B&R

X20AI8039

Data sheet
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1 General information

1.1 Other applicable documents

For additional and supplementary information, see the following documents.

Other applicable documents

Document name	Title
MAX20	X20 System user's manual

1.2 Order data

Order number	Short description	Figure
	Analog input modules	
X20AI8039	X20 analog input module, 8 inputs, configurable signal, ±10 V or 0 to 20 mA / 4 to 20 mA, or Pt100 / Pt1000, 2- or 3-wire connections, ICTD measurement, 16-bit converter resolution, configurable input filter	
	Required accessories	
	Terminal blocks	
X20TBS1	Terminal block set for X20 I/O module: 2x 16-pin terminal block	
X20TBS2	Terminal block set for X20 I/O module: 8x 4-pin terminal block	

Table 1: X20AI8039 - Order data

1.3 Module description

This module is equipped with 8 configurable inputs. The measurement type of each input can be set individually.

The following measurement types are available:

- ±10 V
- 0 to 20 mA / 4 to 20 mA
- 2- or 3-wire Pt100/Pt1000 resistance temperature measurement
- ICTD measurement

Information:

If the module is operated in X2X Link mode directly behind an X20CPx68x product variant, the module is not permitted to be in the first position after the controller; another I/O module must be connected in front of it.

Functions

- Setting the input signal
- Sensor type and resistance measuring range
- Monitoring the input signal
- Input filter
- Conversion rate
- NetTime Technology

Sensor type and measurement range

The module can be used for both measurement sensor and resistance measurement. The measurement range varies depending on the operating mode set.

Monitoring the input signal

The input signal of the analog inputs is monitored against the upper and lower limit values as well as for open circuit.

Input filter

An input filter can be configured for each individual analog input.

Conversion rate

The conversion rate can be set separately for each channel. The number of conversions per second (samples per second - SPS) is specified.

NetTime timestamp of the measurement

Not only is the measured value important for many applications, but also the exact time when the measurement takes place. The module is equipped with a NetTime timestamp function for this that supplies a timestamp for the recorded measurement with microsecond accuracy.

2 Technical description

2.1 Technical data

Order number	X20AI8039
Short description	
I/O module	8 configurable inputs: ±10 V, 0 to 20 mA, 4 to 20 mA, Pt100 / Pt1000 resistance temperature measurement or ICTD measurement
Interfaces	1x X2X Link
General information	
B&R ID code	0x32A4
Status indicators	I/O function per channel, operating state, module status
Diagnostics	
Module run/error	Yes, using LED status indicator and software
Inputs	Yes, using LED status indicator and software
Power consumption	
Bus	0.6 W
Internal I/O	1.3 W
Additional power dissipation caused by actuators (resistive) [W]	-
Certifications	
CE	Yes
UKCA	Yes
Analog inputs	
Input	±10 V, 0 to 20 mA, 4 to 20 mA
Input type	Differential input
Digital converter resolution	
Voltage	±15-bit
Current	15-bit
Conversion time	Configurable for each channel
Output format	
Data type	INT
Voltage	INT 0x8001 - 0x7FFF / 1 LSB = 0x0001 = 305.176 µV
Current	INT 0x0000 - 0x7FFF / 1 LSB = 0x0001 = 610.352 nA
Input impedance in signal range	
Voltage	Typ. 20 GΩ
Current	-
Load	
Voltage	-
Current	<350 Ω
Input protection	Protection against wiring with supply voltage
Permissible input signal	
Voltage	Max. ±32 V
Current	Max. ±50 mA
Output of digital value during overload	
Undershoot	
Voltage	0x8001
Current	0x0000
Overshoot	
Voltage	0x7FFF
Current	0x7FFF
Conversion procedure	Sigma-delta
Max. error [1]	
Voltage	
Gain	±0.08% [2]
Offset	±0.01% [3]
Current	
Gain	0 to 20 mA: 0.1% / 4 to 20 mA: 0.125% [2]
Offset	0 to 20 mA: 0.02% / 4 to 20 mA: 0.025% [4]
Max. gain drift	
Voltage	±0.01%/°C [2]
Current	0 to 20 mA: ±0.01%/°C 4 to 20 mA: ±0.013%/°C [2]
Max. offset drift	
Voltage	±0.0005%/°C [3]
Current	0 to 20 mA: ±0.001%/°C 4 to 20 mA: ±0.0013%/°C [4]

Table 2: X20AI8039 - Technical data

Technical description

Order number	X20AI8039
Common-mode rejection	
DC	TBD dB
50 Hz	TBD dB
Common-mode range	±12 V
Crosstalk between channels	<-TBD dB
Nonlinearity	
Voltage	<0.01% [3]
Current	<0.01% [4]
Insulation voltage between channel and bus	500 V_{eff}
Input filter	
Hardware	Third-order low-pass filter / Cutoff frequency 10 kHz
Software	Configurable: Sinc 1 to 4 filter or FIR
Resistance measurement temperature inputs	
Input	Resistance measurement with constant current supply for 2- or 3-wire connections
Input protection	Protection against wiring with supply voltage
Digital converter resolution	16- or 18-bit
Conversion time	Configurable for each channel
Conversion procedure	Sigma-delta
Output format	INT/DINT for temperature measurement UINT for resistance measurement
Sensor	
Sensor type	Configurable per channel
Pt100	-200 to 850°C
Pt1000	-200 to 850°C
Resistance measurement range	0.01 to 600 Ω / 0.1 to 4800 Ω
Resistance measurement resolution	600 Ω: 0.01 Ω / 4800 Ω: 0.1 Ω
Sensor standard	EN 60751
Common-mode range	>0.7 V
Insulation voltage between channel and bus	500 V_{eff}
Linearization method	Internal
Measurement current	250 µA with Pt100 or 600 Ω 100 µA with Pt1000 or 4800 Ω
Reference	5000 Ω ±0.1%
Permissible input signal	Max. ±32 V
Max. error at 25°C	
Gain	Pt100 and 600 Ω: ±1% / Pt1000 and 4800 Ω: ±0.5% [5]
Offset	Pt100 and 600 Ω: ±0.2% / Pt1000 and 4800 Ω: ±0.1% [6]
Max. gain drift	Pt100 and 600 Ω: ±0.05%/°C Pt1000 and 4800 Ω: ±0.025%/°C [5]
Max. offset drift	Pt100 and 600 Ω: ±0.01%/°C Pt1000 and 4800 Ω: ±0.005%/°C [6]
Nonlinearity	<0.01% [6]
Standardized range of values for resistance measurement	600 Ω: 0.01 to 600.00 Ω / 4800 Ω: 0.1 to 4800.0 Ω
Crosstalk between channels	<-TBD dB
Temperature sensor resolution	
Pt100	1 LSB = 0.1 or 0.01°C
Pt1000	1 LSB = 0.1 or 0.01°C
Input filter	
Hardware	Third-order low-pass filter / Cutoff frequency 10 kHz
Software	Configurable: Sinc 1 to 4 filter or FIR
Common-mode rejection	
50 Hz	>TBD dB
DC	>TBD dB
Temperature sensor normalization	
Pt100	INT: -200.0 to 850.0°C DINT: -200.00 to 850.00°C
Pt1000	INT: -200.0 to 850.0°C DINT: -200.00 to 850.00°C
Temperature measurement monitoring	
Range undershoot	0x8001
Range overshoot	0x7FFF
Open circuit	0x7FFF
General fault	0x8000
Open inputs	0x7FFF
Resistance measurement monitoring	
Range overshoot	0xFFFF
Open circuit	0xFFFF
General fault	0xFFFF
Open inputs	0xFFFF
ICTD measurement	
Input	ICTD measurement
Type of output	5 V power supply output for the ICTD sensor

Table 2: X20AI8039 - Technical data

Order number	X20AI8039
Sensor	ICTD measuring probe
Digital converter resolution	16-bit
Conversion time	Configurable for each channel
Conversion procedure	Sigma-delta
Output format	
Data type	INT
Temperature sensor	1 LSB = 0x0001 = TBD nA
Current measurement range	233 to 373 µA
Temperature sensor normalization	-40.0 to 100.0°C
Input filter	
Hardware	Third-order low-pass filter / Cutoff frequency 10 kHz
Software	Configurable: Sinc 1 to 4 filter or FIR
Input protection	Protection against wiring with supply voltage Exception: Terminal "ICTD x +: 5 V" - see section "Pinout".
Max. error at 25°C	
Gain	±0.5% [2]
Offset	±1.2% [7]
Max. gain drift	±0.03%/°C [2]
Max. offset drift	±0.06%/°C [7]
Common-mode rejection	TBD
Common-mode range	TBD
Crosstalk between channels	TBD
Nonlinearity	<0.01%
Insulation voltage between channel and bus	500 V_{eff}
Electrical properties	
Electrical isolation	Channel isolated from bus Channel not isolated from channel
Operating conditions	
Mounting orientation	
Horizontal	Yes
Vertical	Yes
Installation elevation above sea level	
0 to 2000 m	No limitation
>2000 m	Reduction of ambient temperature by 0.6°C per 100 m
Maximum	4000 m
Degree of protection per EN 60529	IP20
Ambient conditions	
Temperature	
Operation	
Horizontal mounting orientation	-25 to 60°C
Vertical mounting orientation	-25 to 50°C
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 terminal blocks separately (see section "Order data").
Dimensions	
Width (pitch)	$27.5^{+0.2}$ mm
Height	124 mm
Depth	92 mm

Table 2: X20AI8039 - Technical data

1) At 25°C.
2) Based on the current measured value.
3) Based on the 20 V measurement range.
4) Based on the 20 mA measurement range.
5) Based on the current measured resistance value.
6) Based on the entire resistance measurement range.
7) Based on the entire current measurement range.

2.2 LED status indicators

For a description of the various operating modes, see section "Additional information - Diagnostic LEDs" in the X20 system user's manual.

Figure	LED	Color	Status	Description
	r	Green	Off	No power to module
			Single flash	Mode RESET
			Double flash	Mode BOOT (during firmware update)[1]
			Blinking	Mode PREOPERATIONAL
			On	Mode OPERATE
	e	Red	Off	Module not supplied with power or everything OK
			On	Error or reset state
			Double flash	A module-internal error occurred. [2]
	1 - 8	Green	Off	The following causes are possible depending on the measurement performed: • Voltage measurement: Open circuit or disconnected sensor • Current measurement: Disconnected sensor
			Blinking	The following causes are possible depending on the measurement performed: • Pt100/Pt1000 or resistance measurement: Open circuit detected • ICTD measurement: Disconnected sensor
			On	Analog/Digital converter running, value OK

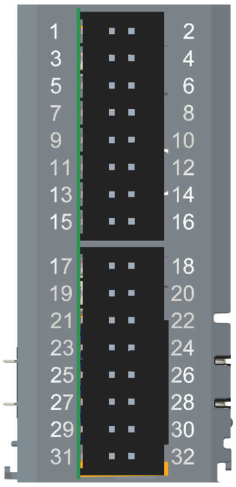
1) Depending on the configuration, a firmware update can take up to several minutes.
2) Please contact B&R Support.

2.3 Pinout

Terminal connection

The 32 terminal connections are connected via terminal blocks. Corresponding sets can be ordered from B&R (see "Order data" on page 3).

The following image contains an overview of the 32 terminal connections.



Channel mapping

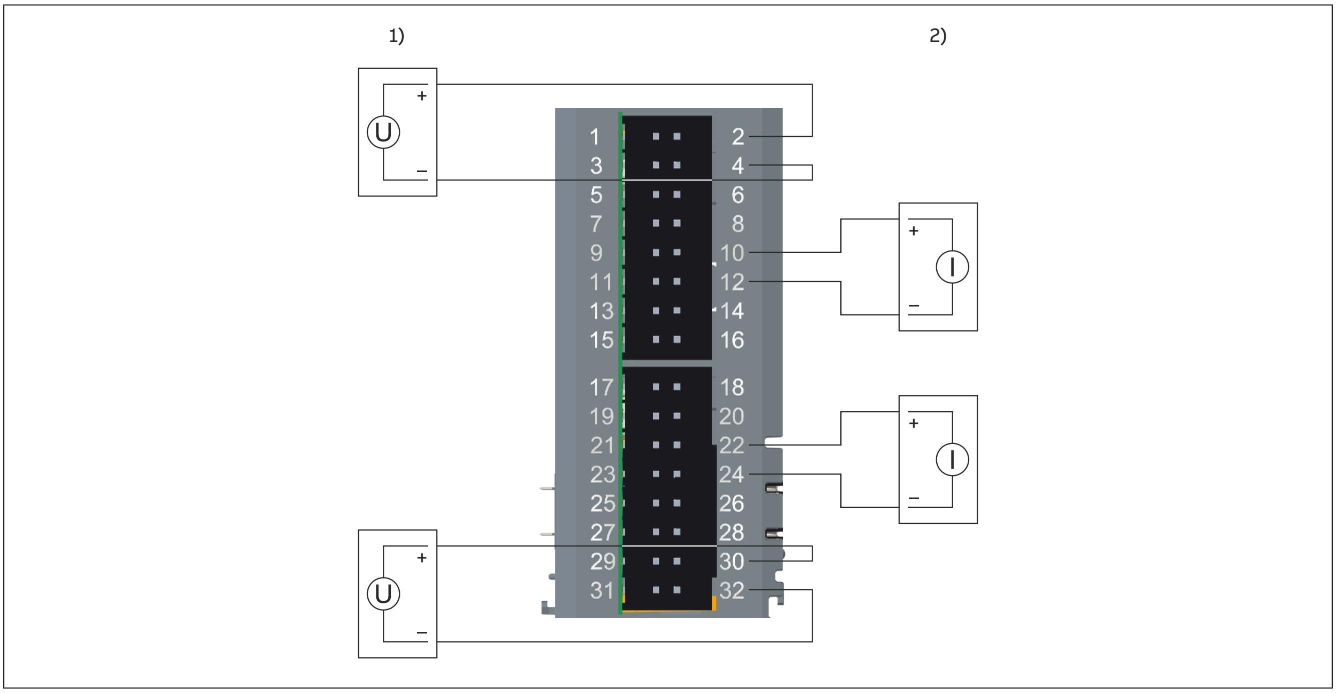
The following overview shows the assignment of terminal connections to the I/O channels and their properties.

> **Information:**
>
> **External voltage is not permitted to be connected to the "ICTD x +: 5 V" terminals. This can damage the module.**

Terminal connection	Channel	Measurement				
		Voltage	Current	RTD 2-wire	RTD 3-wire	ICTD
1	1	-	-	-	-	ICTD 1 +: 5 V
2		U 1 +	I 1 +	Sensor 1 +	Sensor 1 +	ICTD 1 -
3		-	-	-	Sensor 1 -	-
4		U 1 -	I 1 -	Sense 1 -	Sense 1 -	-
5	2	-	-	-	-	ICTD 2 +: 5 V
6		U 2 +	I 2 +	Sensor 2 +	Sensor 2 +	ICTD 2 -
7		-	-	-	Sensor 2 -	-
8		U 2 -	I 2 -	Sense 2 -	Sense 2 -	-
9	3	-	-	-	-	ICTD 3 +: 5 V
10		U 3 +	I 3 +	Sensor 3 +	Sensor 3 +	ICTD 3 -
11		-	-	-	Sensor 3 -	-
12		U 3 -	I 3 -	Sense 3 -	Sense 3 -	-
13	4	-	-	-	-	ICTD 4 +: 5 V
14		U 4 +	I 4 +	Sensor 4 +	Sensor 4 +	ICTD 4 -
15		-	-	-	Sensor 4 -	-
16		U 4 -	I 4 -	Sense 4 -	Sense 4 -	-
17	5	-	-	-	-	ICTD 5 +: 5 V
18		U 5 +	I 5 +	Sensor 5 +	Sensor 5 +	ICTD 5 -
19		-	-	-	Sensor 5 -	-
20		U 5 -	I 5 -	Sense 5 -	Sense 5 -	-
21	6	-	-	-	-	ICTD 6 +: 5 V
22		U 6 +	I 6 +	Sensor 6 +	Sensor 6 +	ICTD 6 -
23		-	-	-	Sensor 6 -	-
24		U 6 -	I 6 -	Sense 6 -	Sense 6 -	-
25	7	-	-	-	-	ICTD 7 +: 5 V
26		U 7 +	I 7 +	Sensor 7 +	Sensor 7 +	ICTD 7 -
27		-	-	-	Sensor 7 -	-
28		U 7 -	I 7 -	Sense 7 -	Sense 7 -	-
29	8	-	-	-	-	ICTD 8 +: 5 V
30		U 8 +	I 8 +	Sensor 8 +	Sensor 8 +	ICTD 8 -
31		-	-	-	Sensor 8 -	-
32		U 8 -	I 8 -	Sense 8 -	Sense 8 -	-

2.4 Connection examples

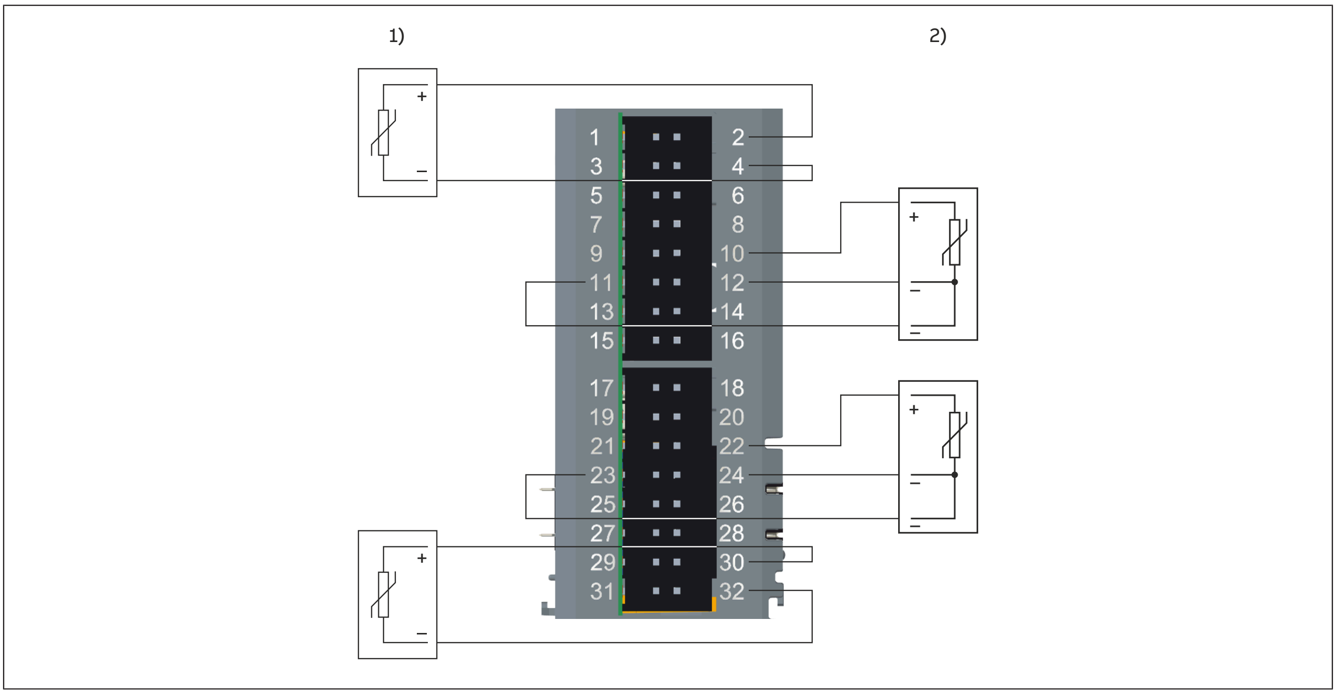
2.4.1 Voltage/Current measurement



1) Voltage measurement

2) Current measurement

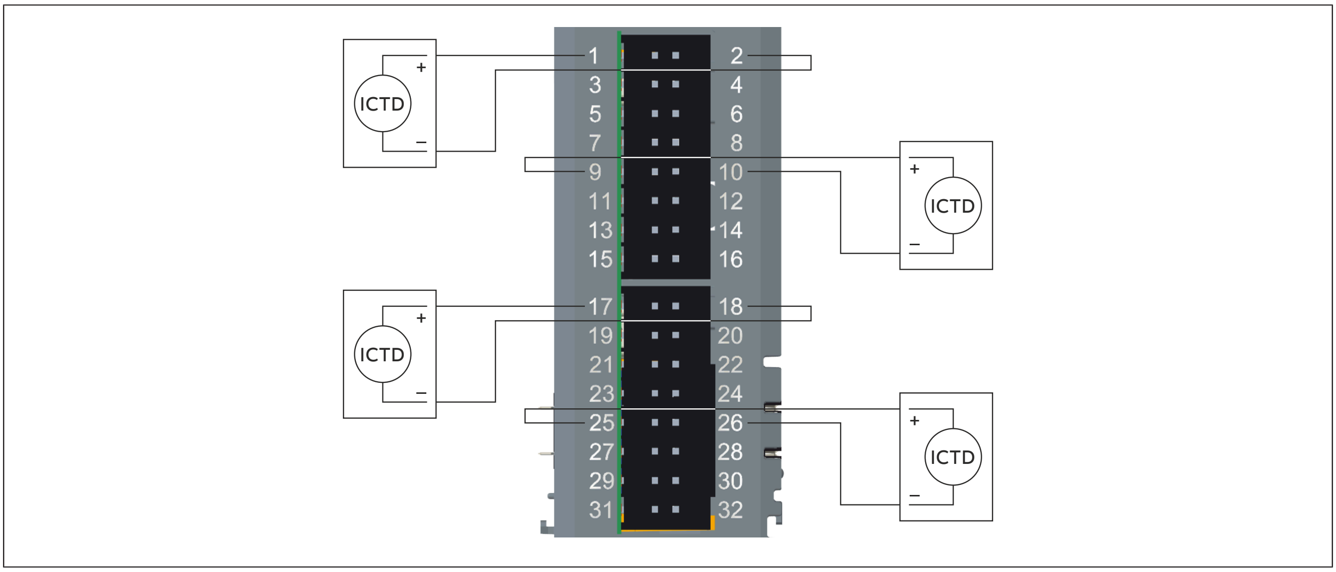
2.4.2 Pt100/Pt1000 temperature measurement



1) 2-wire connections

2) 3-wire connections

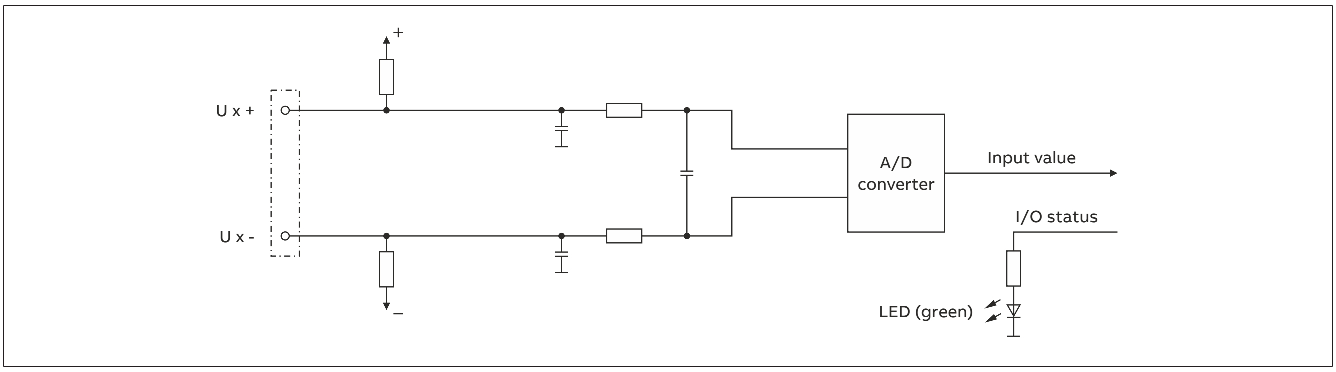
2.4.3 ICTD measurement



2.5 Input circuit diagram

2.5.1 Voltage/Current measurement

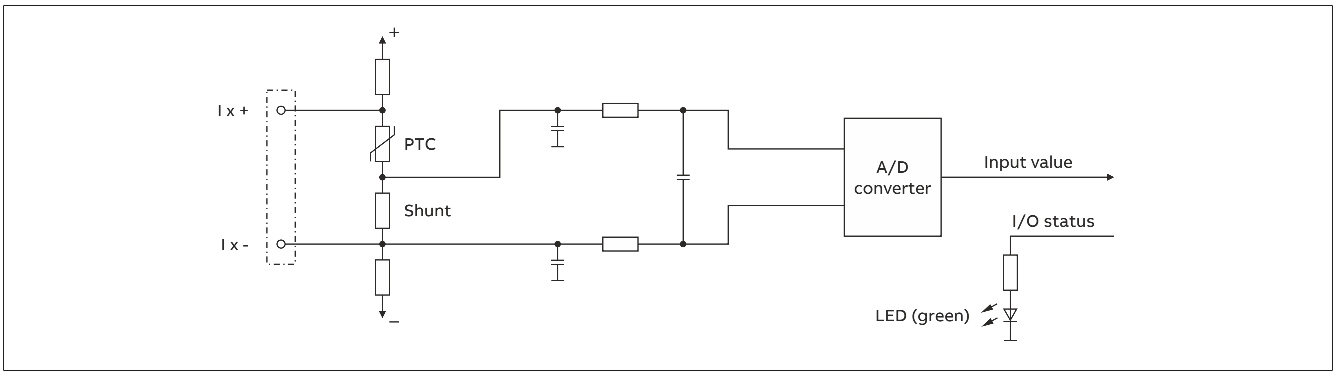
Voltage measurement



The following is an example of the assignment of the signals to the terminal connections of channel 1.

Channel	Terminal connection	Signal
1	1	-
	2	U 1 +
	3	-
	4	U 1 -

Current measurement

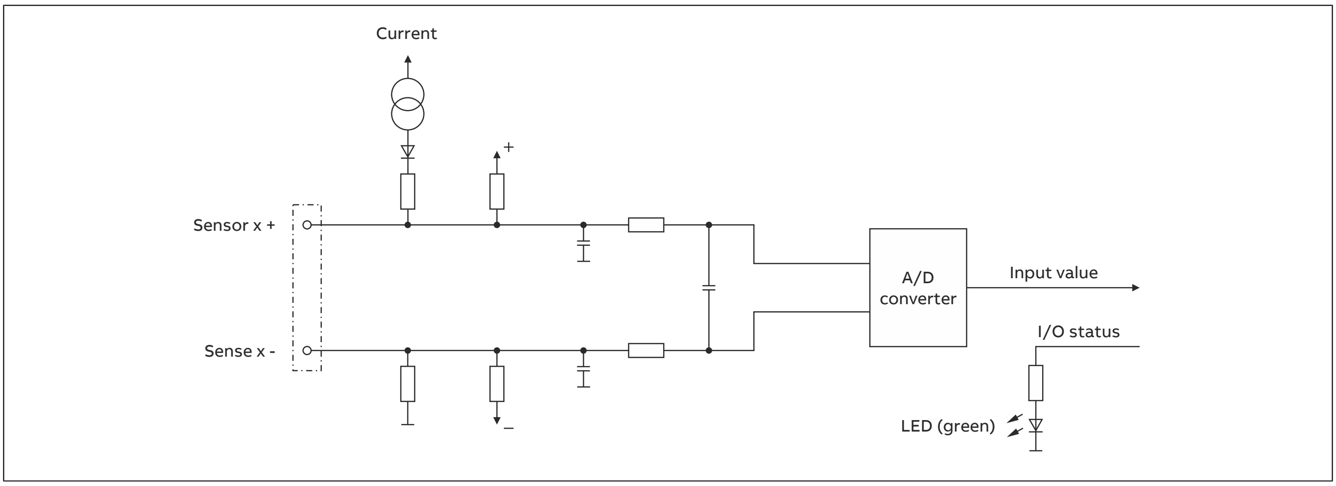


The following is an example of the assignment of the signals to the terminal connections of channel 1.

Channel	Terminal connection	Signal
1	1	-
	2	I 1 +
	3	-
	4	I 1 -

2.5.2 Pt100/Pt1000 temperature measurement

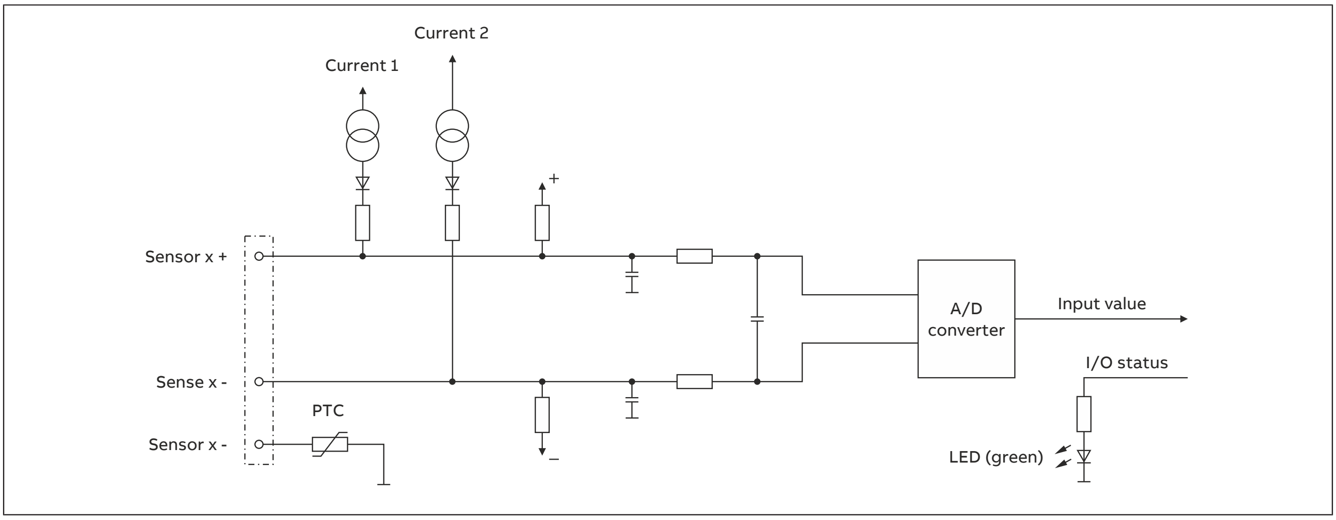
2-wire connections



The following is an example of the assignment of the signals to the terminal connections of channel 1.

Channel	Terminal connection	Signal
1	1	-
	2	Sensor 1 +
	3	-
	4	Sense 1 -

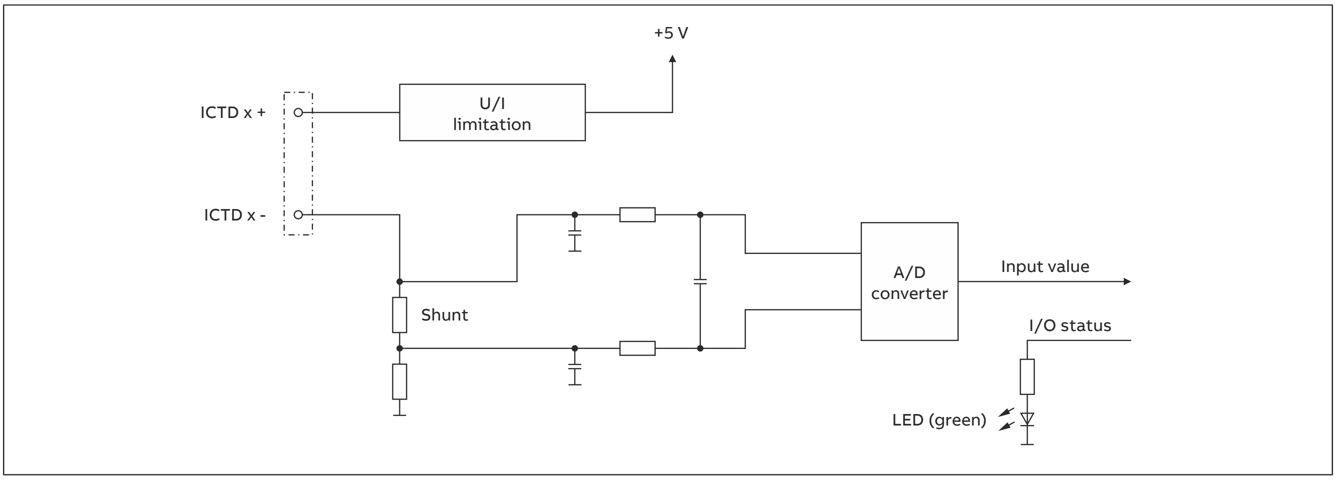
3-wire connections



The following is an example of the assignment of the signals to the terminal connections of channel 1.

Channel	Terminal connection	Signal
1	1	-
	2	Sensor 1 +
	3	Sensor 1 -
	4	Sense 1 -

2.5.3 ICTD measurement



The following is an example of the assignment of the signals to the terminal connections of channel 1.

Channel	Terminal connection	Signal
1	1	ICTD 1 +
	2	ICTD 1 -
	3	-
	4	-

3 Function description

3.1 Setting the input signal

The measurement type can be set individually for each input. The following measurement types are available:

- ±10 V voltage measurement
- 0 to 20 mA current measurement
- 4 to 20 mA current measurement
- 2- or 3-wire Pt100/Pt1000 resistance temperature measurement
- ICTD measurement

Information:

The register is described in "Input signal" on page 27.

3.2 Sensor type and resistance measuring range

The module can be used for both measurement sensor and resistance measurement. The following measurement ranges result depending on the set operating mode:

Input signal	Measurement range
Pt100 sensor type	-200.0 to 850.0°C
Pt1000 sensor type	-200.0 to 850.0°C
Resistance measurement	0.01 to 600 Ω
Resistance measurement	0.1 to 4800 Ω

In order for the user to always be supplied with a defined output value, the following must be taken into consideration:

- Value output until the first conversion:
  0x8000 or 0x80000000
- Value output when switching the operating mode until the first conversion:
  0x8000 or 0x80000000

Information:

The register is described in "Input signal" on page 27.

3.3 Monitoring the input signal

The module's inputs are monitored. A change in the monitoring status is actively transmitted as an error message.

Bit value	Information
00	No error
01	Lower limit value undershot
10	Upper limit value overshot
11	Open circuit

3.3.1 Voltage, current and ICTD measurement

Limit value monitoring

The input signal is monitored against the upper and lower limit values. These must be defined according to the operating mode:

Limit value (default)	Voltage signal ±10 V		Current signal 0 to 20 mA		Current signal 4 to 20 mA	
Upper maximum limit value	+10 V	+32767 (0x7FFF)	20 mA	+32767 (0x7FFF)	20 mA	+32767 (0x7FFF)
Lower minimum limit value	-10 V	-32767 (0x8001)	0 mA	0 1)	4 mA	-8192 (0xE000)

1)
- **Default setting:** The input value has a lower limit of 0x0000. Underflow monitoring is therefore not necessary.
- **After lower limit value change:** The input value is limited to the set value. The status bit is set if undershot.

Limit value (default)	ICTD measurement	
Upper maximum limit value	100°C	3730 (0x0E92)
Lower minimum limit value	-40°C	-400 (0xFE70)

Other limit values can be defined if necessary. The limit values can be set separately for each channel. These are enabled automatically by writing to the limit value registers. From this point on, the analog values will be monitored and limited according to the new limits. The results of monitoring are displayed in the status register.

Examples of limit value settings

Use case	Limit value settings
Current signal: 4 to 20 mA	If values <4 mA should be measured for a current signal with 4 to 20 mA, a negative limit value must be set: 0 mA corresponds to value -8192 (0xE000).
Mixed voltage and current signal	The set limit values apply to all channels. A compromise must therefore be made for mixed operation (voltage and current signal mixed). The following setting has proven to be effective: Upper limit value = +32767, lower limit value = -32767 This also allows negative voltage values to be measured. With a lower limit value of 0, the voltage value would be limited to 0.
Current signal on all channels	All channels are configured for current measurement. The limit value setting in Automation Studio is not adjusted automatically. This means that +32767 is set for the upper limit value and -32767 for the lower limit value. The necessary adjustments must be made by the user, e.g. lower limit value = 0

Limiting the analog value

In addition to the status information, the analog value is fixed to the values listed below by default in an error state. The analog value is limited to the new values if the limit values were changed.

Open circuit

Input signal	Input value Default limits	Input value Configured limit values
±10 V	+32767 (0x7FFF)	Upper limit
0 to 20 mA	0	Lower limit
4 to 20 mA	-8192 (0xE000)	Lower limit
ICTD	-400 (0xFE70)	Lower limit

Other error states

Error state	Digital value on error (default values)	
	Voltage/Current measurement	ICTD measurement
Upper limit value overshot	+32767 (0x7FFF)	3730 (0x0E92)
Lower limit value undershot	-32767 (0x8001)	-400 (0xFE70)
Invalid value	-32768 (0x8000)	-32768 (0x8000)

Information:

The register is described in "Status of the inputs" on page 30.

3.3.2 Pt100/Pt1000 resistance temperature measurement

Limit value monitoring

The input signal is monitored against the upper and lower limit values. The following table contains the default values based on the input signal. The values for the upper and lower limit can be adjusted within the specified range.

Input signal	Upper maximum limit value	Lower minimum limit value
Pt100	0.1°C resolution: +8500 (0x2134) 0.01°C resolution: +85000 (0x00014C08)	0.1°C resolution: -2000 (0xF830) 0.01°C resolution: -20000 (0xFFFFB1E0)
Pt1000	0.1°C resolution: +8500 (0x2134) 0.01°C resolution: +85000 (0x00014C08)	0.1°C resolution: -2000 (0xF830) 0.01°C resolution: -20000 (0xFFFFB1E0)
600 Ω	+60000 (0xEA60)	0
4800 Ω	+48000 (0xBB80)	0

Open circuit

In addition to the status information, the analog value is fixed to the values listed below by default in the event of an open circuit. The analog value is limited to the new values if the limit values were changed.

Input signal	Input value Default limits	Input value Configured limit values
Pt100	0.1°C resolution: +32767 (0x7FFF) 0.01°C resolution: +2,147,483,647 (0x7FFFFFFF)	Upper limit
Pt1000	0.1°C resolution: +32767 (0x7FFF) 0.01°C resolution: +2,147,483,647 (0x7FFFFFFF)	Upper limit
600 Ω	+65535 (0xFFFF)	Upper limit
4800 Ω	+65535 (0xFFFF)	Upper limit

Information:

The register is described in "Status of the inputs" on page 30.

3.4 Input filter

The module is equipped with a configurable input filter. Since very different input signals can be set, the input filter can also be configured separately for each channel.

The following filters are available:

Value	Input filter
1	Sinc 1
2	Sinc 2
3	Sinc 3
4	Sinc 4
5	FIR

Information:

The register for the module configuration is described under "Input filter for the module" on page 26.

The register for the channel-specific configuration is described under "Input filter for the channel" on page 28.

3.5 Conversion rate

The number of conversions per second (samples per second - SPS) can be set for the module. Since very different input signals can be set, the conversion rate can also be set separately for each channel.

The following conversion rates are available:

Value	Conversion rate per second
1	2.5
2	5
3	10
4	16
5	20
6	50
7	60
8	100

Information:

The register for the module configuration is described under "Conversion rate for the module" on page 26.

The register for the channel-specific configuration is described under "Conversion rate for the channel" on page 28.

3.6 Conversion process

The channels of the module are converted consecutively. A distinction is made between the following operating modes:

- Voltage or current measurement
- Pt100/Pt1000, resistance or ICTD measurement
- Mixed operation

3.6.1 Voltage or current measurement

These are fast measurements. An example of the converter time calculation is described in "Example 1 - Analog inputs" on page 21.

3.6.2 Pt100/Pt1000, resistance or ICTD measurement

These are slow measurements. An example of the converter time calculation is described in "Example 2 - Pt100 resistance temperature measurement" on page 21.

3.6.3 Mixed operation

In mixed mode, both slow and fast measurements are performed. To ensure that the fast measurements are not delayed by the slow measurements, the measurements are prioritized differently.

Due to the different prioritization, all fast measurements are always performed in one conversion cycle. Only one of the slow measurements is performed in each conversion cycle. This ensures that the fast measurements are not held up by the slow measurements.

Classification of the measurement types

For the following example, the measurement types are divided into fast and slow measurements. The terms "Fast_Channel" and "Slow_Channel" are used for the example.

Input signal	Type of measurement	Name for example
±10 V	Fast	Fast_Channel
0 to 20 mA	Fast	Fast_Channel
4 to 20 mA	Fast	Fast_Channel
Pt100	Slow	Slow_Channel
Pt1000	Slow	Slow_Channel
600 Ω	Slow	Slow_Channel
4800 Ω	Slow	Slow_Channel
ICTD	Slow	Slow_Channel

Example

This example illustrates the conversion process in mixed mode. The following input signals are used:

Channel	Input signal	Type of measurement	Conversion rate	Input filter	Conversion time per channel1)
1	±10 V	Fast_Channel	Sinc 3	20 SPS	151 ms
2	Pt1000	Slow_Channel	Sinc 4	5 SPS	811 ms
3	4 to 20 mA	Fast_Channel	Sinc 3	20 SPS	151 ms
4	Pt100	Slow_Channel	Sinc 4	5 SPS	811 ms
5	Pt100	Slow_Channel	Sinc 4	5 SPS	811 ms
6	ICTD	Slow_Channel	Sinc 4	5 SPS	801 ms
7	0 to 20 mA	Fast_Channel	Sinc 3	20 SPS	151 ms
8	0 to 20 mA	Fast_Channel	Sinc 3	20 SPS	151 ms

1) For examples of calculating the converter time, see "Calculation examples for conversion time" on page 21.

Overview of the fast measurements

Channel	Input signal	Type of measurement	Conversion time per channel1)
1	±10 V	Fast_Channel[0]	151 ms
3	4 to 20 mA	Fast_Channel[1]	151 ms
7	0 to 20 mA	Fast_Channel[2]	151 ms
8	0 to 20 mA	Fast_Channel[3]	151 ms

1) For examples of calculating the converter time, see "Calculation examples for conversion time" on page 21.

Overview of the slow measurements

Channel	Input signal	Type of measurement	Conversion time per channel1)
2	Pt1000	Slow_Channel[0]	811 ms
4	Pt100	Slow_Channel[1]	811 ms
5	Pt100	Slow_Channel[2]	811 ms
6	ICTD	Slow_Channel[3]	801 ms

1) For examples of calculating the converter time, see "Calculation examples for conversion time" on page 21.

All fast measurements are always performed in one conversion cycle. A slow measurement is also performed.

Conversion 1

Channel	Input signal	Type of measurement	Conversion time per channel
1	±10 V	Fast_Channel[0]	151 ms
3	4 to 20 mA	Fast_Channel[1]	151 ms
7	0 to 20 mA	Fast_Channel[2]	151 ms
8	0 to 20 mA	Fast_Channel[3]	151 ms
2	Pt1000	Slow_Channel[0]	811 ms

This conversion cycle results in a total conversion time of 1415 ms.

Conversion 2

Channel	Input signal	Type of measurement	Conversion time per channel
1	±10 V	Fast_Channel[0]	151 ms
3	4 to 20 mA	Fast_Channel[1]	151 ms
7	0 to 20 mA	Fast_Channel[2]	151 ms
8	0 to 20 mA	Fast_Channel[3]	151 ms
4	Pt100	Slow_Channel[1]	811 ms

This conversion cycle results in a total conversion time of 1415 ms.

Conversion 3

Channel	Input signal	Type of measurement	Conversion time per channel
1	±10 V	Fast_Channel[0]	151 ms
3	4 to 20 mA	Fast_Channel[1]	151 ms
7	0 to 20 mA	Fast_Channel[2]	151 ms
8	0 to 20 mA	Fast_Channel[3]	151 ms
5	Pt100	Slow_Channel[2]	811 ms

This conversion cycle results in a total conversion time of 1415 ms.

Conversion 4

Channel	Input signal	Type of measurement	Conversion time per channel
1	±10 V	Fast_Channel[0]	151 ms
3	4 to 20 mA	Fast_Channel[1]	151 ms
7	0 to 20 mA	Fast_Channel[2]	151 ms
8	0 to 20 mA	Fast_Channel[3]	151 ms
6	ICTD	Slow_Channel[3]	801 ms

This conversion cycle results in a total conversion time of 1405 ms.

Conversion 5

Conversion 5 corresponds to conversion 1. A new conversion cycle is started again.

Channel	Input signal	Type of measurement	Conversion time per channel
1	±10 V	Fast_Channel[0]	151 ms
3	4 to 20 mA	Fast_Channel[1]	151 ms
7	0 to 20 mA	Fast_Channel[2]	151 ms
8	0 to 20 mA	Fast_Channel[3]	151 ms
2	Pt1000	Slow_Channel[0]	811 ms

This conversion cycle results in a total conversion time of 1415 ms.

3.7 Conversion time

The channels of the module are converted consecutively. This section describes the calculation of the converter time.

Conversion time per channel

The conversion time per channel can be calculated from the input filter and the conversion rate.

Formula for calculating the conversion time per channel in milliseconds:

$$\text{Conversion time [ms]} = \frac{1000}{\text{Conversion rate}} \times \text{Input filter}$$

Delay time before measurement

Before the measurement of a channel can be started, a delay time of 1 ms must be taken into account.

Pt100/Pt1000 resistance temperature measurement

For Pt100/Pt1000 resistance temperature measurement, 10 ms must also be taken into account for open-circuit detection before each measurement.

The conversion of the channel is only started after this time has elapsed.

3.8 Calculation examples for conversion time

The following examples show the converter time calculation for different configurations.

3.8.1 Example 1 - Analog inputs

In the following example, a current measurement is performed for all channels. The same setting is used for all channels. The conversion time of the module is calculated for all channels.

Value

Measuring signal: 0 to 20 mA for all 8 channels
Conversion rate: 20 SPS
Input filter: Sinc 3

Conversion time per channel

$$\text{Conversion time [ms]} = \frac{1000}{20} \times 3 = 150\text{ ms}$$

Conversion time of the module

Before the measurement of a channel can be started, a delay time of 1 ms must be taken into account. The total conversion time of the module is therefore calculated as follows:

$$\text{Conversion time [ms]} = 8 \times (1 + 150) = 1208\text{ ms}$$

3.8.2 Example 2 - Pt100 resistance temperature measurement

In the following example, a Pt100 resistance temperature measurement is performed for all channels. The same setting is used for all channels. The conversion time of the module is calculated for all channels.

Value

Measuring signal: PtT100 resistance temperature measurement for all 8 channels
Conversion rate: 5 SPS
Input filter: Sinc 4

Conversion time per channel

$$\text{Conversion time [ms]} = \frac{1000}{5} \times 4 = 800\text{ ms}$$

Before the measurement of a channel can be started, a delay time of 1 ms must be taken into account. A waiting time of 10 ms for open-circuit detection must also be taken into account for Pt100/Pt1000 resistance measurement.

The total conversion time of the module is therefore calculated as follows:

$$\text{Conversion time [ms]} = 8 \times (1 + 10 + 800) = 6488\text{ ms}$$

3.9 NetTime Technology

NetTime refers to the ability to precisely synchronize and transfer system times between individual components of the controller or network (controller, I/O modules, X2X Link, POWERLINK, etc.).

This allows the moment that events occur to be determined system-wide with microsecond precision. Upcoming events can also be executed precisely at a specified moment.

NetTime TECHNOLOGY

3.9.1 Time information

Various time information is available in the controller or on the network:

- System time (on the PLC, Automation PC, etc.)
- X2X Link time (for each X2X Link network)
- POWERLINK time (for each POWERLINK network)
- Time data points of I/O modules

The NetTime is based on 32-bit counters, which are increased with microsecond resolution. The sign of the time information changes after 35 min, 47 s, 483 ms and 648 µs; an overflow occurs after 71 min, 34 s, 967 ms and 296 µs.

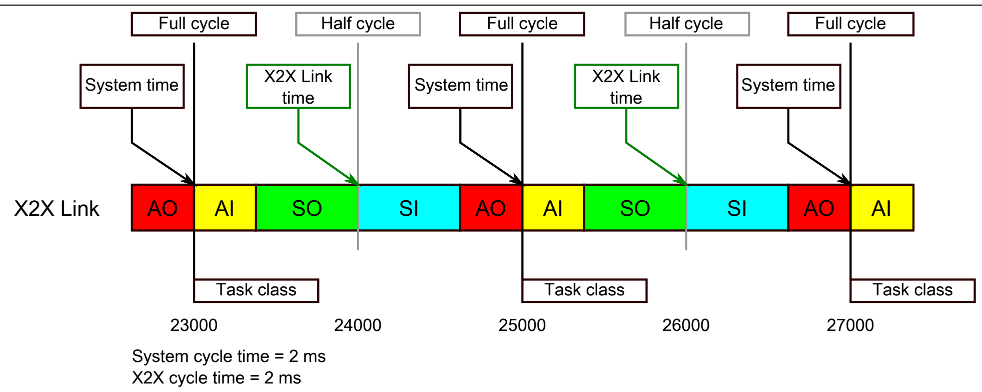
The initialization of the times is based on the system time during the startup of the X2X Link, the I/O modules or the POWERLINK interface.

Current time information in the application can also be determined via library AsIOTime.

3.9.1.1 Controller data points

The NetTime I/O data points of the controller are latched to each system clock and made available.

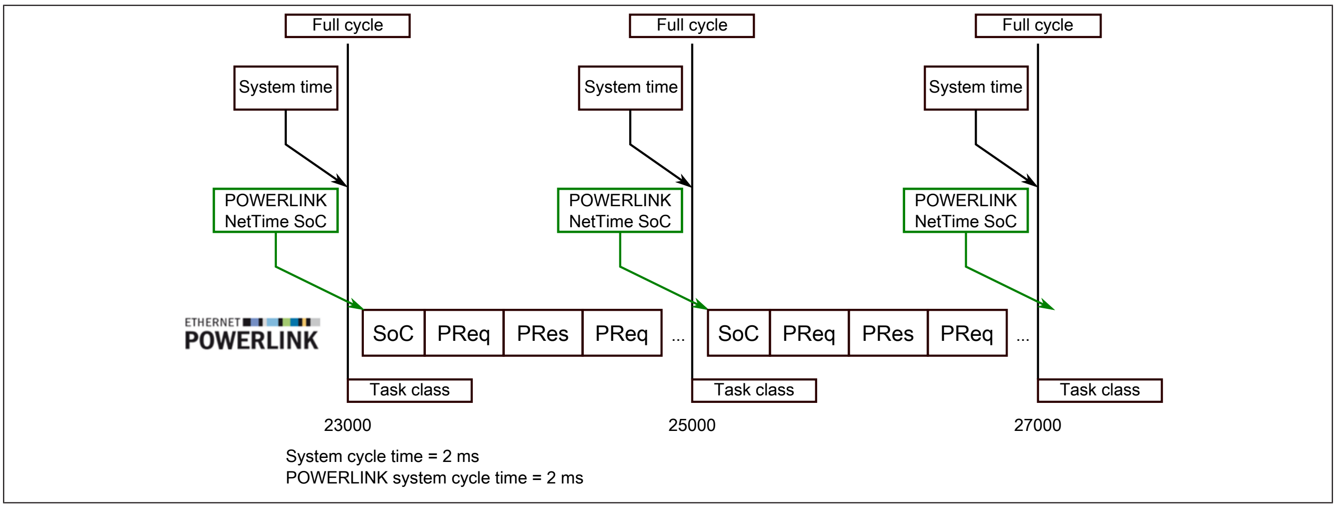
3.9.1.2 X2X Link - Reference time point



The reference time point on the X2X Link network is always calculated at the half cycle of the X2X Link cycle. This results in a difference between the system time and the X2X Link reference time point when the reference time is read out.

In the example above, this results in a difference of 1 ms, i.e. if the system time and X2X Link reference time are compared at time 25000 in the task, then the system time returns the value 25000 and the X2X Link reference time returns the value 24000.

3.9.1.3 POWERLINK - Reference time point

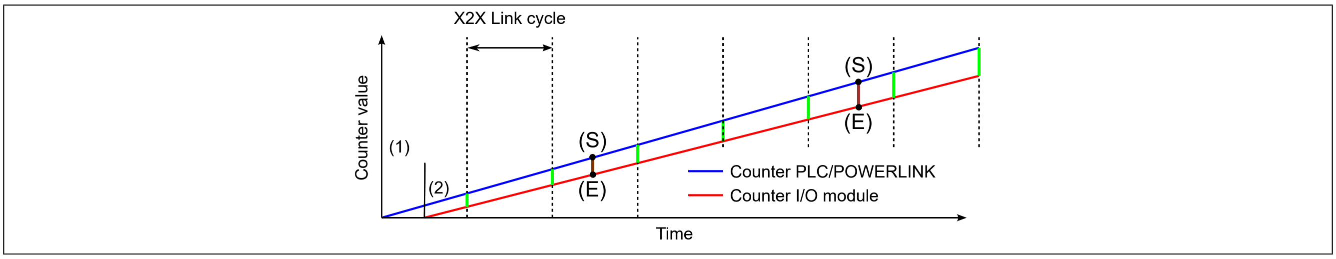


The POWERLINK reference time point is always calculated at the start of cycle (SoC) of the POWERLINK network. The SoC starts 20 µs after the system clock due to the system. This results in the following difference between the system time and the POWERLINK reference time:

POWERLINK reference time = System time - POWERLINK cycle time + 20 µs

In the example above, this means a difference of 1980 µs, i.e. if the system time and POWERLINK reference time are compared at time 25000 in the task, then the system time returns the value 25000 and the POWERLINK reference time returns the value 23020.

3.9.1.4 Synchronization of system time/POWERLINK time and I/O module



At startup, the internal counters for the controller/POWERLINK (1) and the I/O module (2) start at different times and increase the values with microsecond resolution.

At the beginning of each X2X Link cycle, the controller or POWERLINK network sends time information to the I/O module. The I/O module compares this time information with the module's internal time and forms a difference (green line) between the two times and stores it.

When a NetTime event (E) occurs, the internal module time is read out and corrected with the stored difference value (brown line). This means that the exact system moment (S) of an event can always be determined, even if the counters are not absolutely synchronous.

Note

The deviation from the clock signal is strongly exaggerated in the picture as a red line.

3.9.2 Timestamp functions

NetTime-capable modules provide various timestamp functions depending on the scope of functions. If a timestamp event occurs, the module immediately saves the current NetTime. After the respective data is transferred to the controller, including this precise moment, the controller can then evaluate the data using its own NetTime (or system time), if necessary.
For details, see the respective module documentation.

3.9.2.1 Time-based inputs

NetTime Technology can be used to determine the exact moment of a rising edge at an input. The rising and falling edges can also be detected and the duration between 2 events can be determined.

Information:

The determined moment always lies in the past.

3.9.2.2 Time-based outputs

NetTime Technology can be used to specify the exact moment of a rising edge on an output. The rising and falling edges can also be specified and a pulse pattern generated from them.

Information:

The specified time must always be in the future, and the set X2X Link cycle time must be taken into account for the definition of the moment.

3.9.2.3 Time-based measurements

NetTime Technology can be used to determine the exact moment of a measurement that has taken place. Both the starting and end moment of the measurement can be transmitted.

4 Register description

4.1 General data points

In addition to the registers described in the register description, the module has additional general data points. These are not module-specific but contain general information such as serial number and hardware variant.

General data points are described in section "Additional information - General data points" in the X20 System user's manual.

4.2 Function model 0 - Standard

Register	Name	Data type	Read		Write	
			Cyclic	Acyclic	Cyclic	Acyclic
Configuration - General						
514	ConfigSampleRate (conversion rate)	UINT				•
518	ConfigFilterType (input filter)	UINT				•
Channel-specific configuration						
260 + N * 32	ConfigChannelType01-08 (N = 0 to 7) (channel type)	UINT				•
266 + N * 32	ConfigLowerLimit01-08 (N = 0 to 7) (lower limit value)	INT, UINT				•
268 + N * 32		DINT				
274 + N * 32	ConfigUpperLimit01-08 (N = 0 to 7) (upper limit value)	INT, UINT				•
276 + N * 32		DINT				
282 + N * 32	ConfigSampleRateChn01-08 (N = 0 to 7) (conversion rate)	UINT				•
286 + N * 32	ConfigFilterTypeChn01-08 (N = 0 to 7) (input filter)	UINT				•
Input data						
2 + N * 4	AnalogInput01-08 (N = 0 to 7)	INT, UINT	•			
196 + N * 8		DINT				
34 + N * 8	SampleTime01-08 (N = 0 to 7) (NetTime of the conversion)	INT		•		
36 + N * 8		DINT				
98 + N * 8	SampleCount01-08 (N = 0 to 7) (conversion counter)	UINT		•		
100 + N * 8		UDINT				
164	ChannelStatusInput	UDINT	•			
170	GenericStatusInput (status of the module)	UINT	•			
178 + N * 4	ICTDsupplyVoltage01-02 (N = 0 to 1)	UINT		•		
Output data						
5	Enable ICTD supply voltage	USINT			•	
	EnableICTDsupply01	Bit 0				
	EnableICTDsupply02	Bit 1				

4.3 Configuration - General

These registers are used to configure the conversion rate and filter type for the entire module. The values can be overwritten individually for each channel if required (see "Channel-specific configuration" on page 27).

4.3.1 Conversion rate for the module

Name:
ConfigSampleRate

The conversion rate of all inputs is configured in this register. The value defines the number of conversions per second (samples per second - SPS).

Data type	Value	Conversion rate per second
UINT	1	2.5
	2	5
	3	10
	4	16
	5	20
	6	50
	7	60
	8	100

4.3.2 Input filter for the module

Name:
ConfigFilterType

The input filter of all inputs is configured in this register.

Data type	Value	Input filter
UINT	1	Sinc 1
	2	Sinc 2
	3	Sinc 3
	4	Sinc 4
	5	FIR

4.4 Channel-specific configuration

These registers are used for channel-specific configuration.

4.4.1 Input signal

Name:
ConfigChannelType01 to ConfigChannelType08

The type and range of signal measurement are set in this register.

Data type	Values
UINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0 - 7	Channel switched off	0000 0000	
	Voltage measurement	0001 0001	±10 V
	Current measurement	0010 0001	0 to 20 mA
		0010 0010	4 to 20 mA
	Pt100/Pt1000 resistance temperature measurement	0011 0001	Resistance measurement 4800.0 Ω
		0011 0010	Pt100
		0011 0011	Pt1000
		0011 0100	Resistance measurement 600.00 Ω
	ICTD measurement	0100 0001	Temperature
8 - 10	Reserved	0	
11	Connection Pt100/Pt1000 resistance and temperature measurement	0	3-wire connections
		1	2-wire connections
12	Resolution Pt100/Pt1000 temperature measurement	0	0.1°C/bit
		1	0.01°C/bit
13	Limit value settings	0	Default setting
		1	Limit value specification
14 - 15	Reserved	0	

4.4.2 Lower limit value

Name:
ConfigLowerLimit01 to ConfigLowerLimit08

The lower limit value of the analog value can be set individually for each channel in this register. If the analog value undershoots the limit value, it is frozen at this value and the corresponding error state bit is set.

Data type	Values
UINT	0 to 65535
INT	-32768 to 32767
DINT	-2,147,483,648 to 2,147,483,647

4.4.3 Upper limit value

Name:
ConfigUpperLimit01 to ConfigUpperLimit08

The upper limit value of the analog value can be set individually for each channel in this register. If the analog value overshoots the limit value, it is frozen at this value and the corresponding error state bit is set.

Data type	Values
UINT	0 to 65535
INT	-32768 to 32767
DINT	-2,147,483,648 to 2,147,483,647

4.4.4 Conversion rate for the channel

Name:
ConfigSampleRate01 to ConfigSampleRate08

The conversion rate is configured individually for each input in this register. The value defines the number of conversions per second (samples per second - SPS).

Data type	Value	Conversion rate per second
UINT	1	2.5
	2	5
	3	10
	4	16
	5	20
	6	50
	7	60
	8	100

4.4.5 Input filter for the channel

Name:
ConfigFilterType01 to ConfigFilterType08

The input filter is configured individually for each input in this register.

Data type	Value	Input filter
UINT	1	Sinc 1
	2	Sinc 2
	3	Sinc 3
	4	Sinc 4
	5	FIR

4.5 Input data

4.5.1 Input values

Name:
AnalogInput01 to AnalogInput08

This register contains the input value depending on the configured operating mode.

Data type	Values	Input signal
Voltage signal		
INT	-32768 to 32767	-10 to 10 VDC
Current signal		
INT	0 to 32767	0 to 20 mA
	-8192 to 32767	4 to 20 mA (value 0 corresponds to 4 mA)
Pt100/Pt1000 resistance temperature measurement		
INT	-200.0 to 850.0°C	Pt100 / Pt1000
DINT	-200.00 to 850.00°C	Pt100 / Pt1000
UINT	0 to 48000	0 to 4800.0 Ω
	0 to 60000	0 to 600.00 Ω
ICTD measurement		
INT	-40.0 to 100.0°C	Temperature
UINT	0 to 40000	0 to 400.00 µA

4.5.2 NetTime of the last conversion

Name:
SampleTime01 to SampleTime08

The NetTime of the last valid input value that was read is displayed as a 16 or 32-bit value.

For additional information about NetTime and timestamps, see "NetTime Technology" on page 22.

Data type	Values	Information
INT	-32768 to 32767	NetTime in microseconds
DINT	-2,147,483,648 to 2,147,483,647	

4.5.3 Conversion counter

Name:
SampleCount01 to SampleCount08

The valid conversions are counted and displayed in a circular counter. This counter is incremented with every valid conversion and therefore signals a new conversion.

Data type	Values
UINT	0 to 65535
UDINT	0 to 4,294,967,295

4.5.4 Status of the inputs

Name:
ChannelStatusInput

The module's inputs are monitored. A change in the monitoring status is actively issued as an error message and, in the event of an error, the analog value is fixed at defined values. For details, see "Monitoring the input signal" on page 16.

Data type	Values
UDINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0 - 3	Channel 1	00	No error
		01	Lower limit value undershot
		10	Upper limit value overshot
		11	Open circuit
4 - 7	Channel 2	00	No error
		01	Lower limit value undershot
		10	Upper limit value overshot
		11	Open circuit
8 - 11	Channel 3	00	No error
		01	Lower limit value undershot
		10	Upper limit value overshot
		11	Open circuit
12 - 15	Channel 4	00	No error
		01	Lower limit value undershot
		10	Upper limit value overshot
		11	Open circuit
16 - 19	Channel 5	00	No error
		01	Lower limit value undershot
		10	Upper limit value overshot
		11	Open circuit
20 - 23	Channel 6	00	No error
		01	Lower limit value undershot
		10	Upper limit value overshot
		11	Open circuit
24 - 27	Channel 7	00	No error
		01	Lower limit value undershot
		10	Upper limit value overshot
		11	Open circuit
28 - 31	Channel 8	00	No error
		01	Lower limit value undershot
		10	Upper limit value overshot
		11	Open circuit

4.5.5 Status of the module

Name:
GenericStatusInput

The status of the module is monitored. A change in the monitoring status is actively transmitted as an error message.

Data type	Values
UINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0	ADC: Communication timeout	0	No error
		1	ADC timeout
1	ADC: General error	0	No error
		1	General fault
2	ADC: Range overshoot / Range undershoot	0	No error
		1	Signal outside the permitted range
3	Reserved	0	
4	ICTD 1: Power supply error	0	No error
		1	ICTD supply voltage 1 error
5	ICTD 2: Power supply error	0	No error
		1	ICTD supply voltage 2 error
6 - 15	Reserved	0	

4.5.6 ICTD supply voltage

Name:
ICTDsupplyVoltage01 to ICTDsupplyVoltage02

This register contains the current value of the ICTD supply voltage.

Data type	Values	Information
UINT	0 to 142	0 to 14.2 V

4.6 Output data

4.6.1 Enable ICTD supply voltage

Name:
EnableICTDsupply01 to EnableICTDsupply02

This register enables both ICTD supply voltages.

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0	EnableICTDsupply01	0	ICTD supply voltage 1 disabled
		1	ICTD supply voltage 1 enabled
1	EnableICTDsupply02	0	ICTD supply voltage 2 disabled
		1	ICTD supply voltage 2 enabled
2 - 7	Reserved	0	

4.7 Minimum cycle time

The minimum cycle time specifies how far the bus cycle can be reduced without communication errors occurring. It is important to note that very fast cycles reduce the idle time available for handling monitoring, diagnostics and acyclic commands.

Minimum cycle time
400 µs

4.8 Minimum I/O update time

The minimum I/O update time specifies how far the bus cycle can be reduced so that an I/O update is performed in each cycle.

The I/O update time can vary greatly depending on the module configuration. Notes about calculating the converter time are listed in the following sections:

- "Conversion time" on page 20
- "Calculation examples for conversion time" on page 21
- "Mixed operation" on page 18