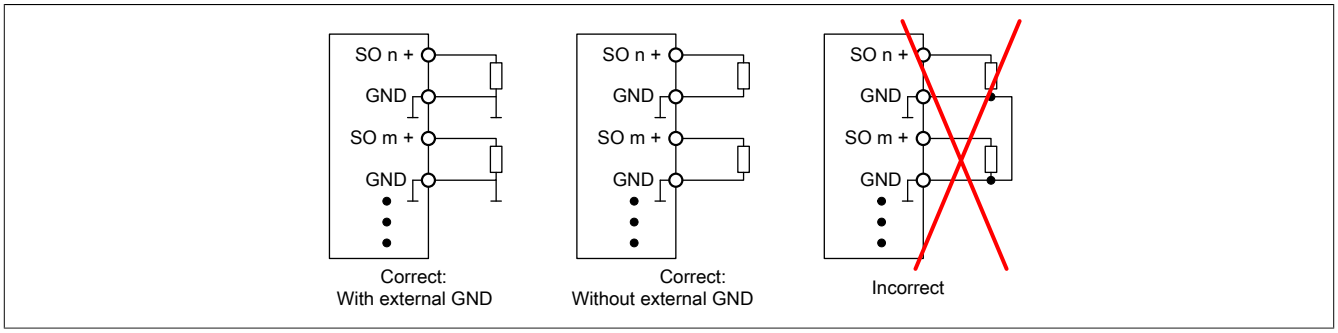


Figure 12: Invalid wiring

8.2.2 Connecting single-channel sensors with contacts

By default, every input channel is assigned a dedicated pulse output. This pulse output issues a specific signal that helps detect wiring problems, such as a short circuit to 24 VDC, GND or other signal channels. The status of the connected switches is indicated by channel-specific LEDs. The LEDs "OO" and "OC" have no significance with this type of connection.

With this type of connection in combination with the configuration "Pulse Mode = Internal", the modules can detect the following errors:

Error	Error on contact	
	Open	Closed
Ground fault on the pulse output	Detected	Detected
Pulse output shorted to 24 VDC	Detected	Detected
Cross fault between the pulse output and the other pulse signal	Detected	Detected
Ground fault on signal input	**Not detected**	Detected
Signal input shorted to 24 VDC	Detected	Detected
Cross fault between the signal input and the other pulse signal	Detected	Detected
Cross fault between the pulse output and the signal input	**Not detected**	**Not detected**
Open circuit	**Not detected**	**Not detected**

Table 10: SI error detection when "Pulse mode = Internal"

8.2.3 Connecting two-channel sensors with contacts

By default, every input channel is assigned a dedicated pulse output. This pulse output issues a specific signal that helps detect wiring problems, such as a short circuit to 24 VDC, GND or other signal channels.

The status of the connected switches is signaled via channel-specific LEDs, and the status of the dual-channel evaluation is signaled via the "OO" (for combinations with N.C./N.C. contacts) or "OC" LED (for combinations with N.C./N.O. contacts). On module types that do not have these LEDs, errors detected in the dual-channel evaluation are indicated by the respective channel LED blinking red.

With this type of connection in combination with the configuration "Pulse Mode = Internal" and combined with dual-channel evaluation in the module or in SafeDESIGNER, the modules can detect the following errors:

Error	Error on contact	
	Open	Closed
Ground fault on the pulse output	Detected	Detected
Pulse output shorted to 24 VDC	Detected	Detected
Cross fault between the pulse output and the other pulse signal	Detected	Detected
Ground fault on signal input	**Not detected**	Detected
Signal input shorted to 24 VDC	Detected	Detected
Cross fault between the signal input and the other pulse signal	Detected	Detected
Cross fault between the pulse output and the signal input	Detected[1)]	**Not detected**
Open circuit	**Not detected**	Detected[1)]

Table 11: SI error detection with "Pulse Mode = Internal" combined with dual-channel evaluation in the module or in SafeDESIGNER

1) Dual-channel evaluation of the module.

8.2.4 Connecting multi-channel sensors with contacts

The status of the connected switches is indicated by channel-specific LEDs. The LEDs "OO" and "OC" have no significance with this type of connection.

With this wiring, the following errors can be detected:

Error	
Ground fault on the pulse output	Detected
Pulse output shorted to 24 VDC	Detected
Cross fault between the pulse output and the other pulse signal	Detected[1)]
Ground fault on signal input (active signal)	Detected[1)]
Ground fault on signal input (inactive signal)	**Not detected**
Signal input shorted to 24 VDC	Detected
Cross fault between the signal input and the other pulse signal	Detected[1)]
Cross fault between the pulse output and the signal input (active signal)	**Not detected**
Open circuit (active signal)	Detected[1)]
Cross fault between the pulse output and the signal input (inactive signal)	Detected[1)]
Open circuit (inactive signal)	**Not detected**

Table 12: SI error detection when "Pulse Mode = External"

1) Detected by PLCopen function block "SF_ModeSelector" in the application.

Danger!

If "Pulse Mode = External" is used in the channel configuration, then an additional TOFF filter with 5 ms is enabled in the module. The corresponding information regarding the TOFF filter must also be considered when using the "Pulse Mode = External" setting.

Information:

With the configuration "Pulse Mode = Internal", the pulses have a low phase of approximately 300 µs. This low phase is designed such that no additional degradation of the total response time can occur in the system. If line lengths exceed the max. line length (see technical data), problems may occur with this configuration. In these cases, configuration "Pulse Mode = External" can also be useful for normal sensors with contacts. The reduced error detection and extension of the total response time must be taken into account, however.

8.2.5 Connecting electronic sensors

A pulse pattern cannot be used with electronic sensors. The input channels must therefore be configured to "Pulse Mode = No Pulse".

Any gaps when testing the connected OSSD outputs must be masked out with the module's cutoff filter in order to avoid an unintended shutdown.

Danger!

With the configuration "Pulse Mode = No Pulse", the module itself is not able to detect wiring errors. Internal errors are still detected, however. All errors resulting from incorrect or faulty wiring must be handled through supplementary measures per EN ISO 13849-2:2012 or by the connected device.

Danger!

Configuring a switch-off filter lengthens the safety response time. The configured filter value must be added to the total response time.

8.2.6 Safety actuator connection

Error / module	Disable OSSD = No		Disable OSSD = Yes-ATTENTION	
	Error on output			
	Switched off	Switched on	Switched off	Switched on
Ground fault on SOx+ (output type A) or SOx (output type B)				
All SO types	**Not detected**	Detected	**Not detected**	Detected
Ground fault on SOx- (output type A)				
X20SC0xxx	**Not detected**	Detected	**Not detected**	**Not detected**
X20SLXxxx				
X20SRTxxx				
X20SOx1x0				
SOx+ shorted to 24 VDC (output type A)				
X20SC0xxx	Detected	Detected	Detected	**Not detected**
X20SLXxxx				
X20SRTxxx				
X20SOx1x0				
SOx shorted to 24 VDC (output type B)				
X20SC0xxx	Detected [1]	**Not detected**	Detected [1]	**Not detected**
X20SLXxxx				
X20SRTxxx				
X20SO6300				
X20SP1130				
X20SC2212		Detected [1]		
X67SC4122.L12				
SOx- shorted to 24 VDC (output type A)				
X20SC0xxx	Detected	Detected	Detected	Detected
X20SLXxxx				
X20SRTxxx				
X20SOx1x0				
GND shorted to 24 VDC				
X20SC0xxx	**Not detected**	**Not detected**	**Not detected**	**Not detected**
X20SLXxxx				
X20SRTxxx				
X20SO6300				
X20SP1130				
X20SC2212				
X67SC4122.L12				
Cross fault between SOx+ (output type A) and the other signal (high)				
X20SC0xxx	Detected	Detected	Detected	**Not detected**
X20SLXxxx				
X20SRTxxx				
X20SOx1x0				
Cross fault between SOx (output type B) and the other signal (high)				
X20SC0xxx	Detected [1]	**Not detected**	Detected [1]	**Not detected**
X20SLXxxx				
X20SRTxxx				
X20SO6300				
X20SP1130				
X20SC2212		Detected [1]		
X67SC4122.L12				
Cross fault between SOx- (output type A) and the other signal (high)				
X20SC0xxx	Detected	Detected	Detected	**Not detected**
X20SLXxxx				
X20SRTxxx				
X20SOx1x0				
Cross fault between GND and the other signal (high)				
X20SC0xxx	**Not detected**	**Not detected**	**Not detected**	**Not detected**
X20SLXxxx				
X20SRTxxx				
X20SO6300				
X20SP1130				
X20SC2212				
X67SC4122.L12				
Open circuit (output type A and B)				
X20SC0xxx	**Not detected**	**Not detected**	**Not detected**	**Not detected**
X20SLXxxx				
X20SRTxxx				
X20SOx1x0		**Not detected** [2]		**Not detected** [2]
X20SO6300		**Not detected**		**Not detected**
X20SP1130				
X20SC2212				
X67SC4122.L12				

Table 13: SO error detection

Error / module	Disable OSSD = No		Disable OSSD = Yes-ATTENTION	
	Error on output			
	Switched off	Switched on	Switched off	Switched on
Short circuit between SOx+ (output type A) and SOx- (output type A)				
X20SC0xxx	**Not detected**	Detected	**Not detected**	Detected
X20SLXxxx				
X20SRTxxx				
X20SOx1x0				

Table 13: SO error detection

1) If SOx is shorted to high potentials, this will be detected by the module, but the connected actuator cannot be cut off due to the "only-plus-switching" design of the channel.
2) Open circuit can be detected via signal "CurrentOK". However, this signal cannot be used for safety purposes.

Danger!

With "Disable OSSD = Yes-ATTENTION", the module has reduced error detection capabilities and no longer meets the requirements for SIL 3 per EN 62061:2013 or PL e per EN ISO 13849-1:2015.

In order to meet the requirements for applications up to SIL 2 per EN 62061:2013 or PL d per EN ISO 13849-1:2015, the user must check the safety function on a daily basis when using type B output channels.
For type B2 output channels, it is also important to ensure that all of the module's output channels are simultaneously in a switched-off state for at least 1 s during this test.

On X20SRTxxx modules, each output channel being used must be checked before the first safety request and every 24 hours. For this check, the corresponding channel must be switched on and off at least once.

Danger!

Possible error behavior of the actuators must be analyzed and avoided using corresponding responses (positively driven read-back contacts on a contactor, pressure switch on valves, etc.).

Danger!

This danger warning applies to all the modules listed in the "SO error detection" table with the exception of output channels of type A!

If SOx is shorted to high potentials, this will be detected by the module, but the connected actuator cannot be cut off due to the "only-plus-switching" design of the channel. Make sure that the wiring is correct in order to rule out SOx short circuits to high potentials (see EN ISO 13849-2:2012, Annex D.2.4, Table D.4).

9 Input circuit diagram

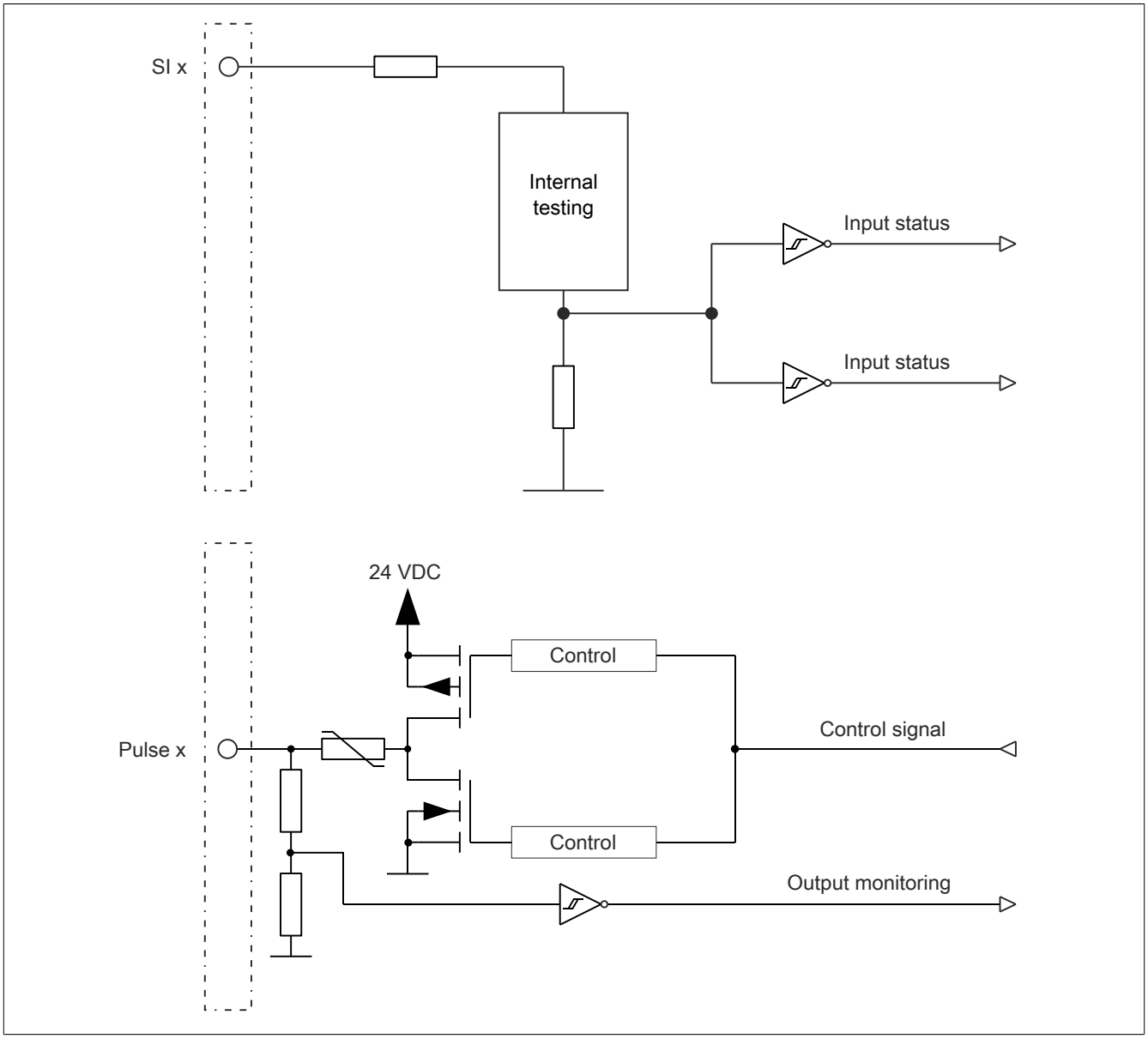


Figure 13: Input circuit diagram

10 Type B output circuit diagram

Type B digital output channels are designed for positive and positive switching inside the module.

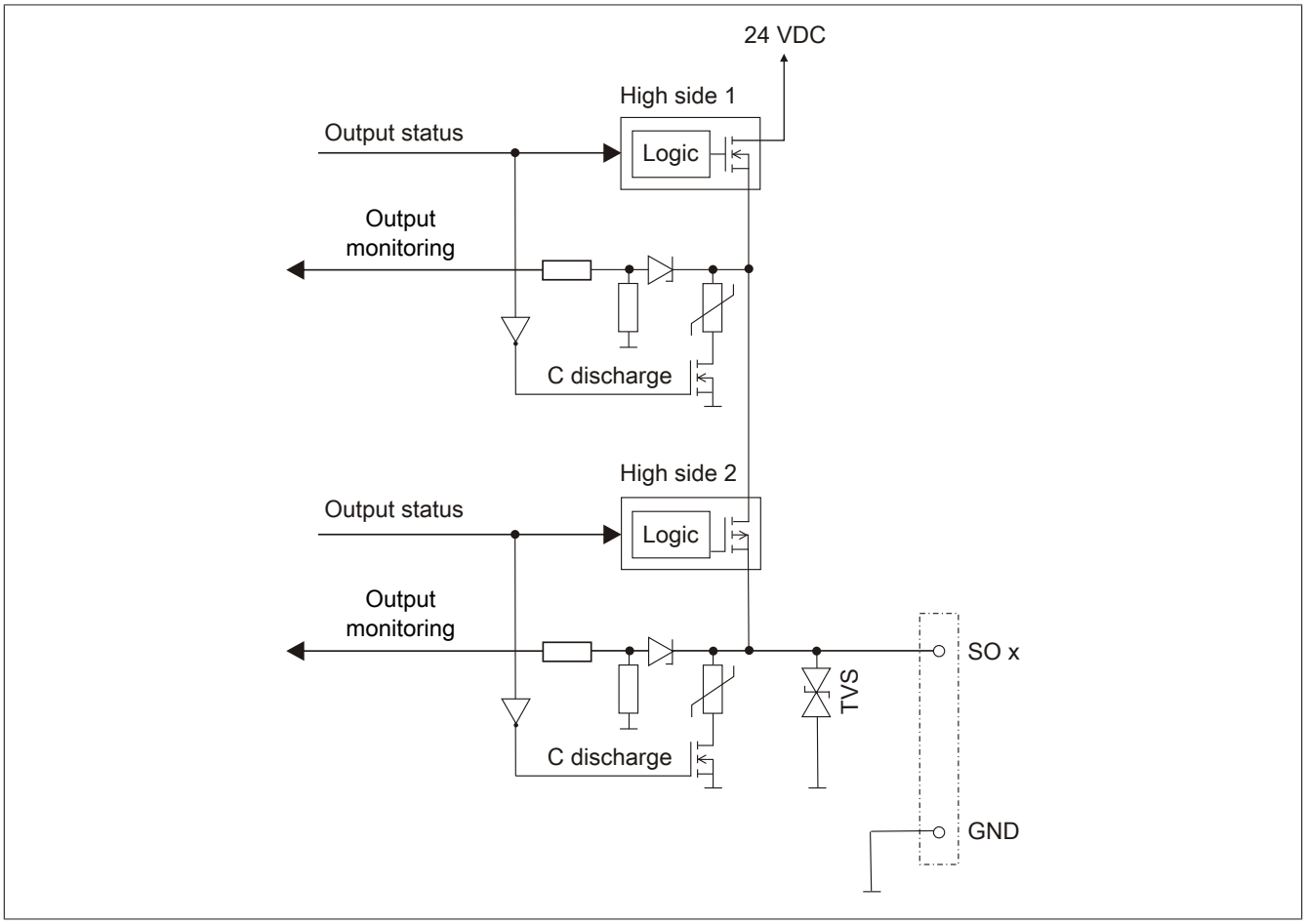


Figure 14: Type B output circuit diagram

11 Minimum cycle time

The minimum cycle time specifies the time up to which the bus cycle can be reduced without communication errors occurring.

Minimum cycle time
200 µs

12 I/O update time

The time needed by the module to generate a sample is specified by the I/O update time.

Minimum I/O update time
500 µs

Maximum I/O update time for input channels
2150 µs + Filter time (see chapter "Filter")

Maximum I/O update time for output channels
1800 µs

13 Filter

All safe digital input modules are equipped with separately configurable switch-on and switch-off filters. The functionality of the filters depends on the firmware version and is illustrated in the following table and figures:

Module type	Version	TOFF filter diagram	Filter time to be considered in addition to the total response time
I/O modules	<301	Diagram 1	2x TOFF filter time
SafeLOGIC-X	301, 311, 312	Diagram 1	2x TOFF filter time
I/O modules	≥301	Diagram 2	1x TOFF filter time
SafeLOGIC-X	302, ≥313	Diagram 2	1x TOFF filter time

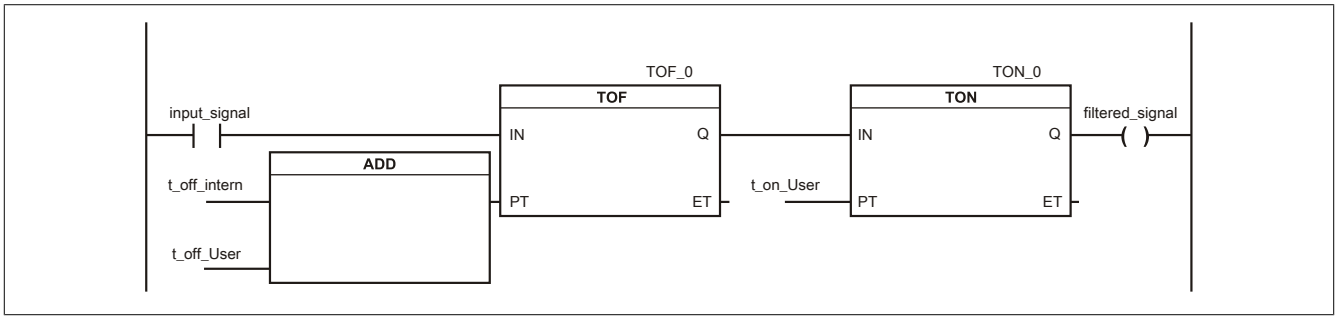


Figure 15: SI input filter - Diagram 1

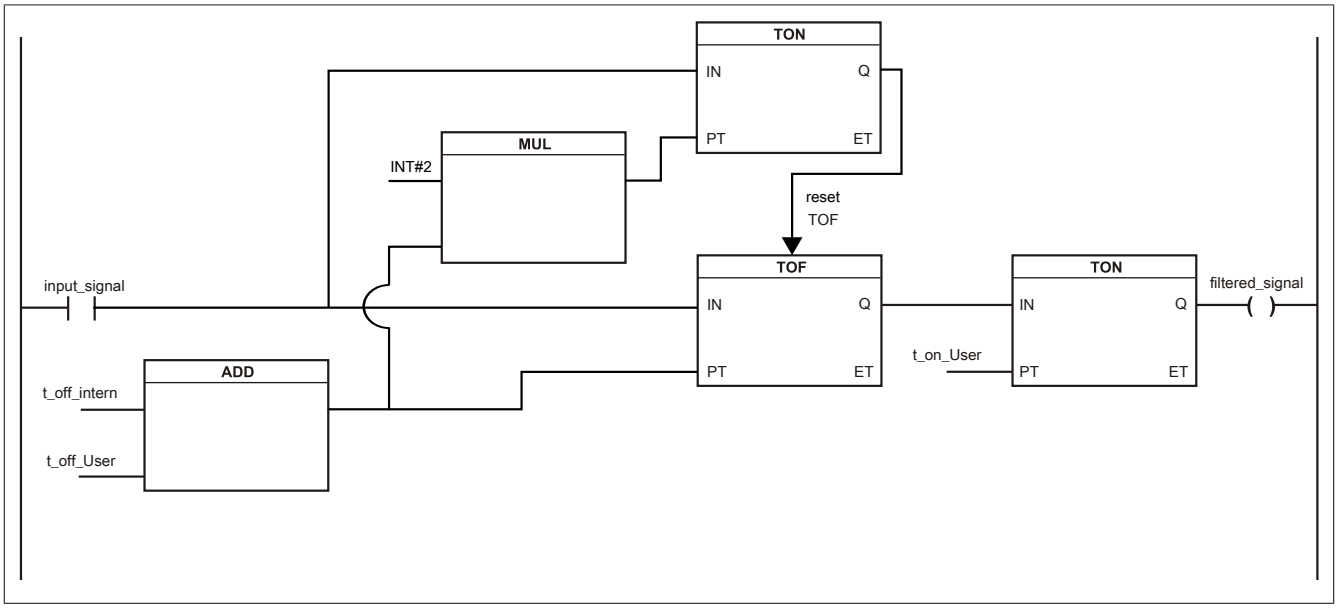


Figure 16: SI input filter - Diagram 2

Key:

- input_signal: Status of the input channel
- filtered_signal: Filtered status of the input channel. This is used as an input for the PLCopen function block and forwarded to the SafeLOGIC controller
- t_off_intern: Internal parameter (5 ms) for suppressing "external" test pulses (only with "Pulse Mode = External")
- t_off_User: Parameter for the switch-off filter
- t_on_User: Parameter for the switch-on filter

Unfiltered

The input state is collected with a fixed offset to the network cycle and transferred.

Switch-on filter

When switching from 0 to 1, the filtered status is collected with a fixed offset to the network cycle and transferred. The filter value can be configured (limit values are listed in the technical data).

Danger!

Errors that result from cross faults to other signals are detected by the module within the error detection time at the latest. By default, the switch-on filter is set to the error detection time value, which filters out faulty signals caused by possible cross faults. If the switch-on filter is set to a value smaller than the error detection time, faulty signals can cause temporary switch-on pulses to occur.

Information:

The actual effective filter depends on the I/O cycle time of the module. The actual effective filter can therefore deviate below the input value by the I/O cycle time (see the technical data for the module). If filter times are set less than the I/O cycle time of the module, no filter is effective.

Switch-off filter

When switching from 1 to 0, the filtered status is collected with a fixed offset to the network cycle and transferred. The switch-off filter can be configured separately. This makes it possible to use the switch-off filter in actual applications (e.g. testing gaps of the light curtain) and to shorten response times. The filter value can be configured (limit values are listed in the technical data).

Danger!

Configuring a switch-off filter lengthens the safety response time!
The configured filter value must be added to the total response time once or twice depending on the firmware version (for details, see the chapter "Filters" in the technical data sheet).
Configuring a switch-off filter causes signals with a low phase shorter than the switch-off filter to be filtered out. If this results in a problem concerning safety functionality, then the switch-off filter must be set to 0.
To minimize the effect of EMC interference, the max. line lengths between the pulse output and input specified in the technical data must be taken into account.
When connecting devices with OSSD signals (signals with test pulses), you must select a switch-off filter in each case that is substantially smaller than the repeat rate of the test pulses.

Information:

The actual effective filter depends on the I/O cycle time of the module. The actual effective filter can therefore deviate below the input value by the I/O cycle time (see the technical data for the module). If filter times are set less than the I/O cycle time of the module, no filter is effective.

Danger!

If "Pulse Mode = External" is used in the channel configuration, then an additional TOFF filter with 5 ms is enabled in the module. The corresponding information regarding the TOFF filter must also be considered when using the "Pulse Mode = External" setting.

14 Enabling principle

Each output channel has an additional standard switching signal that can be used to access the output channel from the standard application. As soon as the output channel has been enabled from a safety-related point of view (the setting of the channel is enabled from the point of view of the safety technology), the output channel can be set or cleared in the standard application independently of the additional safety-related runtime and jitter times.

Use of the enabling principle is specified in the I/O configuration in Automation Studio.

15 Restart behavior

Each digital input channel is not equipped with an internal restart interlock, which means that the associated channel data reverts back to the proper state automatically after an error situation on the module and/or network.
It is the responsibility of the user to connect the channel data of the safe input channels correctly and to provide them with a restart interlock. The restart interlocks of PLCopen function blocks can be used here, for example.
Using input channels without a correctly connected restart interlock can result in an automatic restart.

Each output channel is equipped with an internal restart interlock, which means that the following sequence must be followed in order to switch on a channel after an error situation on the module/network and/or after ending the safety function:

- Correct all module, channel or communication errors.
- Enable the safety-related signal for this channel (SafeOutput, etc.).
- Pause to ensure that the safety-related signal has been processed on the module (min. 1 network cycle).
- Positive edge on the release channel

For switching the release signal, the notes for manual reset function in EN ISO 13849-1:2015 must be observed.

The restart interlock functions independently of the enabling principle, which means that the behavior described above is not influenced by the parameter settings for the enabling principle or by the chronological position of the functional switching signal.

An automatic restart of the module can be configured by setting parameters. With this function, the output channel can be enabled using safety technology without an additional signal edge on the release channel. This function remains active as long as the release signal is TRUE and there is no error situation on the module/network.

Regardless of this parameter, a positive edge is required on the release channel for enabling the output channel in the following situations:

- After switching on
- After correcting an error on the safe communication channel
- After correcting a channel error
- After the release signal drops out

The automatic restart is configured in SafeDESIGNER using the channel parameters. If using an automatic restart, note the information in EN ISO 13849-1:2015.

Danger!

Configuring an automatic restart can result in critical safety conditions. Take additional measures to ensure proper safety-related functionality.

16 Register description

16.1 Parameters in the I/O configuration

Group: Function model

Parameter	Description	Default value	Unit
Function model	This parameter is reserved for future functional expansions.	Default	-

Table 14: I/O configuration parameters: Function model

Group: General

Parameter	Description	Default value	Unit
Module supervised	System behavior when a module is missing	On	-
	Parameter value / **Description** On: A missing module triggers service mode. Off: A missing module is ignored.		
Module information (up to AS 3.0.90)	This parameter enables/disables the module-specific information in the I/O mapping: • SerialNumber • ModuleID • HardwareVariant • FirmwareVersion	Off	-
Blackout mode (hardware upgrade 1.10.0.6 or later)	This parameter enables blackout mode (see section Blackout mode in Automation Help under: Hardware → X20 system → Additional information → Blackout mode).	Off	-
	Parameter value / **Description** On: Blackout mode is enabled. Off: Blackout mode is disabled.		
Channel status information	This parameter enables/disables the channel-specific status information in the I/O mapping.	On	-
State number of 2-channel evaluation	This parameter enables/disables the status information of dual-channel evaluation.	Off	-
Restart inhibit state numbers	This parameter enables/disables restart interlock status information.	Off	-
SafeLOGIC ID	In applications with multiple SafeLOGIC controllers, this parameter defines the module's association with a particular SafeLOGIC controller. • Permissible values: 1 to 1024	Assigned automatically	-
SafeMODULE ID	Unique safety address of the module • Permissible values: 2 to 1023	Assigned automatically	-
Max switching frequency channel x (up to firmware version < 300)	Maximum switching frequency of the output channel. • Permissible values: 1 Hz, 10 Hz, 100 Hz, 1000 Hz This value specifies the max. switching frequency of the actuator connected to the output. It is especially important to adjust this parameter to the actual conditions for inductive or capacitive loads because the internal delay for checking the voltage to see if it is 0 V after a cutoff signal occurs is calculated using this parameter. Therefore, if this value is too high (e.g. 1000 Hz) and the voltage does not go to 0 within the corresponding time (in this example 500 µs) after a cutoff signal because of the connected actuator, then a channel error occurs. If the output is controlled by the application using a higher switching frequency than configured, a channel-specific error may erroneously be detected on the module, which causes the channel to be cut off.	1	Hz

Table 15: I/O configuration parameters: General

Group: Output signal path

Parameter	Description	Default value	Unit
DigitalOutputxx	This parameter specifies the mode that can be used by the standard application to access the output channel.	Direct	-
	Parameter value / **Description** Direct: The output channel can be accessed directly by the standard application. Signals "DigitalOutputxx" are available in the I/O mapping accordingly. Via SafeLOGIC: The output channel cannot be accessed directly by the standard application. Signals "DigitalOutputxx" are not available in the I/O mapping accordingly. It is only possible for the standard application to influence the output channel via the communication channels from the CPU to the SafeLOGIC controller.		

Table 16: I/O configuration parameters: Output signal path

16.2 Parameters in SafeDESIGNER - up to Release 1.9

Group: Basic

<table>
<tr><th>Parameter</th><th>Description</th><th>Default value</th><th>Unit</th></tr>
<tr><td>Min_required_FW_Rev</td><td>This parameter is reserved for future functional expansions.</td><td>Basic Release</td><td>-</td></tr>
<tr><td>Optional</td><td>This parameter can be used to configure the module as "optional". Optional modules do not have to be present, i.e. the SafeLOGIC controller will not indicate that these modules are not present. However, this parameter does not influence the module's signal or status data.</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>No</td><td>This module is mandatory for the application.

The module must be in OPERATIONAL mode after startup, and safe communication to the SafeLOGIC controller must be established without errors (SafeModuleOK = SAFETRUE). Processing of the safety application on the SafeLOGIC controller is delayed after startup until this state is achieved for all modules with "Optional = No".

After startup, module problems are indicated by a quickly blinking "MXCHG" LED on the SafeLOGIC controller. An entry is also made in the logbook.</td></tr>
<tr><td>Yes</td><td>The module is not required for the application.

The module is not taken into account during startup, which means the safety application is started regardless of whether the modules with "Optional = Yes" are in OPERATIONAL mode or if safe communication is properly established between these modules and the SafeLOGIC controller.

After startup, module problems are NOT indicated by a quickly blinking "MXCHG" LED on the SafeLOGIC controller. An entry is NOT made in the logbook.</td></tr>
<tr><td>Startup</td><td>This module is optional. The system determines how the module will proceed during startup.

If it is determined that the module is physically present during startup (regardless of whether it is in OPERATIONAL mode or not), then the module behaves as if "Optional = No" is set.

If it is determined that the module is not physically present during startup, then the module behaves as if "Optional = Yes" is set.</td></tr>
<tr><td>Not_Present
(Release 1.9 and later)</td><td>The module is not required for the application.

The module is ignored during startup, which means the safety application is started regardless of whether the modules with "Optional = Not_Present" are physically present.

Unlike when "Optional = Yes" is configured, the module is not started with "Optional = Not_Present", which optimizes system startup behavior.

After startup, module problems are NOT indicated by a quickly blinking "MXCHG" LED on the SafeLOGIC controller. An entry is NOT made in the logbook.</td></tr>
</table></td></tr>
<tr><td>External_UDID</td><td>This parameter enables the option on the module for the expected UDID to be specified externally by the CPU.</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-ATTENTION</td><td>The UDID is determined by the CPU. The SafeLOGIC controller must be restarted if the UDID is changed.</td></tr>
<tr><td>No</td><td>The UDID is specified by a teach-in procedure during startup.</td></tr>
</table></td></tr>
<tr><td>Disable_OSSD</td><td>This parameter can be used to switch off automatic testing of the output driver for all of the module's channels.</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-ATTENTION</td><td>Automatic testing of the output driver is switched off.</td></tr>
<tr><td>No</td><td>Automatic testing of the output driver is enabled.</td></tr>
</table></td></tr>
</table>

Table 17: SafeDESIGNER parameters: Basic

Danger!

If function "External_UDID = Yes-ATTENTION" is used, incorrect specifications from the CPU can lead to safety-critical situations.
Perform an FMEA (Failure Mode and Effects Analysis) in order to detect these situations and implement additional safety measures to handle them.

Danger!

With "Disable_OSSD = Yes-ATTENTION", the module has reduced error detection capabilities and no longer meets the requirements for SIL 3 per EN 62061:2010 or PL e per EN ISO 13849-1:2015.

In order to meet the requirements for applications up to SIL 2 per EN 62061:2010 or PL d per EN ISO 13849-1:2015, a daily check of the safety function by the user is necessary.

Group: Safety_Response_Time

<table>
<tr><th>Parameter</th><th>Description</th><th>Default value</th><th>Unit</th></tr>
<tr><td>Manual_Configuration</td><td>This parameter makes it possible to manually and individually configure the safety response time for the module.

The parameters for the safety response time are generally set in the same way for all stations involved in the application. For this reason, these parameters are configured for the SafeLOGIC controller in SafeDESIGNER. For application situations in which individual safety functions require optimal response time behavior, the parameters for the safety response time can be configured individually on the respective module.</td><td>No</td><td>-</td></tr>
<tr><td></td><td colspan="3"><table><tr><th>Parameter value</th><th>Description</th></tr><tr><td>Yes</td><td>Data from the module's "Safety_Response_Time" group is used to calculate the safety response time for the module's signals.</td></tr><tr><td>No</td><td>The parameters for the safety response time are taken from the "Safety_Response_Time" group on the SafeLOGIC controller.</td></tr></table></td></tr>
<tr><td>Synchronous_Network_Only</td><td>This parameter describes the synchronization characteristics of the network being used. They are defined in Automation Studio / Automation Runtime.</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 safety response time, networks must be synchronous and their cycle times must either be the same or an integer ratio of the cycle times.</td></tr><tr><td>No</td><td>No requirement for synchronization of the networks</td></tr></table></td></tr>
<tr><td>Max_X2X_CycleTime_us</td><td>This parameter specifies the maximum X2X cycle time used to calculate the safety response time.
• Permissible values: 200 to 25,000 µs (corresponds to 0.2 to 25 ms)</td><td>5000</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 safety response time.
• Permissible values: 200 to 25,000 µs (corresponds to 0.2 to 25 ms)</td><td>5000</td><td>µs</td></tr>
<tr><td>Max_CPU_CrossLinkTask_
CycleTime_us</td><td>This parameter specifies the maximum cycle time for the copy task on the CPU used to calculate the safety response time. The value 0 indicates that a copy task is not included for the response time.
• Permissible values: 0 to 25,000 µs (corresponds to 0 to 25 ms)</td><td>5000</td><td>µs</td></tr>
<tr><td>Min_X2X_CycleTime_us</td><td>This parameter specifies the minimum X2X cycle time used to calculate the safety response time.
• Permissible values: 200 to 25,000 µs (corresponds to 0.2 to 25 ms)</td><td>200</td><td>µs</td></tr>
<tr><td>Min_Powerlink_CycleTime_us</td><td>This parameter specifies the minimum POWERLINK cycle time used to calculate the safety response time.
• Permissible values: 200 to 25,000 µs (corresponds to 0.2 to 25 ms)</td><td>200</td><td>µs</td></tr>
<tr><td>Min_CPU_CrossLinkTask_
CycleTime_us</td><td>This parameter specifies the minimum cycle time for the copy task on the CPU used to calculate the safety response time. The value 0 indicates that configurations without a copy task are also included for the response time.
• Permissible values: 0 to 25,000 µs (corresponds to 0 to 25 ms)</td><td>0</td><td>µs</td></tr>
<tr><td>Worst_Case_Response_Time_us</td><td>This parameter specifies the limit value for monitoring the safety response time.
• Permissible values: 3000 to 5,000,000 µs (corresponds to 3 ms to 5 s)</td><td>50000</td><td>µs</td></tr>
<tr><td>Node_Guarding_Lifetime</td><td>This parameter specifies the maximum number of attempts to be made during the time set with parameter "Node_Guarding_Timeout_s". The purpose of these attempts is to ensure that the module is available.
• Permissible values: 1 to 255
Note
• The larger the configured value, the greater the amount of asynchronous data traffic.
• This setting is not critical to safety functionality. The time for safely cutting off actuators is determined independently using parameter "Worst_Case_Response_Time_us".</td><td>5</td><td>-</td></tr>
</table>

Table 18: SafeDESIGNER parameters: Safety_Response_Time

Group: SafeDigitalInputxx

<table>
<tr><th>Parameter</th><th>Description</th><th>Default value</th><th>Unit</th></tr>
<tr><td>Pulse_Source</td><td>This parameter can be used to specify the pulse source for the input channel.

<table>
<tr><th></th><th colspan="6">Possible "Pulse_Source"</th></tr>
<tr><th>Channel</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th></tr>
<tr><td>1</td><td>Default</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>2</td><td>Channel 1</td><td>Default</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>3</td><td>Channel 1</td><td>-</td><td>Default</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>4</td><td>Channel 1</td><td>-</td><td>Channel 3</td><td>Default</td><td>-</td><td>-</td></tr>
<tr><td>5</td><td>Channel 1</td><td>-</td><td>-</td><td>-</td><td>Default</td><td>-</td></tr>
<tr><td>6</td><td>Channel 1</td><td>-</td><td>-</td><td>-</td><td>Channel 5</td><td>Default</td></tr>
</table>
Note:
If a value other than "Default" is set for "Pulse_Source", then parameter "Pulse_Mode" must be set to "Internal" on the respective channel of the selected "Pulse_Source".</td><td>Default</td><td>-</td></tr>
<tr><td>Pulse_Mode</td><td>This parameter can be used to specify the pulse mode for the input channel.

<table>
<tr><th>Parameter value</th><th>Description</th></tr>
<tr><td>Internal</td><td>The channel works exclusively with the pulse output that is set for "Pulse_Source".</td></tr>
<tr><td>No Pulse</td><td>The pulse check on the channel is disabled. Potential low phases of the signal must be removed using the switch-off filter in order to prevent unintended cutoff.</td></tr>
</table></td><td>Internal</td><td>-</td></tr>
<tr><td>Filter_Off_us</td><td>Switch-off filter for the channel to remove potentially disruptive signal "low phases".
• Permissible values: 0 to 500,000 µs (corresponds to 0 to 0.5 s)</td><td>0</td><td>µs</td></tr>
<tr><td>Filter_On_us</td><td>Switch-on filter for the channel that can be used to "debounce" the signals. This function also makes it possible for the module to lengthen a switch-off signal that would otherwise be too short.
• Permissible values: 0 to 500,000 µs (corresponds to 0 to 0.5 s)</td><td>200000</td><td>µs</td></tr>
<tr><td>Discrepancy_Time_us</td><td>Parameter only available for odd-numbered channels.
This parameter specifies the maximum time for the "Dual-channel evaluation" function during which the state of both physical individual channels is permitted to be undefined without triggering an error.
• Permissible values: 0 to 10,000,000 µs (corresponds to 0 to 10 s)</td><td>0</td><td>µs</td></tr>
</table>

Table 19: SafeDESIGNER parameters: SafeDigitalInputxx

Danger!

Configuring a switch-off filter lengthens the safety response time!

Danger!

Signals with a low phase shorter than the safety response time can potentially be lost. Such signals should be lengthened accordingly using the "switch-on filter" function on the input module.

Danger!

Configuring a switch-off filter causes signals with a low phase shorter than the switch-off filter to be filtered out. If this results in a problem concerning safety functionality, then the switch-off filter must be set to 0. Lengthening the low phase with a switch-on filter is not possible in these cases.

Group: SafeDigitalOutputxx, SafeDigitalOutputxxyy

Parameter	Description	Default value	Unit
Auto_Restart	This parameter can be used to configure an automatic restart on the module (see section "Restart behavior").	No	-

Parameter value	Description
Yes-ATTENTION	"Automatic restart" function is activated.
No	"Automatic restart" function is not activated.

Table 20: SafeDESIGNER parameters: SafeDigitalOutputxx, SafeDigitalOutputxxyy

Danger!

Configuring an automatic restart can result in critical safety conditions. Take additional measures to ensure proper safety-related functionality.

16.3 Parameters in SafeDESIGNER - Release 1.10 and later

Group: Basic

Parameter	Description	Default value	Unit
Min required FW Rev	This parameter is reserved for future functional expansions.	Basic Release	-
Optional	This parameter can be used to configure the module as "optional". Optional modules do not have to be present, i.e. the SafeLOGIC controller will not indicate that these modules are not present. However, this parameter does not influence the module's signal or status data.	No	-

Parameter value	Description
No	This module is absolutely necessary for the application. The module must be in OPERATIONAL mode after startup, and safe communication to the SafeLOGIC controller must be established without errors (SafeModuleOK = SAFETRUE). Processing of the safety application on the SafeLOGIC controller is delayed after startup until this state is achieved for all modules with "Optional = No". After startup, module problems are indicated by a quickly blinking "MXCHG" LED on the SafeLOGIC controller. An entry is also made in the logbook.
Yes	This module is not necessary for the application. The module is not taken into account during startup, which means the safety application is started regardless of whether the modules with "Optional = Yes" are in OPERATIONAL mode or if safe communication is properly established between these modules and the SafeLOGIC controller. After startup, module problems are NOT indicated by a quickly blinking "MXCHG" LED on the SafeLOGIC controller. An entry is NOT made in the logbook.
Startup	This module is optional. The system determines how the module will proceed during startup. If it is determined that the module is physically present during startup (regardless of whether it is in OPERATIONAL mode or not), then the module behaves as if "Optional = No" is set. If it is determined that the module is not physically present during startup, then the module behaves as if "Optional = Yes" is set.
NotPresent	This module is not necessary for the application. The module is ignored during startup, which means the safety application is started regardless of whether the modules with "Optional = NotPresent" are physically present. Unlike when "Optional = Yes" is configured, the module is not started with "Optional = NotPresent", which optimizes system startup behavior. After startup, module problems are NOT indicated by a quickly blinking "MXCHG" LED on the SafeLOGIC controller. An entry is NOT made in the logbook.

External UDID	This parameter enables the option on the module for the expected UDID to be specified externally by the CPU.	No	-

Parameter value	Description
Yes-ATTENTION	The UDID is determined by the CPU. The SafeLOGIC controller must be restarted if the UDID is changed.
No	The UDID is specified by a teach-in procedure during startup.

Table 21: SafeDESIGNER parameters: Basic

Danger!

If function "External UDID = Yes-ATTENTION" is used, incorrect specifications from the CPU can lead to safety-critical situations.
Perform an FMEA (Failure Mode and Effects Analysis) in order to detect these situations and implement additional safety measures to handle them.

Group: Safety Response Time

Parameter	Description	Default value	Unit
Manual Configuration	This parameter makes it possible to manually and individually configure the safety response time for the module. The parameters for the safety response time are generally set in the same way for all stations involved in the application. For this reason, these parameters are configured for the SafeLOGIC controller in SafeDESIGNER. For application situations in which individual safety functions require optimal response time behavior, the parameters for the safety response time can be configured individually on the respective module.	No	-
	Parameter value / **Description** Yes: Data from the module's "Safety Response Time" group is used to calculate the safety response time for the module's signals. No: The parameters for the safety response time are taken from the "Safety Response Time" group on the SafeLOGIC controller.		
Safe Data Duration	This parameter specifies the maximum permissible data transmission time between the SafeLOGIC controller and SafeIO module. For more information about the actual data transmission time, see section Diagnostics and service → Diagnostics tools → Network analyzer → Editor → Calculation of safety runtime of Automation Help. The cycle time of the safety application must also be added. • Permissible values: 2000 to 10,000,000 µs (corresponds to 2 ms to 10 s)	20000	µs
Additional Tolerated Packet Loss	This parameter specifies the number of additional tolerated lost packets during data transfer. • Permissible values: 0 to 10	0	Packets
Packets per Node Guarding	This parameter specifies the maximum number of packets used for node guarding. • Permissible values: 1 to 255 **Note** • The larger the configured value, the greater the amount of asynchronous data traffic. • This setting is not critical to safety functionality. The time for safely cutting off actuators is determined independently of this.	5	Packets

Table 22: SafeDESIGNER parameters: Safety Response Time

Group: Module Configuration

Parameter	Description	Default value	Unit
Disable OSSD	This parameter can be used to switch off automatic testing of the output driver for all of the module's channels.	No	-
	Parameter value / **Description** Yes-ATTENTION: Automatic testing of the output driver is switched off. No: Automatic testing of the output driver is enabled.		

Table 23: SafeDESIGNER parameters: Module Configuration

Danger!

With "Disable OSSD = Yes-ATTENTION", the module has reduced error detection capabilities and no longer meets the requirements for SIL 3 per EN 62061:2013 or PL e per EN ISO 13849-1:2015.

In order to meet the requirements for applications up to SIL 2 per EN 62061:2013 or PL d per EN ISO 13849-1:2015, the user must check the safety function on a daily basis when using type B output channels.
For type B2 output channels, it is also important to ensure that all of the module's output channels are simultaneously in a switched-off state for at least 1 s during this test.

On X20SRTxxx modules, each output channel being used must be checked before the first safety request and every 24 hours. For this check, the corresponding channel must be switched on and off at least once.

Group: SafeDigitalInputxx

<table>
<tr><th>Parameter</th><th>Description</th><th>Default value</th><th>Unit</th></tr>
<tr><td>Pulse Source</td><td>This parameter can be used to specify the pulse source for the input channel.

<table>
<tr><th></th><th colspan="6">Possible "Pulse Source"</th></tr>
<tr><th>Channel</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th></tr>
<tr><td>1</td><td>Default</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>2</td><td>Channel 1</td><td>Default</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>3</td><td>Channel 1</td><td>-</td><td>Default</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>4</td><td>Channel 1</td><td>-</td><td>Channel 3</td><td>Default</td><td>-</td><td>-</td></tr>
<tr><td>5</td><td>Channel 1</td><td>-</td><td>-</td><td>-</td><td>Default</td><td>-</td></tr>
<tr><td>6</td><td>Channel 1</td><td>-</td><td>-</td><td>-</td><td>Channel 5</td><td>Default</td></tr>
</table>
Note:
If a value other than "Default" is set for "Pulse Source", then the "Pulse Mode" parameter must be set to "Internal" on the respective channel of the selected "Pulse Source".</td><td>Default</td><td>-</td></tr>
<tr><td>Pulse Mode</td><td>This parameter can be used to specify the pulse mode for the input channel.

<table>
<tr><th>Parameter value</th><th>Description</th></tr>
<tr><td>Internal</td><td>The channel works exclusively with the pulse output that is configured for "Pulse Source".</td></tr>
<tr><td>No Pulse</td><td>The pulse check on the channel is disabled. Potential low phases of the signal must be removed using the switch-off filter in order to prevent unintended cutoff.</td></tr>
</table></td><td>Internal</td><td>-</td></tr>
<tr><td>Filter Off</td><td>Switch-off filter for the channel to remove potentially disruptive signal "low phases".
• Permissible values: 0 to 500,000 µs (corresponds to 0 to 0.5 s)</td><td>0</td><td>µs</td></tr>
<tr><td>Filter On</td><td>Switch-on filter for the channel that can be used to "debounce" the signals. This function also makes it possible for the module to lengthen a switch-off signal that would otherwise be too short.
• Permissible values: 0 to 500,000 µs (corresponds to 0 to 0.5 s)</td><td>200000</td><td>µs</td></tr>
<tr><td>Discrepancy Time</td><td>Parameter only available for odd-numbered channels.
This parameter specifies the maximum time for "dual-channel evaluation", during which the status of both physical individual channels can remain undefined without triggering an error.
• Permissible values: 0 to 10,000,000 µs (corresponds to 0 to 10 s)</td><td>50000</td><td>µs</td></tr>
</table>

Table 24: SafeDESIGNER parameters: SafeDigitalInputxx

Danger!

Configuring a switch-off filter lengthens the safety response time!
The configured filter value must be added to the total response time.

Danger!

Signals with a low phase shorter than the safety response time can potentially be lost. Such signals should be lengthened accordingly using the "switch-on filter" function on the input module.

Danger!

Configuring a switch-off filter causes signals with a low phase shorter than the switch-off filter to be filtered out. If this results in a problem concerning safety functionality, then the switch-off filter must be set to 0. Lengthening the low phase with a switch-on filter is not possible in these cases.

Group: SafeDigitalOutputxx

Parameter	Description	Default value	Unit
Auto Restart	This parameter can be used to configure an automatic restart on the module (see section "Restart behavior").	No	-

Parameter value	Description
Yes-ATTENTION	"Automatic restart" function is activated.
No	"Automatic restart" function is not activated.

Table 25: SafeDESIGNER parameters: SafeDigitalOutputxx

Danger!

Configuring an automatic restart can result in critical safety conditions. Take additional measures to ensure proper safety-related functionality.

16.4 Channel list

<table>
<tr><th>Channel name</th><th>Access via Automation Studio</th><th>Access via SafeDESIGNER</th><th>Data type</th><th>Description</th></tr>
<tr><td>ModuleOk</td><td>Read</td><td>-</td><td>BOOL</td><td>Indicates if the module is OK</td></tr>
<tr><td>SerialNumber</td><td>Read</td><td>-</td><td>UDINT</td><td>Module serial number</td></tr>
<tr><td>ModuleID</td><td>Read</td><td>-</td><td>UINT</td><td>Module ID</td></tr>
<tr><td>HardwareVariant</td><td>Read</td><td>-</td><td>UINT</td><td>Hardware variant</td></tr>
<tr><td>FirmwareVersion</td><td>Read</td><td>-</td><td>UINT</td><td>Firmware version of the module</td></tr>
<tr><td>UDID_low</td><td>(Read) 1)</td><td>-</td><td>UDINT</td><td>UDID, lower 4 bytes</td></tr>
<tr><td>UDID_high</td><td>(Read) 1)</td><td>-</td><td>UINT</td><td>UDID, upper 2 bytes</td></tr>
<tr><td>SafetyFWversion1</td><td>(Read) 1)</td><td>-</td><td>UINT</td><td>Firmware version - Safety processor 1</td></tr>
<tr><td>SafetyFWversion2</td><td>(Read) 1)</td><td>-</td><td>UINT</td><td>Firmware version - Safety processor 2</td></tr>
<tr><td>SafetyFWcrc1
(hardware upgrade 1.10.1.0 or later)</td><td>(Read) 1)</td><td>-</td><td>UINT</td><td>CRC of firmware header on safety processor 1</td></tr>
<tr><td>SafetyFWcrc2
(hardware upgrade 1.10.1.0 or later)</td><td>(Read) 1)</td><td>-</td><td>UINT</td><td>CRC of firmware header on safety processor 2</td></tr>
<tr><td>Bootstate
(hardware upgrade 1.10.1.0 or later)</td><td>(Read) 1)</td><td>-</td><td>UINT</td><td>Startup state of the module.
Notes:
Some of the boot states do not occur during normal startup or are cycled through so quickly that they are not visible externally.
The boot states usually cycle through in ascending order. There are cases, however, in which a previous value is captured.
<table>
<tr><th>Value</th><th>Description</th></tr>
<tr><td>0x0003</td><td>Startup communication processor OK, no communication to the safety processors (check 24 V supply voltage!)</td></tr>
<tr><td>0x0010</td><td>FAILSAFE. At least one of the safety processors is in the safe state.</td></tr>
<tr><td>0x0020</td><td>Internal communication to safety processors started</td></tr>
<tr><td>0x0024</td><td>Firmware update of safety processors</td></tr>
<tr><td>0x0040</td><td>Firmware of safety processors started</td></tr>
<tr><td>0x0440</td><td>Firmware of safety processors running</td></tr>
<tr><td>0x0840</td><td>Waiting for openSAFETY "Operational" (loading SafeDESIGNER application or no valid application exists, waiting on acknowledgments such as module exchange)</td></tr>
<tr><td>0x1040</td><td>Evaluating the configuration according to the SafeDESIGNER application</td></tr>
<tr><td>0x3440</td><td>Stabilizing cyclic openSAFETY data exchange.
Note:
If the boot state remains here, check SafeDESIGNER parameters "(Default) Safe Data Duration", "(Default) Additional Tolerated Packet Loss".</td></tr>
<tr><td>0x4040</td><td>RUN. Final state, startup completed.</td></tr>
</table></td></tr>
<tr><td>Diag1_Temp</td><td>(Read) 1)</td><td>-</td><td>INT</td><td>Module temperature in °C</td></tr>
<tr><td>PLCopenFBKxy_state</td><td>Read</td><td>-</td><td>USINT</td><td>State number of dual-channel evaluation (PLCopen function block "Equivalent" or "Antivalent")</td></tr>
<tr><td>InputErrorStates</td><td>(Read) 1)</td><td>-</td><td>UDINT</td><td>Channel status, additional information for channel error
<table>
<tr><th>Type of error</th></tr>
<tr><th>Inputs</th></tr>
<tr><th>Input stuck at high</th></tr>
<tr><td>Bit no. 0 to 5 = Channel 1 to 6</td></tr>
</table>
If a bit is set, the corresponding error has been detected on the respective channel.</td></tr>
<tr><td>PulseoutputErrors</td><td>(Read) 1)</td><td>-</td><td>UDINT</td><td>Channel status, additional information for channel error
<table>
<tr><th colspan="2">Type of error
Pulse outputs</th></tr>
<tr><th>Feedback stuck at high (shorted to 24 VDC)</th><th>Feedback stuck at low (ground fault)</th></tr>
<tr><td>Bit no. 8 to 13 = Channel 1 to 6</td><td>Bit no. 0 to 5 = Channel 1 to 6</td></tr>
</table>
If a bit is set, the corresponding error has been detected on the respective channel.</td></tr>
<tr><td>SafeModuleOK</td><td>-</td><td>Read</td><td>SAFEBOOL</td><td>Indicates if the safe communication channel is OK</td></tr>
</table>

Table 26: Channel list

<table>
<tr><th>Channel name</th><th>Access via Automation Studio</th><th>Access via SafeDESIGNER</th><th>Data type</th><th>Description</th></tr>
<tr><td>SafeDigitalInputxx</td><td>Read</td><td>Read</td><td>SAFEBOOL</td><td>Physical channel SI xx</td></tr>
<tr><td>SafeEquivalentInputxxyy</td><td>Read</td><td>Read</td><td>SAFEBOOL</td><td>Dual-channel evaluation of equivalent channel SI xx/yy</td></tr>
<tr><td>SafeAntivalentInputxxyy</td><td>Read</td><td>Read</td><td>SAFEBOOL</td><td>Dual-channel evaluation of antivalent channel SI xx/yy</td></tr>
<tr><td>SafeInputOKxx</td><td>Read</td><td>Read</td><td>SAFEBOOL</td><td>Status of physical channel SI xx</td></tr>
<tr><td>SafeEquivalentOKxxyy</td><td>Read</td><td>Read</td><td>SAFEBOOL</td><td>Status of dual-channel evaluation of equivalent channel SI xx/yy</td></tr>
<tr><td>SafeAntivalentOKxxyy</td><td>Read</td><td>Read</td><td>SAFEBOOL</td><td>Status of dual-channel evaluation of antivalent channel SI xx/yy</td></tr>
<tr><td>DigitalOutputxx</td><td>Write</td><td>-</td><td>BOOL</td><td>Enable signal - Channel SO xx</td></tr>
<tr><td>SafeDigitalOutputxx</td><td>-</td><td>Write</td><td>SAFEBOOL</td><td>Safe channel SO xx</td></tr>
<tr><td>SafeOutputOKxx</td><td>Read</td><td>Read</td><td>SAFEBOOL</td><td>Status of channel SO xx</td></tr>
<tr><td>ReleaseOutputxx</td><td>-</td><td>Write</td><td>BOOL</td><td>Release signal for the restart interlock of channel SO xx</td></tr>
<tr><td>PhysicalStateOutputxx</td><td>Read</td><td>Read</td><td>BOOL</td><td>Read-back value of physical channel SO xx</td></tr>
<tr><td>FBK_Status_1</td><td>Read</td><td>-</td><td>UINT</td><td>State number of the restart interlock of channel x. See "Restart interlock state diagram".
<table><tr><th>Bit 15 to 12</th><th>Bit 11 to 8</th><th>Bit 7 to 4</th><th>Bit 3 to 0</th></tr><tr><td>Reserved</td><td>Reserved</td><td>Channel 2</td><td>Channel 1</td></tr></table></td></tr>
</table>

Table 26: Channel list

1) This data is accessed in Automation Studio using the ASIOACC library.

PLCopen state diagrams "Antivalent" / "Equivalent"

The following state diagrams illustrate the effect of the "Antivalent" and "Equivalent" PLCopen function blocks integrated in the module.
The hexadecimal value in parentheses corresponds to the state number provided via the channels "PLCopenFBKxy_state" and "PLCopenFBKxxyy_state".

The following PLCopen state diagrams show the function for the "SafeAntivalentInput0102" and "SafeEquivalentInput0102" channels. The same diagrams are valid for the "SafeAntivalentInputxxyy" and "SafeEquivalentInputxxyy" channels, but "SafeDigitalInput01" and "SafeDigitalInput02" are to be replaced by the respective input.

In addition to the PLCopen specification, the SignalOK states of channels "SafeChannelOK01" and "SafeChannelOK02" are also checked.
If the SignalOK status of at least one of the two channels is not OK, the function block goes into an error state and the output signal is set to 0.
Error state "ERROR 4" is not taken from the PLCopen specification.

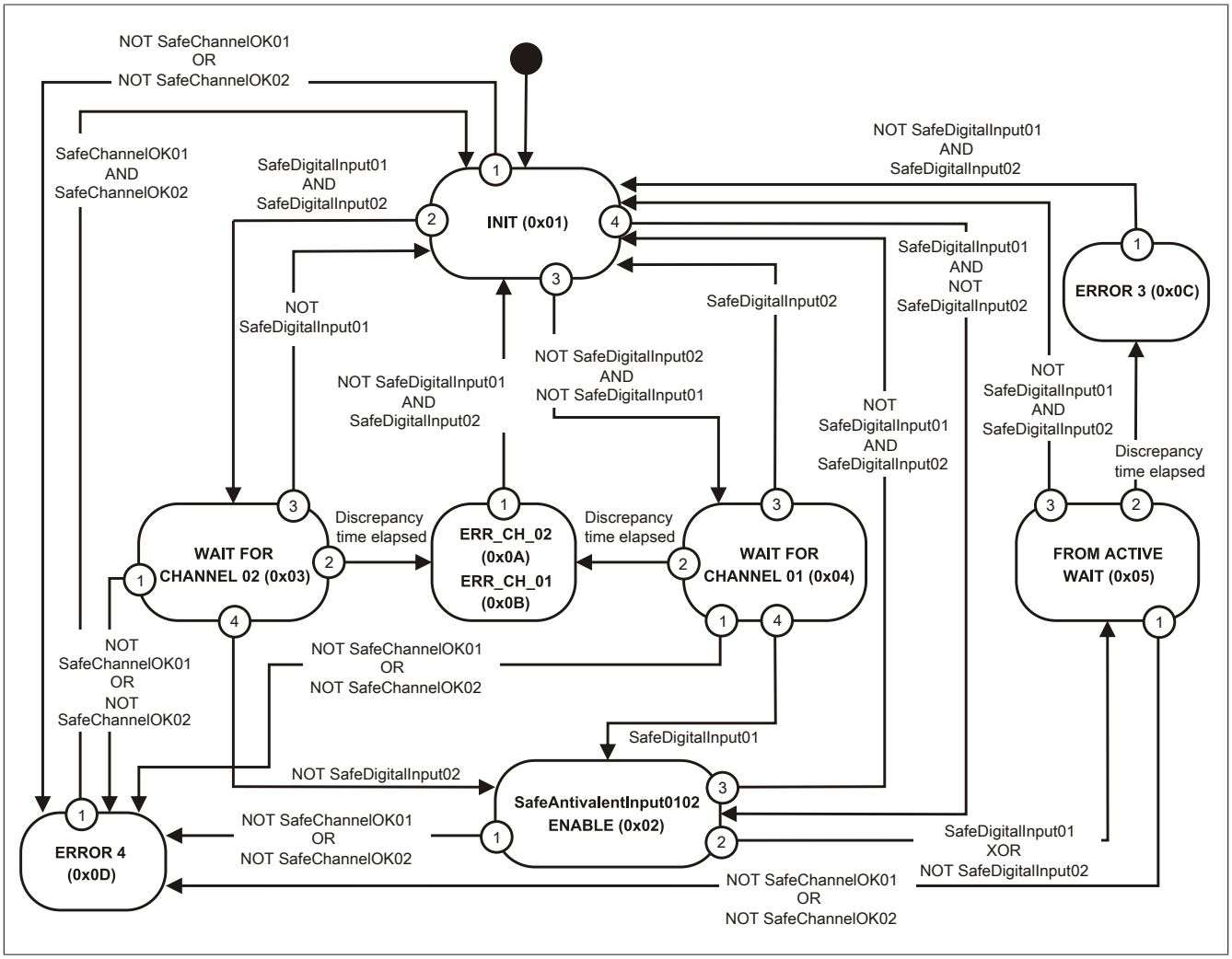


Figure 17: "Antivalent" function block - State diagram

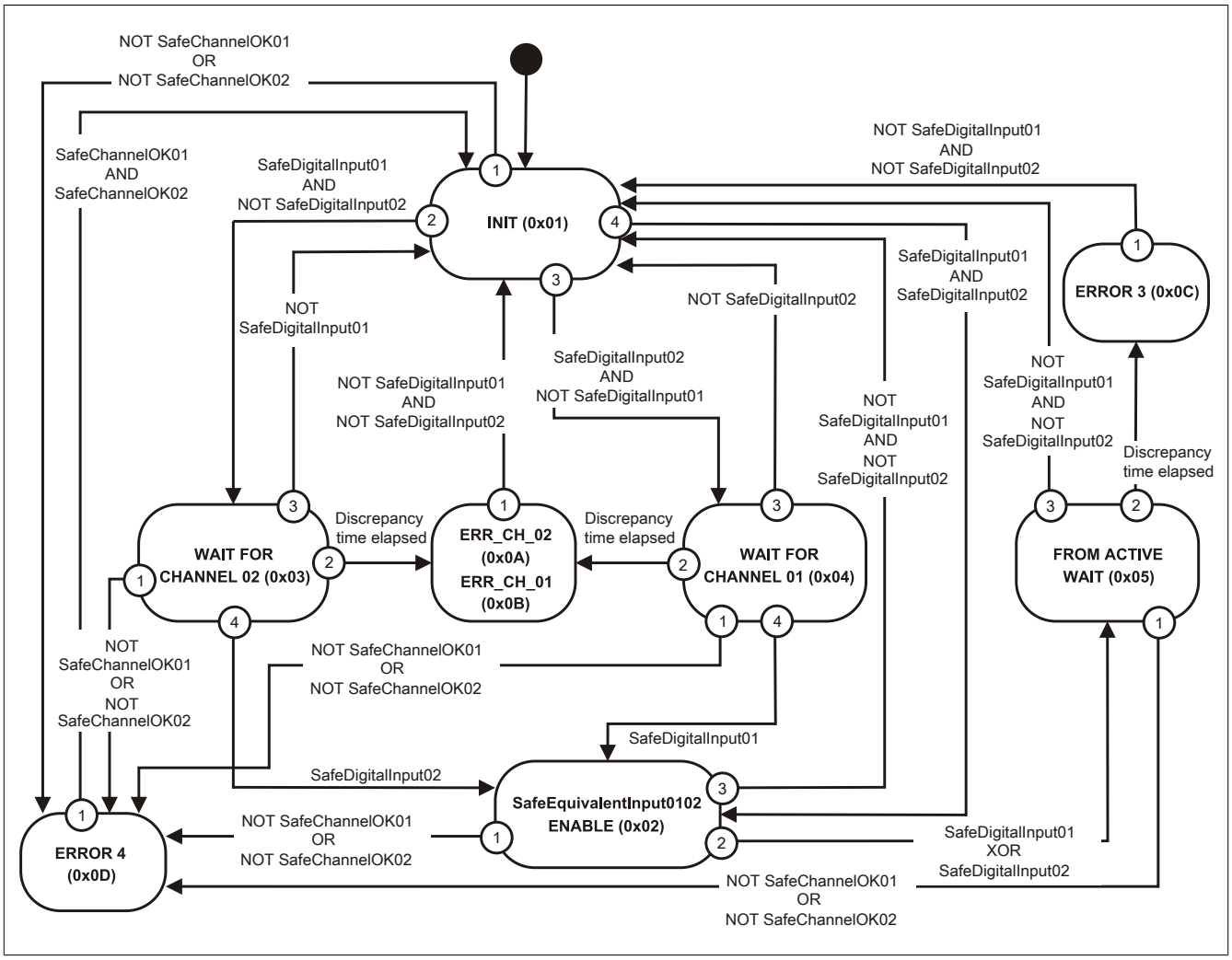


Figure 18: "Equivalent" function block - State diagram

Restart interlock state diagram

The following state diagram illustrates the effect of the restart interlock integrated in the module. The hexadecimal value in parentheses corresponds to the state number that is provided via the channel "FBK_Status_1".
For detailed information regarding restart interlock, see section "Restart behavior".

Information:

To set an output channel, a positive edge on signal "ReleaseOutput0x" is required after signal "SafeDigitalOutput0x". This edge must occur at least 1 network cycle after signal "SafeDigitalOutput0x". If this timing is not adhered to, the output channel remains inactive.

Information:

For the maximum switching frequency, see the technical data for the module.

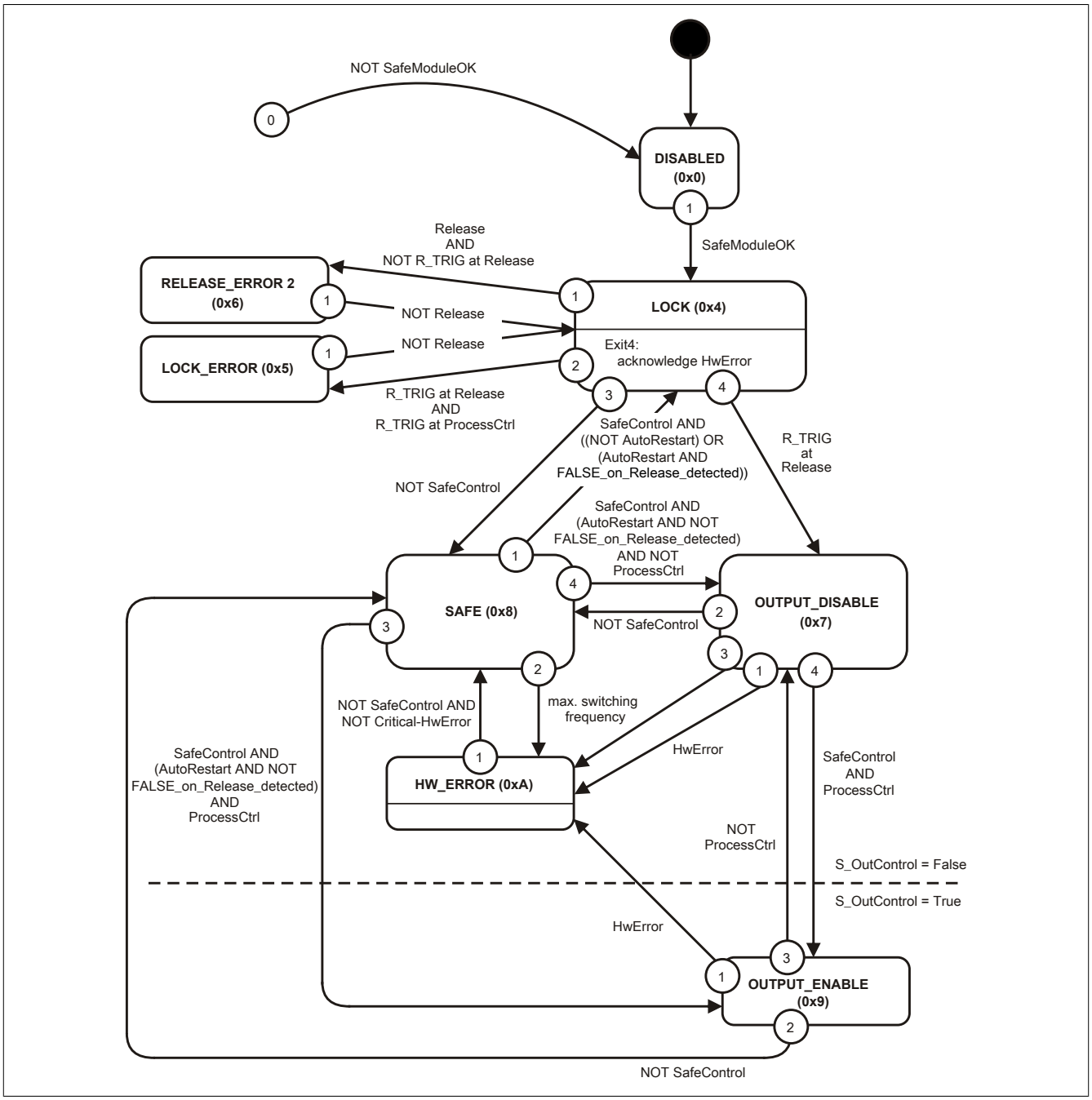


Figure 19: Restart interlock - State diagram

17 Safety response time

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

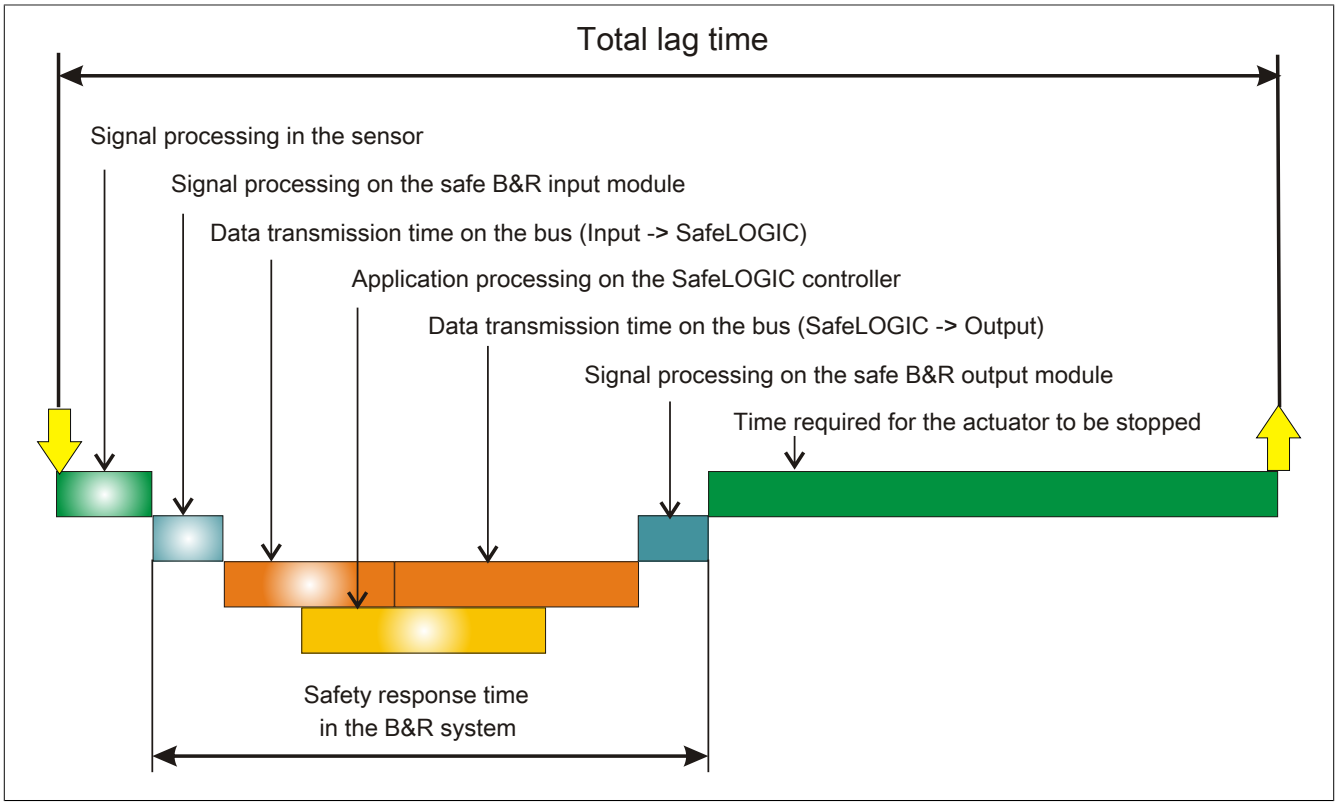


Figure 20: Total lag time

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

- Signal processing on the safe B&R input module
- Data transmission time on the bus (Input -> SafeLOGIC)
- Data transmission time on the bus (SafeLOGIC -> Output)
- Signal processing on the safe B&R output module

Danger!

The following sections are dedicated exclusively to the safety response time in the B&R system. When assessing the complete safety response time, the user must include signal processing in the sensor as well as the time until the actuator is stopped.

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

Information:

The safety response time in B&R products already contains all delays caused by sampling input data (sampling theorem).

17.1 Signal processing on the safe B&R input module

The maximum I/O update time in the "I/O update time" chapter for the respective module must be taken into account when processing signals in the safe B&R input module.

17.2 Data transmission time on the bus

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

- The time needed to transfer data from the input to the SafeLOGIC controller or to the output depends on the sum of the cycle times and CPU copy times in effect on the transfer line.
- POWERLINK MN (managing node, standard CPU) settings are important for the actual timing on the bus, but they cannot be used from a safety point of view since the values can be changed at any time in the course of modifications made outside of the safety application.
- In the SafeLOGIC controller, data transmission times are monitored on the bus using openSAFETY services. The time needed to process the application on the SafeLOGIC controller is taken into account in this test (system-dependent). Monitoring is defined in SafeDESIGNER using the parameters in parameter group "Safety Response Time".

Information:

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

Information:

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

Calculating the maximum data transmission time - up to Release 1.9:

- The total max. data transmission time on the bus is calculated by adding parameter "Worst_Case_Response_Time_us" for the safe input module and parameter "Worst_Case_Response_Time_us" for the safe output module. When doing this, be sure to check parameter "Manual_Configuration". If parameter "Manual_Configuration" is set to "No", the value specified for parameter "Default_Worst_Case_Response_Time_us" is used.
- **Special case: Local inputs on the X20SLX module:**
  The total max. data transmission time on the bus is calculated by adding parameter "Cycle_Time_max_us" + 2000 µs and parameter "Worst_Case_Response_Time_us" for the safe output module. When doing this, be sure to check parameter "Manual_Configuration". If parameter "Manual_Configuration" is set to "No", the value specified for parameter "Default_Worst_Case_Response_Time_us" is used.

Calculating the maximum data transmission time - Release 1.10 and later:

The following parameters are relevant for calculating the data transmission time between the safe input module and safe output module; parameter "Manual Configuration" deserves special attention.

- Relevant parameters for "Manual Configuration = No":
  - "PacketLoss1": Parameter "Default Additional Tolerated Packet Loss" of group "Safety Response Time Defaults" of the SafeLOGIC controller
  - "DataDuration1": Parameter "Default Safe Data Duration" of group "Safety Response Time Defaults" of the SafeLOGIC controller
  - "NetworkSyncCompensation1": 12 ms
  - "PacketLoss2": Same as "PacketLoss1"
  - "DataDuration2": Same as "DataDuration1"
  - "NetworkSyncCompensation2": Same as "NetworkSyncCompensation1"
- Relevant parameters for "Manual Configuration = Yes":
  - "PacketLoss1": Parameter "Additional Tolerated Packet Loss" of group "Safety Response Time" of the safe input module
  - "DataDuration1": Parameter "Safe Data Duration" of group "Safety Response Time" of the safe input module
  - "NetworkSyncCompensation1": 12 ms
  - "PacketLoss2": Parameter "Additional Tolerated Packet Loss" of group "Safety Response Time" of the safe output module
  - "DataDuration2": Parameter "Safe Data Duration" of group "Safety Response Time" of the safe output module
  - "NetworkSyncCompensation2": Same as "NetworkSyncCompensation1"
- **Special case: Local inputs on the X20SLX module:**
  - "PacketLoss1": 0
  - "DataDuration1": Parameter "Cycle Time max" of group "Module Configuration" of the X20SLX + 2000 µs
  - "NetworkSyncCompensation1": 0 ms
- **Special case: Local outputs on the X20SLX module:**
  - "PacketLoss2": 0
  - "DataDuration2": Parameter "Cycle Time max" of group "Module Configuration" of the X20SLX + 2000 µs
  - "NetworkSyncCompensation2": 0 ms
- **Special case: Linking local inputs with local outputs on the X20SRT module:**
  - "PacketLoss1": 0
  - "PacketLoss2": 0
  - "DataDuration1": Parameter "Cycle time" of group "General"
  - "DataDuration2": Parameter "Cycle time" of group "General"
  - "NetworkSyncCompensation1": 0 ms
  - "NetworkSyncCompensation2": 0 ms

The following equation is used to calculate the maximum data transmission time between the safe input module and safe output module:

Maximum data transmission time = (PacketLoss1+1)* DataDuration1 + NetworkSyncCompensation1 + (Packet-Loss2+1)* DataDuration2 + NetworkSyncCompensation2

Information:

In addition to the data transmission time on the bus, the time for signal processing in the safe B&R input and output module must be taken into account (see section 17 "Safety response time").

Information:

For more information about the actual data transmission time, see Automation Help, section Diagnostics and service → Diagnostics tools → Network analyzer → Editor → Calculation of safety runtime. The cycle time of the safety application must also be added.

17.3 Signal processing on the safe B&R output module

The maximum I/O update time in the "I/O update time" chapter for the respective module must be taken into account when processing signals in the safe B&R output module.

17.4 Minimum signal lengths

The parameters in group "Safety Response Time" in SafeDESIGNER influence the maximum number of data packets that are permitted to fail without triggering a safety response. These parameters therefore act like a switch-off filter. If several data packets are lost within the tolerated amount, safety signals may not be detected if their low phase is shorter than the determined data transmission time.

Danger!

Lost signals can result in serious safety errors. Check all signals to determine the smallest possible pulse length and make sure that it is larger than the determined data transmission time.

Suggested solution:

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

18 Intended use

Danger!

Danger from incorrect use of safety-related products/functions

Proper functionality is only ensured if the products/functions are used in accordance with their intended use by qualified personnel and the provided safety information is taken into account. The aforementioned conditions must be observed or covered by supplementary measures on your own responsibility in order to ensure the specified protective functions.

18.1 Qualified personnel

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

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

Qualified personnel in the context of this manual's safety guidelines are those who, because of their training, experience and instruction combined with their knowledge of relevant standards, regulations, accident prevention guidelines and operating conditions, are qualified to carry out essential tasks and recognize and avoid potentially dangerous situations.
In this regard, sufficient language skills are also required in order to be able to properly understand this manual.

18.2 Application range

The safety-related B&R control components described in this manual were designed, developed and manufactured for special applications for machine and personnel protection. They are not suitable for any use involving serious risks or hazards that could lead to the injury or death of several people or serious environmental impact without the implementation of exceptionally stringent safety precautions. In particular, this includes the use of these devices to monitor nuclear reactions in nuclear power plants, flight control systems, air traffic control, the control of mass transport vehicles, medical life support systems and the control of weapon systems.

When using safety-oriented control components, the safety precautions applying to industrial control systems (e.g. the provision of safety devices such as emergency stop circuits, etc.) must be observed in accordance with applicable national and international regulations. The same applies for all other devices connected to the system, e.g. drives or light curtains.

The safety guidelines, information about connection conditions (nameplate and documentation) and limit values specified in the technical data must be read carefully before installation and commissioning and must be strictly observed.

18.3 Security concept

B&R products communicate via a network interface and were developed for integration into a secure network. The network and B&R products are affected by the following hazards (not a complete list):

- Unauthorized access
- Digital intrusion
- Data leakage
- Data theft
- A variety of other types of IT security breaches

It is the responsibility of the operator to provide and maintain a secure connection between B&R products and the internal network as well as other networks, such as the Internet, if necessary. The following measures and security solutions are suitable for this purpose:

- Segmentation of the network (e.g. separation of the IT and OT networks)
- Firewalls for the secure connection of network segments
- Implementation of a security-optimized user account and password concept
- Intrusion prevention and authentication systems
- Endpoint security solutions with modules for anti-malware, data leakage prevention, etc.
- Data encryption

It is the responsibility of the operator to take appropriate measures and to implement effective security solutions.

B&R Industrial Automation GmbH and its subsidiaries are not liable for damages and/or losses resulting from, for example, IT security breaches, unauthorized access, digital intrusion, data leakage and/or data theft.

Before B&R releases products or updates, they are subjected to appropriate functional testing. Independently of this, the development of customized test processes is recommended in order to be able to check the effects of changes in advance. Such changes include, for example:

- Installation of product updates
- Notable system modifications such as configuration changes
- Import of updates or patches for third-party software (non-B&R software)
- Hardware replacement

These tests should ensure that implemented security measures remain effective and that systems behave as expected.

18.4 Safety technology disclaimer

The proper use of all B&R products must be guaranteed by the customer through the implementation of suitable training, instruction and documentation measures. The guidelines set forth in system user's manuals must be taken into consideration here as well. B&R has no obligation to provide verification or warnings with regard to the customer's purpose of using the delivered product.

Changes to the devices are not permitted when using safety-related components. Only certified products are permitted to be used. Currently valid product versions in each case are listed in the corresponding certificates. Current certificates are available on the B&R website (www.br-automation.com) in the Downloads section for the respective product. The use of non-certified products or product versions is not permitted.

All relevant information regarding these safety products must be read in the latest version of the related data sheet and the corresponding safety notices observed before the safety products are permitted to be operated. Certified data sheets are available on the B&R website (www.br-automation.com) in the Downloads section for the respective product.

B&R and its employees are not liable for any damages or loss resulting from the incorrect use of these products. The same applies to misuse that may result from specifications or statements made by B&R in connection with sales, support or application activities. It is the sole responsibility of the user to check all specifications and statements made by B&R for proper application as it pertains to safety-related applications. In addition, the user assumes sole responsibility for the proper design of the safety function as it pertains to safety-related applications.

18.5 X20 system characteristics

Because all X20 safety products are seamlessly integrated into the B&R base system, the same system characteristics and user notices from the X20 system user's manual also apply to X20 safety products.

Warning!

Possible failure of safety function

Malfunction of module due to unspecified operating conditions
The notes for installation and operation of the modules provided in the applicable documents must be observed.

In this regard, this means the content and user notices in the following applicable documentation must be observed for X20 safety products:

- X20 system user's manual
- Installation / EMC guide

18.6 Installation notes for X20 modules

Products must be protected against impermissible dirt and contaminants. Products are protected from dirt and contaminants up to pollution degree II as specified in the IEC 60664 standard.

Pollution degree II can usually be achieved in an enclosure with IP54 protection, but uncoated modules are NOT permitted to be operated in condensing relative humidity and temperatures under 0°C.

The operation of coated modules is allowed in condensing relative humidity.

Danger!

Pollution levels higher than specified by pollution degree II in standard IEC 60664 can result in dangerous failures. It is extremely important that you ensure a proper operating environment.

Danger!

In order to guarantee a specific voltage supply, a SELV power supply that conforms to IEC 60204 must be used to supply the bus, SafeIO and SafeLOGIC controller. This also applies to all digital signal sources that are connected to the modules.

If the power supply is grounded (PELV system), then only a GND connection is permitted for grounding. Grounding types that have ground connected to +24 VDC are not permitted.

The power supply of X20 potential groups must generally be protected using a fuse with a maximum of 10 A.
For more information, see chapter "Mechanical and electrical configuration" of the X20 or X67 user's manual.

18.7 Safe state

If an error is detected by the module (internal or wiring error), the modules enable the safe state. The safe state is structurally designed as a low state or cutoff and cannot be modified.

Danger!

Applications in which the safe state must actively switch on an actuator cannot be implemented with this module. In these cases, other measures must be taken to meet this safety-related requirement (e.g. mechanical brakes for hanging load that engage on power failure).

18.8 Mission time

All safety modules are designed to be maintenance-free. Repairs are not permitted to be carried out on safety modules.

All safety modules have a maximum mission time of 20 years.

This means that all safety 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 safety modules beyond the specified mission time is not permitted! The user must ensure that all safety modules are replaced by new safety modules or removed from operation before their mission time expires.

19 Release information

A manual version always describes the respective range of functions for a given product set release. The following table shows the relationship between manual versions and releases.

<table>
<tr><th>Manual version</th><th>Valid for</th></tr>
<tr><td>V1.141
V1.140
V1.131
V1.130
V1.123
V1.122
V1.121
V1.120
V1.111
V1.110
V1.103
V1.102
V1.101
V1.100
V1.92
V1.91
V1.90
V1.80
V1.71
V1.70
V1.64
V1.63.2
V1.63.1
V1.63
V1.62
V1.61
V1.60
V1.52.1
V1.52
V1.51
V1.50.1
V1.50
V1.42
V1.41
V1.40
V1.20
V1.10</td><td>
<table>
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<tr><td>Product set</td><td>Release 1.2</td><td>Release 1.10</td></tr>
<tr><td>SafeDESIGNER</td><td>2.70</td><td>4.9</td></tr>
<tr><td>Firmware</td><td>270</td><td>399</td></tr>
<tr><td>Upgrades</td><td>1.2.0.0</td><td>1.10.999.999</td></tr>
</table>
</td></tr>
<tr><td>V1.02
V1.01
V1.00</td><td>
<table>
<tr><th>Version</th><th>Starting with</th><th>Up to</th></tr>
<tr><td>Product set</td><td>Release 1.0</td><td>Release 1.1</td></tr>
<tr><td>SafeDESIGNER</td><td>2.58</td><td>2.69</td></tr>
<tr><td>Firmware</td><td>256</td><td>269</td></tr>
<tr><td>Upgrades</td><td>1.0.0.0</td><td>1.1.999.999</td></tr>
</table>
</td></tr>
</table>

Table 27: Release information

20 Version history

Version	Date	Comment
1.141	April 2019	• Chapter 4 "Technical data": Updated standards. • Updated chapter 18.3 "Security concept". • Updated chapter 18.6 "Installation notes for X20 modules".
1.140	February 2019	• Chapter 4 "Technical data": Limited installation elevation to 2000 m. • Chapter 16.1 "Parameters in the I/O configuration": Added parameter "Blackout mode". • Chapter 16.3 "Parameters in SafeDESIGNER - Release 1.10 and later": Added filter value to danger notice. • Chapter 17.2 "Data transmission time on the bus": Updated calculation of maximum data transmission time. • Chapter 18 "Intended use": Added danger notice. • Added chapter "Security notes". • Chapter 18.5 "X20 system characteristics": Added warning notice. • Updated standards. • Editorial changes.
1.120	November 2017	• Chapter 4 "Technical data": – Updated standards and safety characteristics. – Added input characteristics per EN 61131-2. – Updated input current and input resistance. – Added line length between pulse output and input. – Updated braking voltage when switching off inductive loads. – Updated peak short-circuit current. – Added max. switching frequency. – Coated module: Extended temperature range. – Added information. – Updated derating. • Chapter 7 "Connection examples": Added information. • Chapter 15 "Restart behavior": Updated description. • Chapter 16.3 "Parameters in SafeDESIGNER - Release 1.10 and later": Group "Safety Response Time": Removed parameter "Synchronous Network Only" and updated parameter "Safe Data Duration". • Chapter 16.4 "Channel list": Added new channels and information. • Chapter 17.2 "Data transmission time on the bus": Updated description and added information. • Chapter 18.6 "Installation notes for X20 modules": Updated danger notice. • Chapter 18.7 "Safe state": Updated danger notice. • Updated standards. • Editorial changes.
1.101	March 2016	• Chapter 12 "I/O update time": Updated. • Chapter 17 "Safety response time": Added information.
1.100	January 2016	Merged coated/uncoated modules. • Chapter 1 "General information": Added. • Chapter 4 "Technical data": – Updated standards. – Limited output protection to max. 30 minutes. – Updated temperature range. – Updated technical data. • Chapter 8.2.6 "Safety actuator connection": Added new modules. • Revised chapter 12 "I/O update time". • Chapter 16.3 "Parameters in SafeDESIGNER - Release 1.10 and later": Added. • Chapter 16.4 "Channel list": Updated figure "Restart interlock state diagram". • Chapter 17.1 "Signal processing on the safe B&R input module": Updated description. • Chapter 17.2 "Data transmission time on the bus": Updated description with "Release 1.10 and later". • Chapter 17.3 "Signal processing on the safe B&R output module": Updated description. • Chapter 17.4 "Minimum signal lengths": Updated description. • Revised chapter 18.4 "Safety technology disclaimer". • Chapter 19 "Release information": Updated.
1.91	April 2015	• Chapter 4 "Technical data": "Safe digital inputs": "Cable length": Limited to 50 m. • Chapter 8.2.4 "Connecting multi-channel sensors with contacts": Updated danger notice. • Corrected chapter 13 "Filter". • Chapter 17.1 "Signal processing on the safe B&R input module": Updated description.
1.90	October 2014	• Chapter 4 "Technical data": "Temperature": "Operation": "Horizontal mounting orientation": Extended temperature range to 60°C. • Updated chapter 19 "Release information". • Editorial changes.

Table 28: Version history

Version	Date	Comment
1.80	July 2014	• Chapter 4 "Technical data": – "Short description": "I/O module": Adapted text to order data. – Added "System requirements". – Added "Safety-related characteristic values" and deleted chapter "Safety-related characteristic values". – "Pulse outputs": "Output protection": Changed description. – "Temperature": "Operation": Added "Derating bonus at 24 VDC". – "Temperature": "Operation": Added "Derating bonus with dummy modules". – Section "Derating": Updated description and curves. • Chapter 8.2.6 "Safety actuator connection": Newly restructured for all modules. • Chapter 15 "Restart behavior": Updated description. • Chapter 16.2 "Parameters in SafeDESIGNER - up to Release 1.9": Group "Basic": Added parameter value "Not_Present" for "Optional". • Chapter 16.2 "Parameters in SafeDESIGNER - up to Release 1.9": Group "Safety_Response_Time": Added parameter "Node_Guarding_Lifetime". • Chapter 16.4 "Channel list": Section "PLCopen state diagrams": Updated description and figures. • Chapter 17.2 "Data transmission time on the bus": Updated description. • Chapter 18.6 "Installation notes for X20 modules": Removed figure "Protecting various potential groups", updated description accordingly. • Updated chapter 19 "Release information".
1.63	November 2013	• Updated standards. • Chapter 4 "Technical data": Added danger notice. • Chapter 8.1 "Internal module errors": Updated description. • Chapter 8.2 "Wiring errors": Added danger notice and figure "Impermissible wiring". • Chapter 15 "Restart behavior": Updated the behavior of input channels. • Added chapter 17 "Safety response time". • Updated chapter 19 "Release information". • Editorial changes.
1.52.1	October 2013	• Updated standards. • Editorial changes.
1.52	August 2012	• Updated designations of standards. • Chapter 4 "Technical data": Derating added • Chapter 7 "Connection examples": Added following chapter: – 7.1 "Module behavior when GND connection is lost" – 7.1.1 "GND feedback to connection element, no external GND" – 7.1.2 "Using external GND without GND from connection element" – 7.1.3 "Using external GND and GND from connection element" – Grounding • Chapter 7.7 "Connecting safety-oriented actuators for Type B outputs ": Updated description. • Added chapter 18.5 "X20 system characteristics". • Chapter 18.8 "Mission time": Updated description. • Added chapter 21 "EC declaration of conformity".
1.51	May 2012	Chapter 4 "Technical data": Updated technical data.
1.50	February 2012	First edition as a product-specific manual

Table 28: Version history

21 EC declaration of conformity

This document was originally written in the German language. The German edition therefore represents the original documentation in accordance with the 2006/42/EC Machinery Directive. Documents in other languages are to be interpreted as translations of the original documentation.

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The place of jurisdiction, in accordance with article 17 of the European Convention on Courts of Jurisdiction and Enforcement, is A-4910

Ried im Innkreis, Austria, commercial register court: Ried im Innkreis, Austria

Commercial register number: FN 111651 v.

The place of fulfillment in accordance with article 5 of the European Convention on Courts of Jurisdiction and Enforcement is A-5142 Eggelsberg, Austria

VATIN: ATU62367156

The EC declarations of conformity for B&R products can be downloaded from the B&R website www.br-automation.com.