X20ST4492

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 module is equipped with 2 safe analog input pairs for J, K, N, S, R, C and T thermocouple sensors and 1 safe analog input pair for PT100/PT1000 resistance temperature measurement.

The safe temperature module is suitable for safely acquiring temperatures for safety-related applications up to PL e or SIL 3.

This module is designed for X20 16-pin terminal blocks.

- 2 safe analog input pairs for thermocouples
- For sensor types J, K, N, S, R, C, T, raw value measurement
- 1 safe analog input pair for resistance temperature measurement
- For PT100 and PT1000
- Configurable sensor type per channel
- 24-bit digital converter resolution
- Galvanically isolated analog channel pairs
- Input filter configurable
- Integrated terminal temperature compensation
- 2x PT1000 sensor integrated in the terminal (X20TB5E)
- 2x external PT1000 sensor can be connected (X20TB5F)

1.1 Function

Safe temperature measurement

This safe temperature module is suitable for safely connecting PT100, PT1000 or thermocouples for safety-related applications up to PL e or SIL 3.

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

2 Overview

Module	X20ST4492
Thermocouple inputs	
Number of inputs	2x 2 thermocouple inputs
Measurement range	-270.0 to 1768.0 °C
Sensor	Fe-CuNi: Type J NiCr-Ni: Type K NiCrSi-NiSi: Type N PtRh10-Pt: Type S PtRh13-Pt: Type R WRe5-WRe26: Type C Cu-CuNi: Type T Sensor specification in accordance with EN IEC 60584-1:2010
Voltage measurement	Yes: ±65 mV
Terminal temperature compensation	Yes: 1x 2 PT100/PT1000 inputs available on module
Digital converter resolution	24-bit
PT100/PT1000 inputs	
Number of inputs	1x 2 PT100/PT1000 inputs, e.g. for terminal temperature compensation
Measurement range	Firmware version 295: -40.0 to 130.0°C, firmware version 301 or later: -200.0 to 850.0°C
Sensor	PT100 PT1000
Measurement type	2-wire measurement
Digital converter resolution	24-bit

Table 3: Safe temperature module

3 Order data

Model number	Short description	Figure
	Analog input modules	
X20ST4492	X20 safe temperature input module, 2x 2 safe analog inputs for thermocouples, Type: J, K, N, S, R, C, T, resolution 0.1°C, 1x 2 safe analog inputs for PT100/PT1000 sensors, channel pairs galvanically isolated, integrated compensation of terminal temperature, integrated temperature sensor in terminal block X20TB5E, configurable input filter and switching thresholds	
	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	
	Terminal blocks	
X20TB5E	X20 terminal block, 16-pin, safety-keyed, 2x PT1000 integrated for terminal temperature compensation	
X20TB5F	X20 terminal block, 16-pin, safety-keyed	

Table 4: X20ST4492 - Order data

4 Technical data

Model number	X20ST4492
Short description	
I/O module	2x 2 safe analog inputs for thermocouples, 1x 2 safe analog inputs for PT100/ PT1000 sensors, channel pairs galvanically isolated, integrated terminal temperature compensation, integrated temperature sensor in terminal block X20TB5E
General information	
B&R ID code	0xB419
System requirements	
Automation Studio	3.0.81.15 or later
Automation Runtime	3.00 or later
SafeDESIGNER	2.81 or later
Safety Release	1.4 or later
Status indicators	I/O function per channel, operating state, module status
Diagnostics	
Module run/error	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	2 ms
Power consumption	
Bus	0.25 W
Internal I/O	1.2 W
Electrical isolation	
Channel - Bus	Yes
Channel - Channel	No
Channel pair - Channel pair	Yes
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	
Note	The following characteristic values apply only to the use of input channel pairs. Assessing the channels from a safety point of view when they are used individually is not possible. [1)]
EN ISO 13849-1:2015	
Category	Cat. 4
PL	PL e
DC	>94%
MTTFD	2200 years
Mission time	Max. 20 years
IEC 61508:2010, IEC 61511:2004, EN 62061:2013	
SIL CL	SIL 3
SFF	>90%
PFH / PFH_d	
Module	$<1*10^{-9}$
openSAFETY wired	Negligible
openSAFETY wireless	$<1*10^{-14}$ * Number of openSAFETY packets per hour
PFD	$<1*10^{-4}$
Proof test interval (PT)	20 years

Table 5: X20ST4492 - Technical data

Model number	X20ST4492
I/O power supply	
Nominal voltage	24 VDC
Voltage range	24 VDC -15% / +20%
Thermocouple temperature inputs	
Input	Thermocouple
Digital converter resolution	24-bit
Filter time	Configurable between 1 and 66.7 ms
Output format	SAFEINT
Measurement range	
Sensor temperature	
Type J: Fe-CuNi	-210.0 to 1200.0°C
Type K: NiCr-Ni	-270.0 to 1372.0°C
Type N: NiCrSi-NiSi	-270.0 to 1300.0°C
Type S: PtRh10-Pt	-50.0 to 1768.0°C
Type R: PtRh13-Pt	-50.0 to 1768.0°C
Type C: WRe5-WRe26	0 to 2320.0°C
Type T: Cu-CuNi	-270.0 to 400.0°C
Voltage	±65 mV
Max. internal resistance of source during voltage measurement	20 Ω
Terminal temperature compensation	Internal / External
Sensor standard	EN 60584
Resolution	
Sensor temperature	1 LSB = 0.1°C
Voltage	1 LSB = 2 µV
Conversion procedure	Sigma-delta
Linearization method	Internal
Permissible input signal	Max. ±1 V
Input filter	1st-order low pass / cutoff frequency 500 Hz
Basic accuracy [2]	
Type J	0.10%
Type K	0.11%
Type N	0.11%
Type S	0.17%
Type R	0.17%
Type C	0.15%
Type T	0.11%
Voltage	0.06%
Max. gain drift [3]	0.013 %/°C
Max. offset drift [4]	
Type J	0.0021 %/°C
Type K	0.0026 %/°C
Type N	0.0030 %/°C
Type S	0.0090 %/°C
Type R	0.0080 %/°C
Type C	0.0046 %/°C
Type T	0.0050 %/°C
Voltage	0.0013 %/°C
Terminal temperature compensation	
Accuracy of internal terminal temperature	15°C at static temperatures and during safe operation
Common-mode rejection	
DC	>70 dB
50 Hz	>70 dB
Common-mode range	±4 V within channel pair, ±50 V between 2 channel pairs
Crosstalk between channels	≤70 dB
Isolation voltage between channel and bus	500 VDC
Safety-related accuracy per channel [4]	
Type J	2.5%
Type K	2.9%
Type N	3.3%
Type S	8.3%
Type R	7.4%
Type C	4.8%
Type T	4.6%
Voltage	1.6%
Resistance measurement temperature inputs	
Measurement range	
PT100	Firmware version 295: -40.0 to 130.0°C, firmware version 301 or later: -200.0 to 850.0°C
PT1000	Firmware version 295: -40.0 to 130.0°C, firmware version 301 or later: -200.0 to 850.0°C
Basic accuracy [2]	
PT100	1.1%
PT1000	0.3%
Measurement current	262 µA ±5%

Table 5: X20ST4492 - Technical data

Model number	X20ST4492
Max. gain drift [3]	0.004 %/°C
Max. offset drift	
PT100	0.03 %/°C
PT1000	0.003 %/°C
Temperature sensor resolution	
PT100	1 LSB = 0.1°C
PT1000	1 LSB = 0.1°C
Input filter	
Cutoff frequency	500 Hz 1st-order
Max. line length	50 m
Max. line resistance	5 Ω
Safety-related accuracy per channel [4]	
PT100	4%
PT1000	2%
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
Vertical mounting orientation	0 to 50°C
Derating	See section "Derating".
Storage	-40 to 85°C
Transport	-40 to 85°C
Relative humidity	
Operation	5 to 95%, non-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: X20ST4492 - Technical data

1) The related danger warnings in the technical data sheet must also be observed.
2) Based on the entire measurement range at 25°C
3) Based on the measured value
4) Based on the entire measurement range

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 36.

Derating

Starting at a temperature of 55°C (horizontal mounting orientation), dummy modules must be connected next to the X20ST4492.

Module	X20ST4492
Derating bonus	
Dummy module on the left	+0°C
Dummy module on the right	+2.5°C
Dummy module on the left and right	+5°C

Table 6: Derating bonus

4.1 Safety-oriented measurement precision

The following aspects need to be taken into consideration with regard to the safety-oriented measurement precision of a safe analog input module or temperature module:

- The safety-related precision per channel is specified in the technical data.
- The measurement precision of a signal is the result of: Safety-related precision of the channel + Measurement precision of the sensor + Quality of the signal link of the sensor at the measurement point (depends on the installation)
- From a safety standpoint, a channel pair (i.e. signal pair) must always be observed. The measurement precision acquired for the signal pair must be taken into consideration when specifying the "Limit Threshold Equivalent" parameter. The "Limit Threshold Equivalent" parameter must be set as small as possible, but its value should not fall below the functional measurement precision.
- From a safety point of view, a guaranteed measurement precision per signal pair is the result of:
  ± ("Limit Threshold Equivalent" + Measurement precision of signal)
- On input channels for PT100/PT1000 sensors, the line resistance must be taken into consideration from a safety point of view.
- On input channels for thermocouples, the measurement precision of the signal for the terminal temperature must also be added.
- When using the X20TB5E terminal, the measurement precision of the signal for the terminal temperature is specified in the technical data.

5 LED status indicators

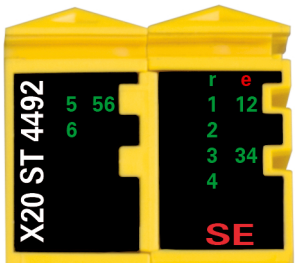
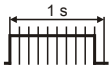
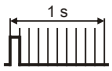
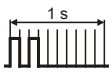
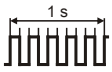
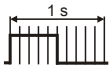
Figure	LED	Color	Status	Description
	r	Green	Off	No power to module
			Single flash	Reset mode
			Double flash	Updating firmware
			Blinking	PREOPERATIONAL mode
			On	RUN mode
	e	Red	Off	No power to module or everything OK
			Pulsating	Boot loader mode
			Triple flash	Updating safety-related firmware
			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 analog input		
		Red	On	Warning/Error on the input channel
			Blinking	Open circuit on corresponding channel
			All on	Error on all channels, connection to the SafeLOGIC controller not OK or booting not yet completed
		Green	On	Channel being used and signal OK
			Blinking	Channel outside of the limits configured in SafeDESIGNER
			Off	Channel not used
	12, 34, 56	Input state of the corresponding analog input channel pair		
		Red	On	Warning/Error on this channel pair
			All on	Error on all channels, connection to the SafeLOGIC controller not OK or booting not yet completed
		Green	On	Signal on channel pair OK
			Off	Signal on channel pair not OK
	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 7: 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

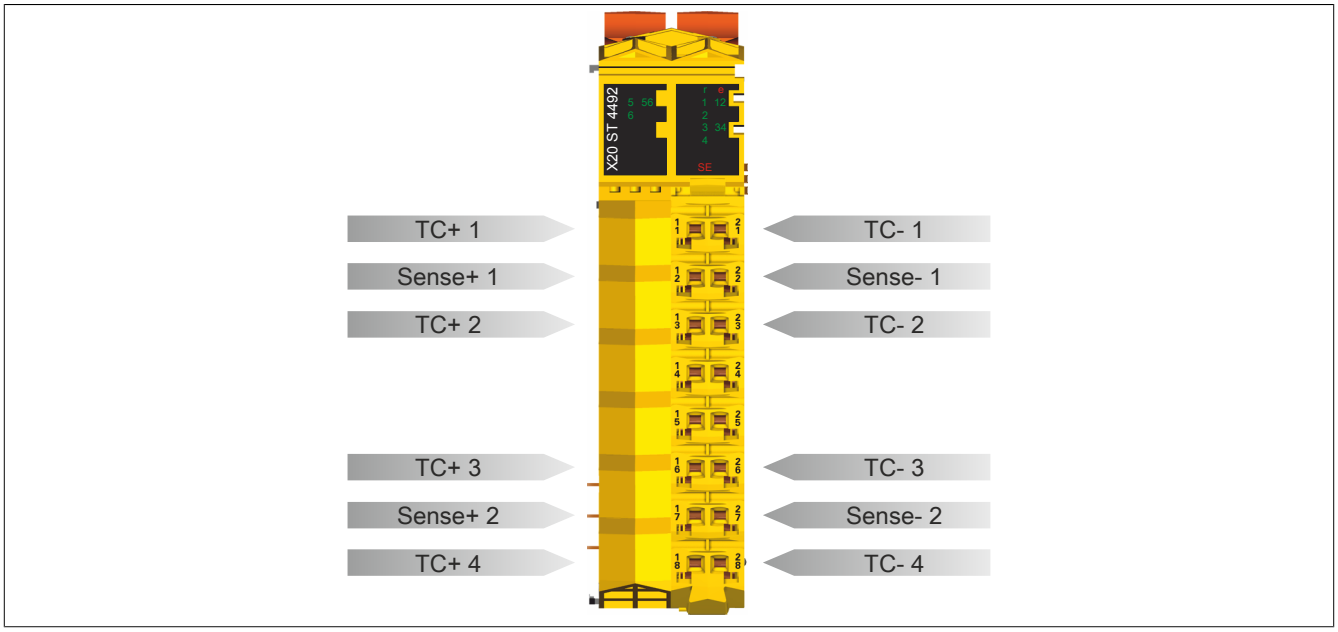


Figure 1: X20ST4492 - Pinout

7 Connection examples

The typical connection examples in this section only represent a selection of the different wiring methods.

The following must be taken into consideration during installation:

- The maximum permissible cable length is 50 m.
- The maximum resistance per stranded wire is 5 ohms.
- All wiring must be shielded.
- All installed wiring must provide short-circuit protection and voltage disturbance protection (fault exclusion per EN ISO 13849-2:2012, appendix D.2.4, table D.4).
- The wiring for the PT100/PT1000 channels must be installed in such a way that contact resistances do not change. This is because they must be included in the safety-related measurement precision (see section "Safety-oriented measurement precision").

Information:

The thermocouple inputs must be wired, otherwise, the module switches to the "FailSafe" state.

7.1 Channel pair applications

The following channel pair applications are sufficient to achieve max. PL e (EN ISO 13849-1:2015), max. SIL 3 (EN 62061:2013), max. SIL 3 (IEC 61508:2010) or max. SIL 3 (IEC 61511:2004).

X20ST4492 - Safe thermocouple input pair with X20TB5E for acquiring terminal temperature

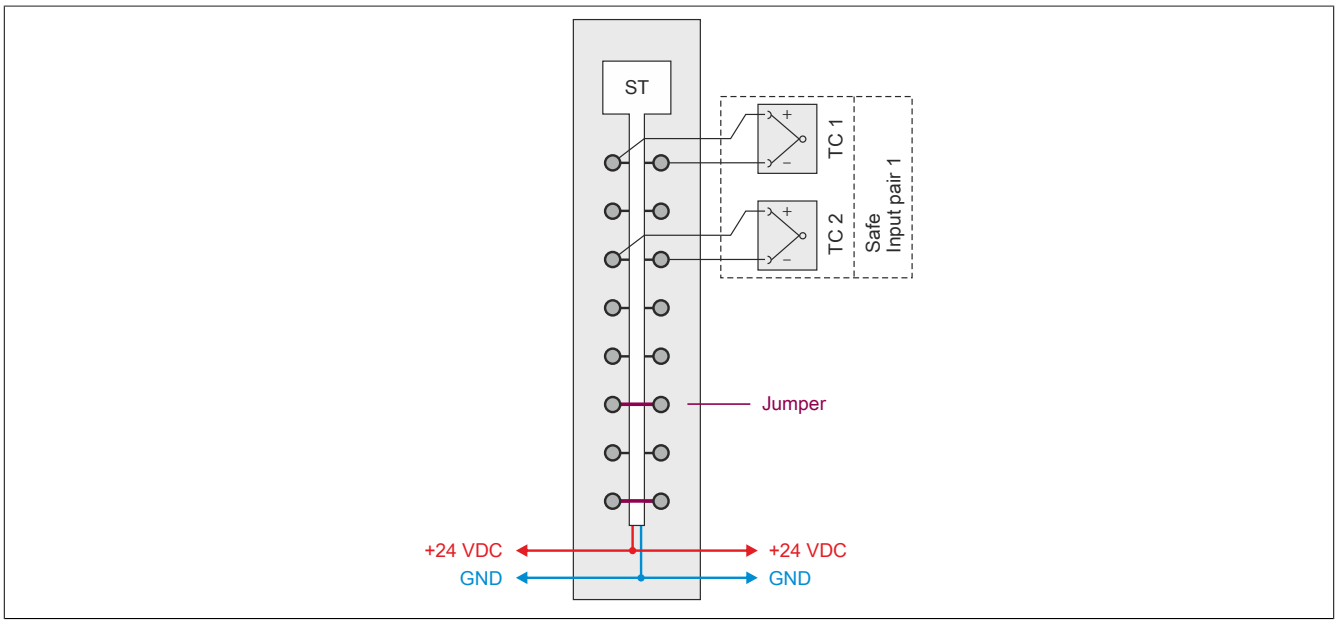


Figure 2: X20ST4492 - Safe thermocouple input pair with X20TB5E for acquiring terminal temperature

X20ST4492 - Safe thermocouple input pair, remote terminal temperature compensation, PT100/PT1000 2-wire connection

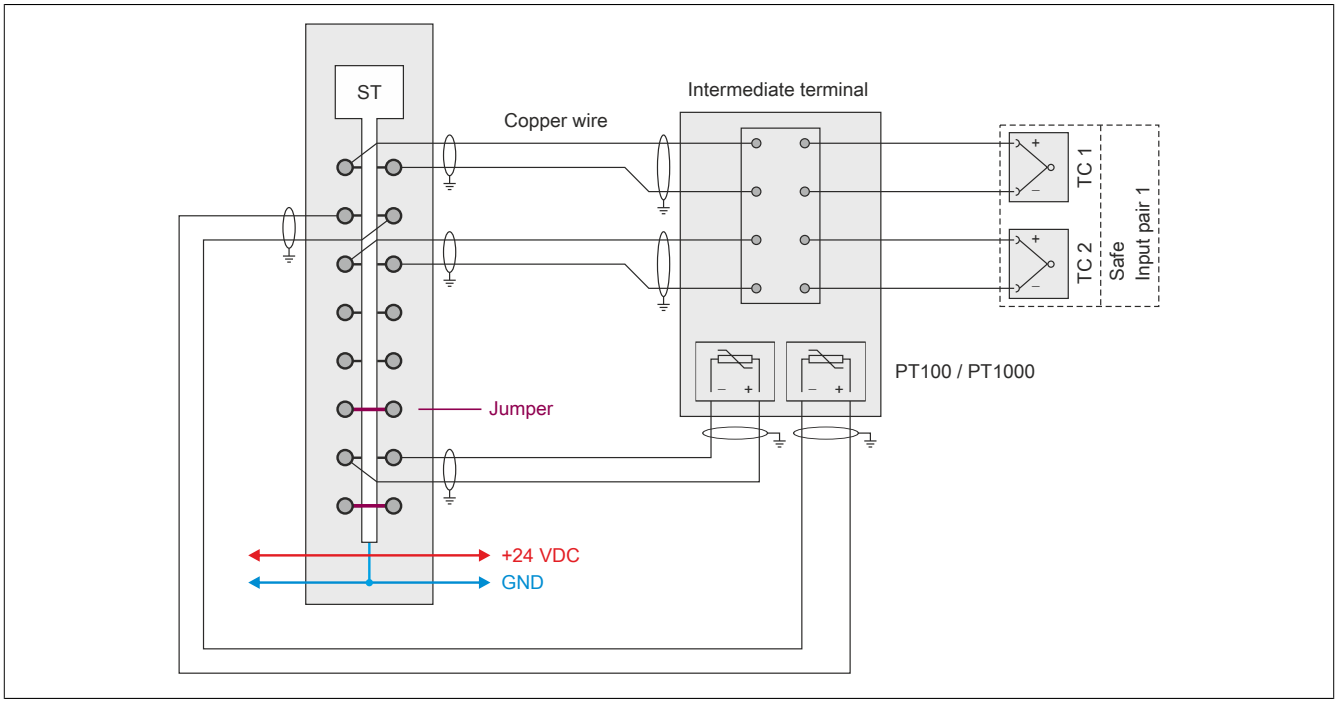


Figure 3: X20ST4492 - Safe thermocouple input pair, remote terminal temperature compensation, PT100/PT1000 2-wire connection

X20ST4492 - Safe PT100/PT1000 input pair, 2-wire connection

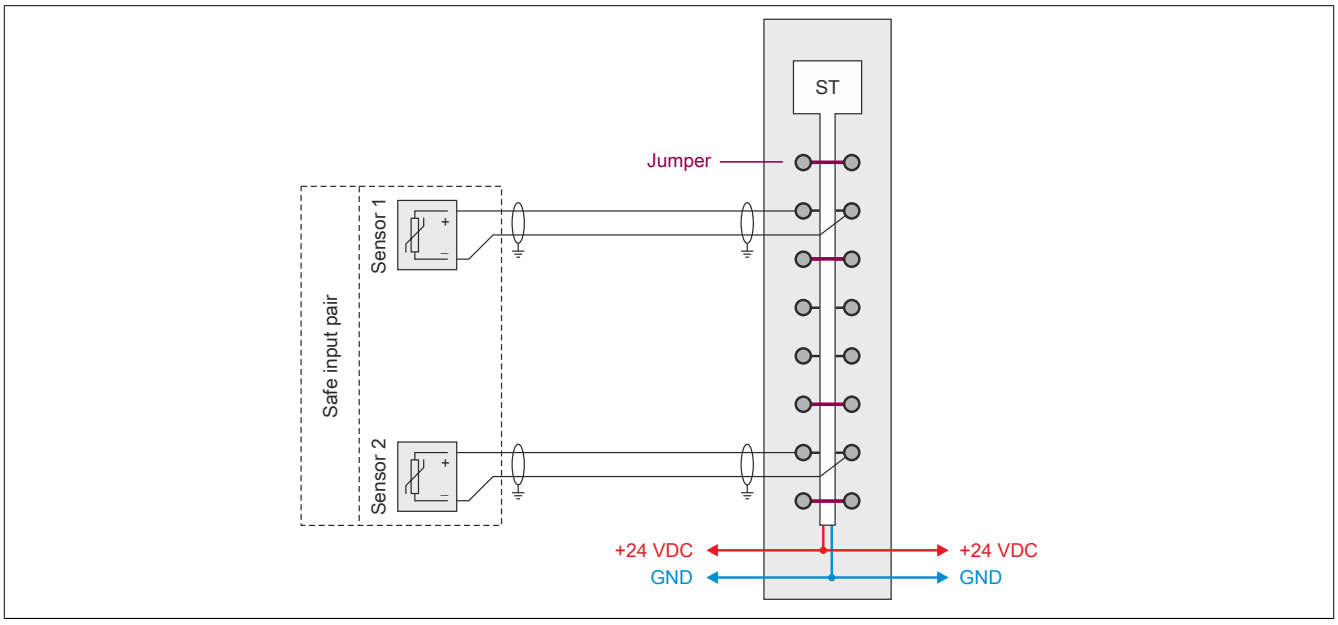


Figure 4: X20ST4492 - Safe PT100/PT1000 input pair, 2-wire connection

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 the following section 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 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!

Errors	Detection	Comment
Open line	Detected	Module switches to the FAILSAFE state
Short circuit between T+ or T- and external 24 V or GND	Not detected	Signal distortion usually does not result due to the electrical isolation of the channels; nevertheless, it is mandatory to use shielded signal lines. The user must take appropriate measures to ensure that this error does not lead to a safety-critical state. Signal and supply lines must be installed in such a way that fault exclusion is possible per EN ISO 13849-2:2012, table D.5.
Short circuit between T+ and T-	Not detected	This error results in signal distortion that may be detected by dual-channel evaluation in some circumstances. The user must take appropriate measures to ensure that this error does not lead to a safety-critical state. Signal and supply lines must be installed in such a way that fault exclusion is possible per EN ISO 13849-2:2012, table D.5.
Reverse polarity of T+ and T-	Not detected	This error results in signal distortion that may be detected by dual-channel evaluation in some circumstances. The user must take appropriate measures to ensure that this error does not lead to a safety-critical state. Signal and supply lines must be installed in such a way that fault exclusion is possible per EN ISO 13849-2:2012, table D.5.
Disturbance voltage	Not detected	This error results in signal distortion that may be detected by dual-channel evaluation in some circumstances. Shielded cables are mandatory for all signal lines. Different installation paths must be used for the cabling of both signals of the signal pair. The user must take appropriate measures to ensure that this error does not lead to a safety-critical state.

Table 8: Error detection for safe inputs of type "Thermocouple"

Errors	Detection	Comment
Open circuit on Sense+ or Sense-	Detected	Channel errors
Short circuit between Sense+, Sense- and external 24 V or GND	Not detected	Signal distortion usually does not result due to the electrical isolation of the channels; nevertheless, it is mandatory to use shielded signal lines. The user must take appropriate measures to ensure that this error does not lead to a safety-critical state. Signal and supply lines must be installed in such a way that fault exclusion is possible per EN ISO 13849-2:2012, table D.5.
Short circuit between Sense+ and Sense-	Detected	Channel errors
Disturbance voltage	Not detected	This error results in signal distortion that may be detected by dual-channel evaluation in some circumstances. Shielded cables are mandatory for all signal lines. Different installation paths must be used for the cabling of both signals of the signal pair. The user must take appropriate measures to ensure that this error does not lead to a safety-critical state.

Table 9: Error detection for safe inputs of type "PT100 / PT1000"

Errors	Detection	Comment
Open line	Detected	Channel errors
Short circuit between signal lines	May not be detected	The user must take appropriate measures to ensure that this error does not lead to a safety-critical state. Signal and supply lines must be installed in such a way that fault exclusion is possible per EN ISO 13849-2:2012, table D.5.
Short circuit between signal and supply line	May not be detected	The user must take appropriate measures to ensure that this error does not lead to a safety-critical state. Signal and supply lines must be installed in such a way that fault exclusion is possible per EN ISO 13849-2:2012, table D.5.
Reverse polarity of signal lines	Detected	Module switches to the FAILSAFE state
Disturbance voltage	Not detected	This error results in signal distortion that may be detected by dual-channel evaluation in some circumstances. Shielded cables are mandatory for all signal lines. Different installation paths must be used for the cabling of both signals of the signal pair. The user must take appropriate measures to ensure that this error does not lead to a safety-critical state.

Table 10: Error detection for safe inputs of type "Current"

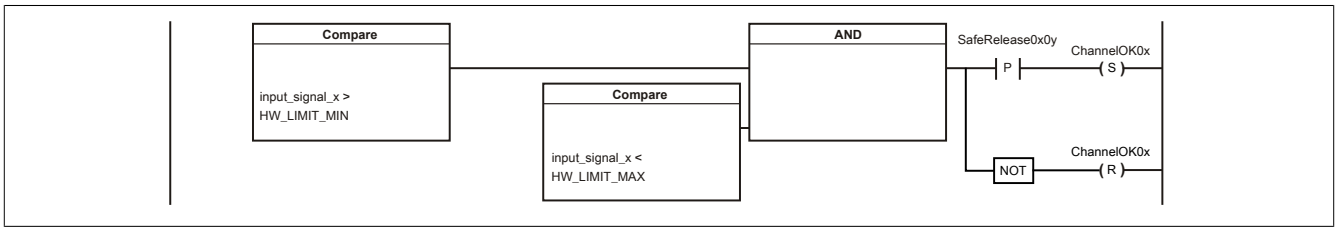
8.3 Signal errors

"HW_LIMIT_MIN" designates the lower limit of the measurement range specified in the technical data.
"HW_LIMIT_MAX" designates the upper limit of the measurement range specified in the technical data.

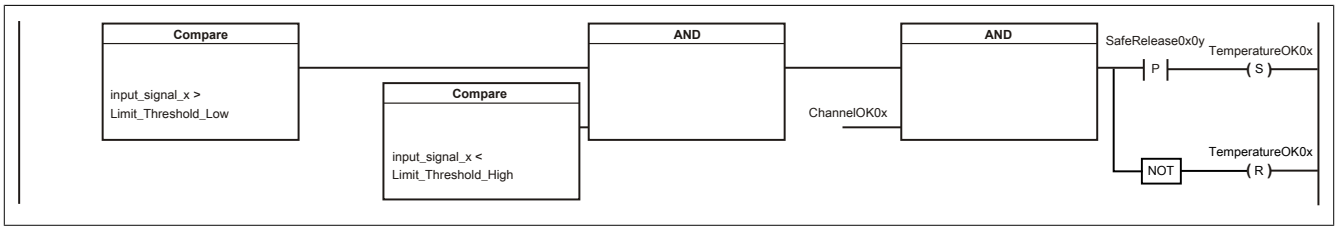
A reset must be performed in order to leave an error state.
For this to be possible, a valid signal must be received at the analog input for the duration of the I/O update time. Then the error can be acknowledged by a rising edge on signal "SafeRelease0x0y".

Signal evaluation takes place in 3 stages:

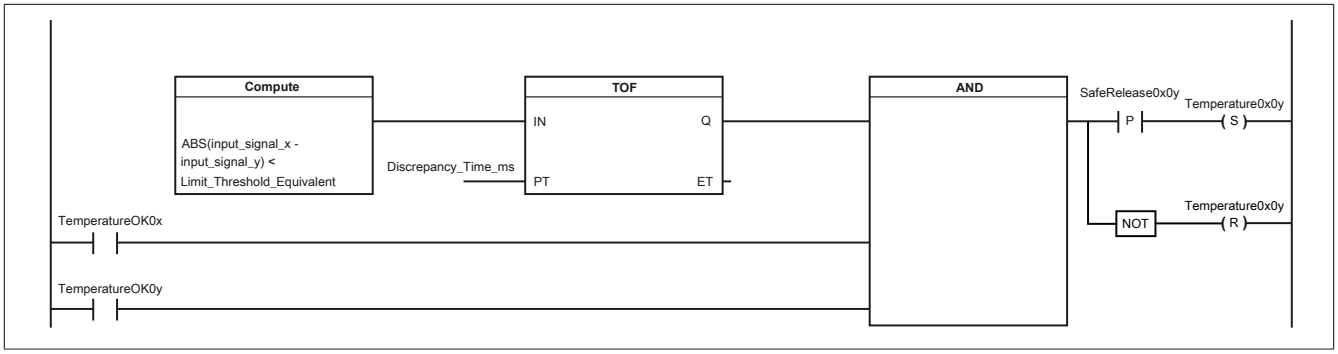
Stage 1: Evaluation of signals against absolute limits



Stage 2: Evaluation of signals against configurable limits



Stage 3: Evaluation of signals against configurable signal pair limits



8.4 Channel diagnostics

Channel electronics are automatically tested internally by the module. Here, a test signal is generated in the module and applied to each channel once per hour for a maximum time of 1 s. To avoid signal distortion, the signal value of the channel being tested is frozen during this time.

Only one channel is tested at a time. Per IEC 61508:2010, the module is considered a 1oo2D system for the duration of the channel test. The resulting probability of a dangerous state was taken into account in the safety characteristics in chapter 5.

Up to firmware version 321, the behavior for the duration of channel diagnostics is structured as follows:

The safe analog input channels (data type SAFEINT) are formed by the arithmetic mean value of the two individual signals. Since the signal value of the channel being tested is frozen for the duration of channel diagnostics, the arithmetic mean value during this period of channel diagnostics for the safe signal is taken from the frozen value of the diagnosed channel and the signal value of the non-diagnosed channel.

In firmware version 322 and later, the behavior for the duration of channel diagnostics is structured as follows:

The safe analog input channels (data type SAFEINT) are formed by the arithmetic mean value of the two individual signals. For the duration of channel diagnostics, however, it is not the arithmetic mean value that is used, but the signal value of the channel that is not currently being diagnosed.
If the behavior of firmware version 321 is desired for compatibility reasons, this can be implemented using parameter "Measurement Result while Testing = Averaged".
An active channel test is indicated by channel "TestActive".

The sequence for channel diagnostics is independent of the firmware version and structured as follows:

		X20SA4430	X20ST4492
Diagnostic Window 1	Hourly	SAI1	TC1, Sense 1
Diagnostic Window 2	Hourly, 15 min after Diagnostic Window 1	SAI3	TC4, Sense 2
Diagnostic Window 3	Hourly, 30 min after Diagnostic Window 1	SAI4	TC3
Diagnostic Window 4	Hourly, 45 min after Diagnostic Window 1	SAI2	TC2

Table 11: Channel diagnostics sequence

9 Module function

The safe temperature module is suitable for safely connecting PT100, PT1000 or thermocouples for safety-related applications up to PL e or SIL 3.

Danger!

Possible failure of safety function
Dangerous system behavior due to incorrect use of analog signal values

When using analog signal values, note the information listed in the data sheet regarding the functionality, precision and scope of the data.

The signal taken via the input terminals is smoothed by the hardware filter (1st-order low pass / cutoff frequency 500 Hz) and digitalized in the subsequent A/D converters.

The filter values configured in the software are applied during digitalization in the A/D converter.

The signals then pass through the 3 stages of digital signal processing.

The safe analog input channels (data type SAFEINT) are formed by the arithmetic mean value of the two individual signals. At this point, also note the information about channel diagnostics.

The validity of analog signals is represented by the associated status signals. These binary status signals (data type SAFEBOOL) must also be evaluated each time the analog signals are used. A binary status signal with the status FALSE indicates an invalid value in the analog signal. In these situations, the analog signal is no longer permitted to be used for safety-related assessments.

To exit an error state, a reset must be carried out. For this to be possible, a valid signal must be received at the analog input for the duration of the I/O update time. The error can then be acknowledged by a rising edge on signal "SafeRelease0x0y".

10 Input circuit diagram

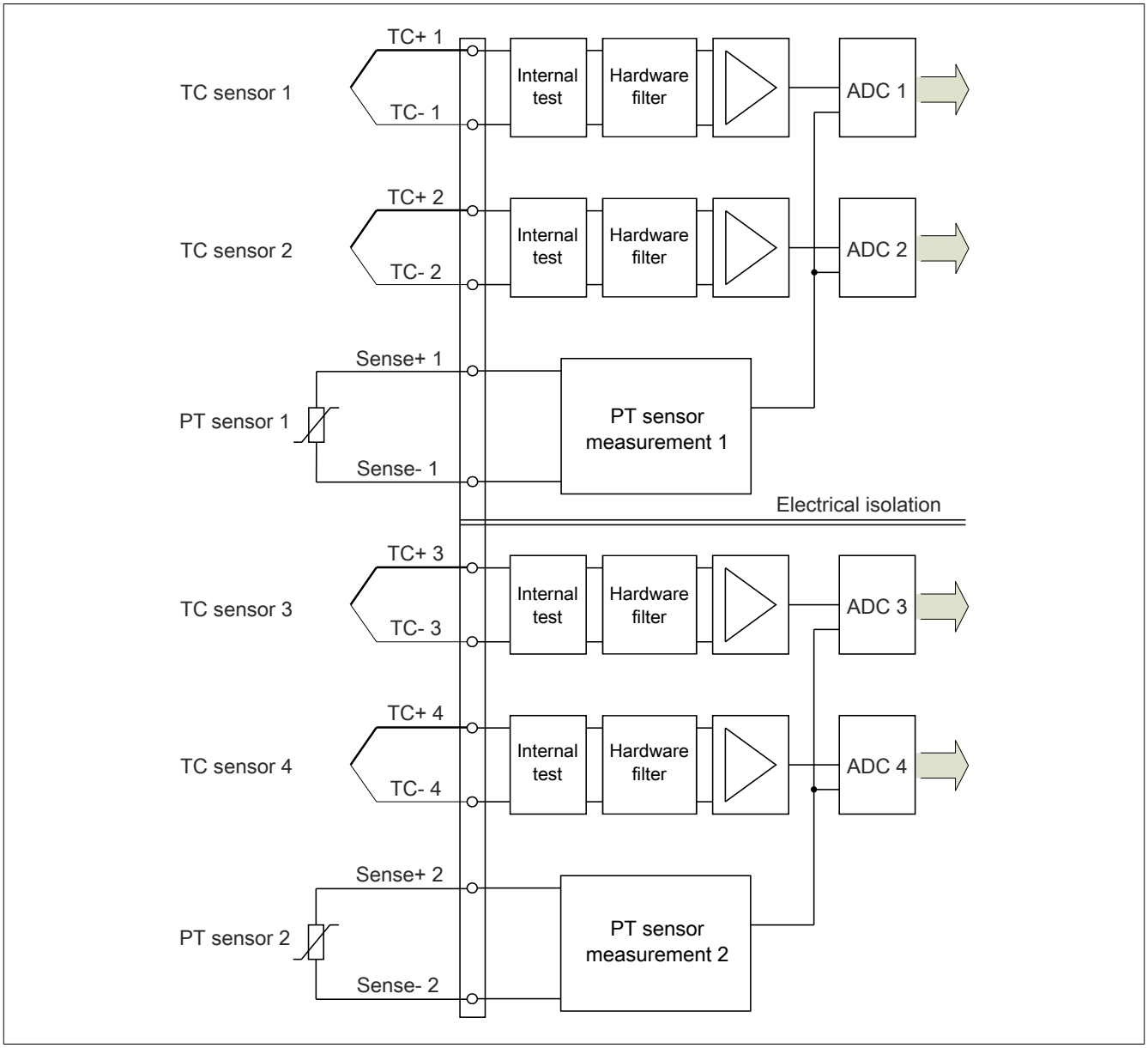


Figure 5: Input circuit diagram

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.

Danger!

With regard to the I/O update time, an I/O update time of 200 ms should generally be considered for temperature modules up to firmware version 301. The maximum I/O update time is 400 ms.

The I/O update time has been optimized in firmware version 302 and later. The optimized times are listed in the table for the maximum I/O update time.

Configured filter	Maximum I/O update time
1 ms	32 ms
2 ms	40 ms
10 ms	86 ms
16.7 ms	132 ms
20 ms	152 ms
33.3 ms	240 ms
40 ms	284 ms
66.7 ms	372 ms

13 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.

14 Register description

14.1 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 12: 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 1.10.1.1 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.		
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	-

Table 13: I/O configuration parameters: General

14.2 Parameters in SafeDESIGNER - up to Release 1.9

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 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.
Yes	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.
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.
Not_Present (Release 1.9 and later)	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.

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.

TwoChannelMode	This value sets the channels being used for dual-channel evaluation.	Channel12	-

Parameter value	Description
Channel12	Channels 1 and 2 as well as Channels 3 and 4 are used for dual-channel evaluation.
Channel13	Channels 1 and 3 as well as Channels 2 and 4 are used for dual-channel evaluation.

Input_Filter_ms	This parameter sets the filter time of A/D converters.	1	ms

Table 14: 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.		
Synchronous_Network_Only	This parameter describes the synchronization characteristics of the network being used. They are defined in Automation Studio / Automation Runtime.	Yes	-
	Parameter value / **Description** Yes: 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. No: No requirement for synchronization of the networks		
Max_X2X_CycleTime_us	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)	5000	µs
Max_Powerlink_CycleTime_us	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)	5000	µs
Max_CPU_CrossLinkTask_ CycleTime_us	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)	5000	µs
Min_X2X_CycleTime_us	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)	200	µs
Min_Powerlink_CycleTime_us	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)	200	µs
Min_CPU_CrossLinkTask_ CycleTime_us	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)	0	µs
Worst_Case_Response_Time_us	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)	50000	µs
Node_Guarding_Lifetime	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".	5	-

Table 15: SafeDESIGNER parameters: Safety_Response_Time

Group: SafeTemperatureInputxx

Parameter	Description	Default value	Unit
Sensor_Type (for SafeTemperatureInput01-04)	This parameter can be used to specify the type of sensor connected. • Permissible values: Type J, Type K, Type N, Type S, Type R, Type C, Type T, Voltage [µV]	Type J	-
Sensor_Type (for SafeTemperatureInput05-06)	This parameter can be used to specify the type of sensor connected. • Permissible values: PT100, PT1000	PT1000	-

Table 16: SafeDESIGNER parameters: SafeTemperatureInputxx

Danger!

The use or configuration of an incorrect TC sensor type CANNOT be detected by the module. The temperature value acquired by the module is incorrect.

Make sure during validation that the correct TC sensor type is installed and configured.

Information:

The use or configuration of an incorrect PT sensor type is detected by the module. The module will switch to the FAILSAFE state.

Group: SafeTemperatureInputxxyy

Parameter	Description	Default value	Unit
Limit_Threshold_High_1, Limit_Threshold_High_2, Limit_Threshold_High_3, Limit_Threshold_High_4	This parameter specifies the current maximum permissible analog input value. • Permissible values during temperature measurement: Corresponds to the thermocouple type • Permissible values during voltage measurement: -32,768 to +32,767	1000	0.1°C 2 µV
Limit_Threshold_Low_1, Limit_Threshold_Low_2, Limit_Threshold_Low_3, Limit_Threshold_Low_4	This parameter specifies the current minimum permissible analog input value. • Permissible values during temperature measurement: Corresponds to the thermocouple type • Permissible values during voltage measurement: -32768 to +32767	0	0.1°C 2 µV
Limit_Threshold_Equivalent_1, Limit_Threshold_Equivalent_2, Limit_Threshold_Equivalent_3, Limit_Threshold_Equivalent_4	This parameter specifies the limit value for the "Dual-channel evaluation" function for the maximum temperature difference between the two channels. • Permissible values during temperature measurement: Corresponds to the thermocouple type • Permissible values during voltage measurement: -32768 to +32767	1000	0.1°C 2 µV
Discrepancy_Time_1_ms, Discrepancy_Time_2_ms, Discrepancy_Time_3_ms, Discrepancy_Time_4_ms	This parameter specifies the maximum time for the "Dual-channel evaluation" function in which the difference between both analog input values is permitted to exceed the limit value. • Permissible values: 0 to 10,000 ms (corresponds to 0 to 10 s)	0	ms

Table 17: SafeDESIGNER parameters: SafeTemperatureInputxxyy

Parameters "Limit_Threshold_High_x", "Limit_Threshold_Low_x", "Limit_Threshold_Equivalent_x" and "Discrepancy_Time_x_ms" together make up a parameter set. The channels "SafeThrSelector_xxyy_Bit1" and "SafeThrSelector_xxyy_Bit2" are available in the SafeDESIGNER application to determine which parameter set in the module is enabled, i.e. it is possible to change the parameter set at runtime.

14.3 Parameters in SafeDESIGNER - Release 1.10 and higher

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 18: 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 19: SafeDESIGNER parameters: Safety Response Time

Group: Module Configuration

Parameter	Description	Default value	Unit
Two-Channel Mode	This value sets the channels being used for dual-channel evaluation.	Channel 1-2	-
	Parameter value / **Description** Channel 1-2: Channels 1 and 2 as well as Channels 3 and 4 are used for dual-channel evaluation. Channel 1-3: Channels 1 and 3 as well as Channels 2 and 4 are used for dual-channel evaluation.		
Input Filter	This parameter sets the filter time of A/D converters. • Permissible values: 1 ms, 2 ms, 10 ms, 16.7 ms, 20 ms, 33.3 ms, 40 ms, 66.7 ms	1	ms
Measurement Result while Testing	This parameter enables the signal behavior specified prior to firmware version 321 for the duration of signal diagnostics (see chapter "Channel diagnostics").	Single channel	-
	Parameter value / **Description** Averaged: During testing, the safe analog signal results from the mean value of the individual signals. Single channel: During testing, the safe analog signal corresponds to the individual signal of the channel that is not currently being diagnosed.		

Table 20: SafeDESIGNER parameters: Module Configuration

Group: SafeTemperaturexx

Parameter	Description	Default value	Unit
Sensor Type (for SafeTemperatureInput01-04)	This parameter can be used to specify the type of sensor connected. • Permissible values: Type J, Type K, Type N, Type S, Type R, Type C, Type T, Voltage (µV)	Type J	-
Sensor Type (for SafeTemperatureInput05-06)	This parameter can be used to specify the type of sensor connected. • Permissible values: PT100, PT1000	PT1000	-

Table 21: SafeDESIGNER parameters: SafeTemperaturexx

Danger!

The use or configuration of an incorrect TC sensor type CANNOT be detected by the module. The temperature value acquired by the module is false.

Make sure during validation that the correct TC sensor type is installed and configured.

Information:

The use or configuration of an incorrect PT sensor type is detected by the module. The module will switch to the FAILSAFE state.

Group: SafeTemperaturexxyy

Parameter	Description	Default value	Unit
Limit Threshold High 1, Limit Threshold High 2, Limit Threshold High 3, Limit Threshold High 4	This parameter specifies the current maximum permissible analog input value. • Permissible values during temperature measurement: Corresponds to the thermocouple type • Permissible values during voltage measurement: -2,147,483,648 to +2,147,483,647	1000	0.1°C 2 µV
Limit Threshold Low 1, Limit Threshold Low 2, Limit Threshold Low 3, Limit Threshold Low 4	This parameter specifies the current minimum permissible analog input value. • Permissible values during temperature measurement: Corresponds to the thermocouple type • Permissible values during voltage measurement: -2,147,483,648 to +2,147,483,647	0	0.1°C 2 µV
Limit Threshold Equivalent 1, Limit Threshold Equivalent 2, Limit Threshold Equivalent 3, Limit Threshold Equivalent 4	This parameter specifies the limit value for the "Dual-channel evaluation" function for the maximum temperature difference between the two channels. • Permissible values during temperature measurement: Corresponds to the thermocouple type • Permissible values during voltage measurement: -2,147,483,648 to +2,147,483,647	1000	0.1°C 2 µV
Discrepancy Time 1, Discrepancy Time 2, Discrepancy Time 3, Discrepancy Time 4	This parameter specifies the maximum time for the "Dual-channel evaluation" function in which the difference between both analog input values is permitted to exceed the limit value. • Permissible values: 0 to 10,000 ms (corresponds to 0 to 10 s)	0	ms

Table 22: SafeDESIGNER parameters: SafeTemperaturexxyy

The parameters "Limit Threshold High x", "Limit Threshold Low x", "Limit Threshold Equivalent x" and "Discrepancy Time x" together make up a parameter set. The channels "SafeThrSelector_xxyy_Bit1" and "SafeThrSelector_xxyy_Bit2" are available in the SafeDESIGNER application to determine which parameter set in the module is enabled, i.e. it is possible to change the parameter set at runtime.

14.4 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 1.10.2.0 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 1.10.2.0 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 1.10.2.0 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>SafeModuleOK</td><td>-</td><td>Read</td><td>SAFEBOOL</td><td>Indicates if the safe communication channel is OK</td></tr>
<tr><td>ChannelOKxx</td><td>Read</td><td>-</td><td>BOOL</td><td>Status of physical channel xx</td></tr>
<tr><td>SafeChannelOKxx</td><td>Read</td><td>Read</td><td>SAFEBOOL</td><td>Status of physical channel xx</td></tr>
<tr><td>SafeTemperatureOKxxyy</td><td>Read</td><td>Read</td><td>SAFEBOOL</td><td>Status of dual-channel temperature evaluation xx/yy</td></tr>
<tr><td>TestActive</td><td>Read</td><td>Read</td><td>BOOL</td><td>Indication of an active channel test</td></tr>
<tr><td>EquivalentThresholdxxyy</td><td>(Read)[1)]</td><td>-</td><td>UINT</td><td>Limit value "Limit Threshold Equivalent" currently in use (see "SafeDESIGNER parameters: SafeTemperaturexxyy")</td></tr>
<tr><td>DiscrepanceTimeThresholdxxyy</td><td>(Read)[1)]</td><td>-</td><td>UINT</td><td>Limit value "Discrepancy Time" currently in use (see "SafeDESIGNER parameters: SafeTemperaturexxyy")</td></tr>
<tr><td>SafeTemperaturexxyy</td><td>Read</td><td>Read</td><td>SAFEINT</td><td>(Temperature channel xx + Temperature channel yy)/2</td></tr>
<tr><td>TemperatureOKxx</td><td>Read</td><td>-</td><td>BOOL</td><td>Status of temperature evaluation xx</td></tr>
<tr><td>Temperature_A</td><td>Read</td><td>-</td><td>INT</td><td>Temperature of the temperature channel selected with "TempChnl_Select_A"</td></tr>
</table>

Table 23: 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>TempChnl_Select_A</td><td>Write</td><td>-</td><td>USINT</td><td>Selection of the temperature to be transferred on the "Temperature_A" channel</td></tr>
<tr><td>SafeThrSelector_xxyy_Bit1</td><td>-</td><td>Write</td><td>SAFEBOOL</td><td rowspan="2"><table><tr><th>**_Bit1</th><th>**_Bit2</th><th>Parameters currently being used</th></tr><tr><td>0</td><td>0</td><td>Parameter set 1</td></tr><tr><td>1</td><td>0</td><td>Parameter set 2</td></tr><tr><td>0</td><td>1</td><td>Parameter set 3</td></tr><tr><td>1</td><td>1</td><td>Parameter set 4</td></tr></table></td></tr>
<tr><td>SafeThrSelector_xxyy_Bit2</td><td>-</td><td>Write</td><td>SAFEBOOL</td></tr>
<tr><td>SafeReleasexxyy</td><td>-</td><td>Write</td><td>SAFEBOOL</td><td>Release signal - Channel xxyy</td></tr>
</table>

Table 23: Channel list

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

Danger!

The validity of analog signals is represented by the associated status signals. These binary status signals (data type SAFEBOOL) must also be evaluated each time the analog signals are used. A binary status signal with the status FALSE indicates an invalid value in the analog signal. When this happens, the analog signal is no longer permitted to be used for safety-related assessments.

15 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.

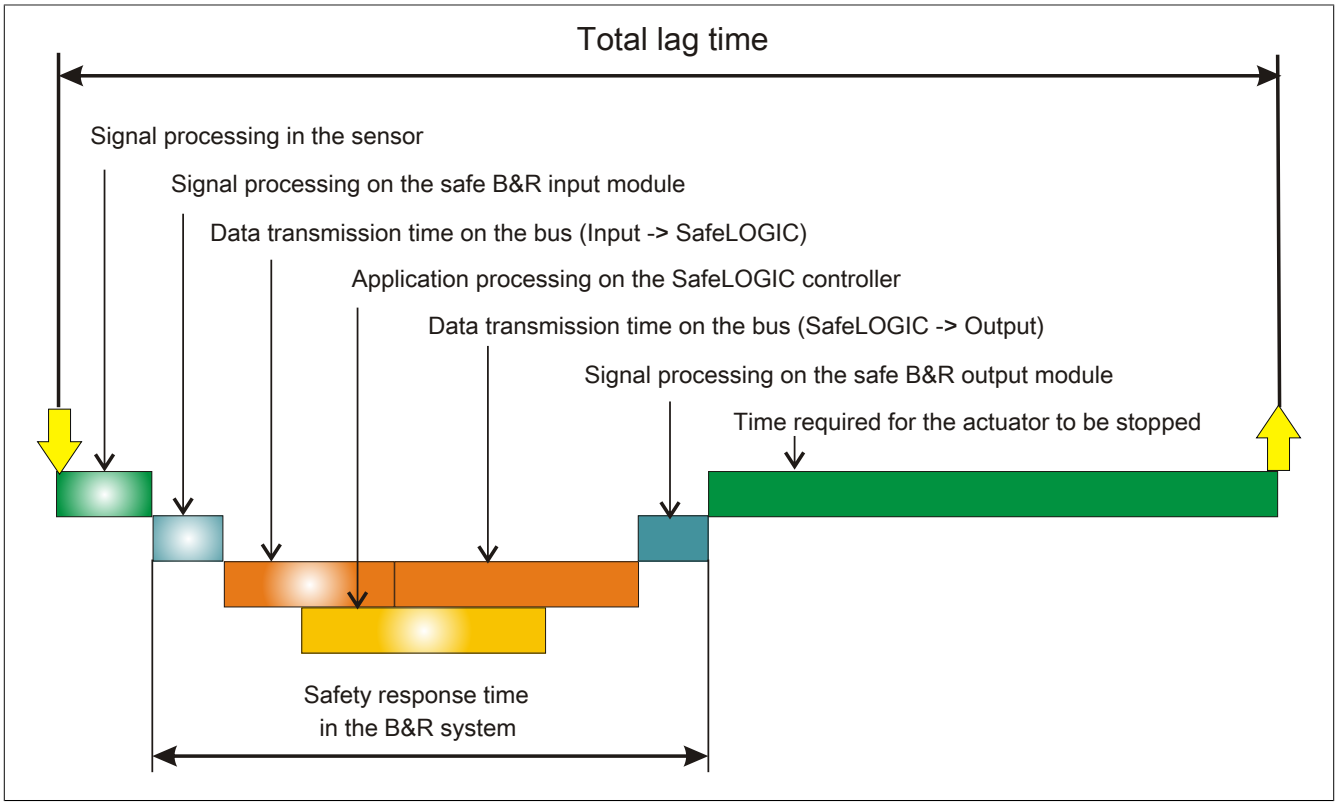


Figure 6: Total lag time

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).

15.1 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.

15.2 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 15 "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.

15.3 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.

15.4 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.

16 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.

16.1 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.

16.2 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.

16.3 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.

16.4 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.

16.5 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

16.6 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.

16.7 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).

16.8 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.

17 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>
<tr><th>Version</th><th>Starting with</th><th>Up to</th></tr>
<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 24: Release information

18 Version history

Version	Date	Comment
1.141	April 2019	• Chapter 4 "Technical data": Updated standards. • Updated chapter 16.3 "Security concept". • Updated chapter 16.6 "Installation notes for X20 modules".
1.140	February 2019	• Chapter 4 "Technical data": Limited installation elevation to 2000 m. • Chapter 14.1 "Parameters in the I/O configuration": Added parameter "Blackout mode". • Chapter 14.3 "Parameters in SafeDESIGNER - Release 1.10 and higher": Updated description of "Safe Data Duration". • Chapter 14.4 "Channel list": Added new channels. • Chapter 15.2 "Data transmission time on the bus": Updated calculation of maximum data transmission time and updated information. • Chapter 16 "Intended use": Added danger notice. • Added chapter "Security notes". • Chapter 16.5 "X20 system characteristics": Added warning notice. • Updated standards. • Editorial changes.
1.110	June 2017	• Chapter 4 "Technical data": Updated standards and safety characteristics. • Chapter 8.3 "Signal errors": Updated description. • Chapter 8.4 "Channel diagnostics": Updated description of the behavior of different firmware versions. • Chapter 9 "Module function": Added. • Chapter 14.3 "Parameters in SafeDESIGNER - Release 1.10 and higher": Group "Module Configuration": Added parameter "Measurement Result while Testing". • Chapter 14.4 "Channel list": Added new channels.
1.101	March 2016	• Chapter 15 "Safety response time": Added information.
1.100	January 2016	• Chapter 1 "General information": Added. • Chapter 4 "Technical data": – Updated standards. – Updated temperature range and derating. – Updated technical data. • Chapter 8.3 "Signal errors": Updated figures. • Revised chapter 12 "I/O update time". • Chapter 14.3 "Parameters in SafeDESIGNER - Release 1.10 and higher": Added. • Chapter 15.1 "Signal processing on the safe B&R input module": Updated description. • Chapter 15.2 "Data transmission time on the bus": Updated description with "Release 1.10 and later". • Chapter 15.3 "Signal processing on the safe B&R output module": Updated description. • Chapter 15.4 "Minimum signal lengths": Updated description. • Revised chapter 16.4 "Safety technology disclaimer". • Chapter 17 "Release information": Updated.
1.92	June 2015	• Chapter 4 "Technical data": – "Resistance measurement temperature input": "Measurement range": Updated values. – "Ambient conditions": "Temperature": "Storage": Extended to -40°C. – "Ambient conditions": "Temperature": "Transport": Extended to -40°C. • Chapter 14.2 "Parameters in SafeDESIGNER - up to Release 1.9": Group "Basic": Updated parameter value "Not_Present" for "Optional". • Chapter 15.1 "Signal processing on the safe B&R input module": Updated description. • Chapter 17 "Release information": Updated.

Table 25: Version history

Version	Date	Comment
1.90	October 2014	• Chapter 4 "Technical data": – "Short description": "I/O module": Adapted text to order data. – "System requirements" updated – Added "Safety-related characteristic values" and deleted chapter "Safety-related characteristic values". • Chapter 8.3 "Signal errors": Updated description. • Chapter 12 "I/O update time": Added table "Max. safety response time", updated danger notice and deleted table "I/O update time". • Chapter 13 "Restart behavior": Updated description. • Chapter 14.2 "Parameters in SafeDESIGNER - up to Release 1.9": Group "Basic": Added parameter value "Not_Present" for "Optional". • Chapter 14.2 "Parameters in SafeDESIGNER - up to Release 1.9": Group "Safety_Response_Time": Added parameter "Node_Guarding_Lifetime". • Chapter 15.2 "Data transmission time on the bus": Updated description. • Updated chapter 17 "Release information".
1.70	February 2014	• Chapter 4 "Technical data": General information: Updated system requirements. • Updated chapter 4.1 "Safety-oriented measurement precision". • Chapter 16.6 "Installation notes for X20 modules": Removed figure "Protecting various potential groups" and updated description.
1.63	November 2013	• Updated standards. • Chapter 4 "Technical data": Added danger notice. • Chapter 8.1 "Internal module errors": Added danger notice and updated description. • Added chapter 13 "Restart behavior". • Updated chapter 17 "Release information". • Editorial changes.
1.51	March 2012	First edition as a product-specific manual

Table 25: Version history

19 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.