X90AT910.0x-00

1 General information

The modular X90 mobile control and I/O system opens up a wide range of possibilities in mobile automation. With the X90 mobile system, flexible automation concepts can be implemented based on a standardized complete system.

Option board X90AT910.0x-00 is integrated in the X90 mobile system and extends the functionality of the entire system.

The AT option board offers 4 or 8 additional channels that can be used for current, voltage or temperature measurement. It is also possible to use the analog inputs as PWM signal outputs or digital inputs (with toggling between sink mode and source mode). Communication to the mainboard is implemented using X2X Link.

- 9 to 32 VDC
- 4 or 8 current, voltage, temperature or digital inputs or PWM outputs
- Temperature measurement
- X2X Link

2 Order data

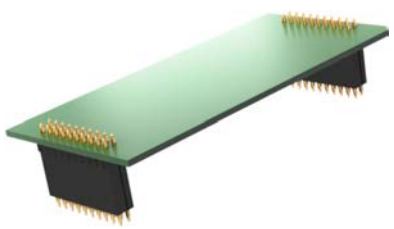
Model number	Short description	Figure
	Temperature measurement	
X90AT910.04-00	X90 mobile option board AT, 4 resistance measurement inputs, PT1000, optional DI, 9 to 32 VDC, sink/source, optional AI, 0 to 10 V / 0 to 32 V, 0 to 20 mA, optional PWM output, 9 to 32 VDC, 10 mA, 1 kHz, configuration using software	
X90AT910.08-00	X90 mobile option board AT, 8 resistance measurement inputs, PT1000, optional DI, 9 to 32 VDC, sink/source, optional AI, 0 to 10 V / 0 to 32 V, 0 to 20 mA, optional PWM output, 9 to 32 VDC, 10 mA, 1 kHz, configuration using software	

Table 1: X90AT910.04-00, X90AT910.08-00 - Order data

Inputs and outputs - Overview

X90AT910.0x-00		Output				Input			
Multifunction I/O	Quantity	PWM	Digital	Analog	PWM signal	Temperature	Analog	Counter functionality	Digital
MF-AT	4/8				X	X	X		X

3 Technical data

Model number	X90AT910.04-00	X90AT910.08-00
Short description		
I/O module	4 inputs for PT1000 resistance temperature measurement, analog inputs, PWM signal outputs, 1-wire connections	8 inputs for PT1000 resistance temperature measurement, analog inputs, PWM signal outputs, 1-wire connections
General information		
B&R ID code	0xEC23	0xEC22
Status indicators	-	
Diagnostics		
Digital inputs	External resistor connection	
Power consumption	0.6 W	0.66 W
Electrical isolation		
Digital - Digital	No	
Digital - Analog	No	
Certifications		
UN ECE-R10	Yes	
CE	Yes	
Multi-function inputs		
Multifunction resistance measurement inputs (MFAT)		
Quantity	4	8
Functions	Resistance measurement input PT1000, digital input, sink/source circuit, analog input 0 to 10 V, 0 to 32 V, 0 to 20 mA, PWM signal output high-side, configurable per channel	
Digital inputs		
Quantity	0 to 4, depends on the use of multifunction inputs/outputs	0 to 8, depends on the use of multifunction inputs/outputs
Input voltage	9 to 32 VDC	
Input current at 24 VDC	Typ. 2.4 mA	
Input circuit	Sink/Source, configurable	
Input filter		
Hardware	500 µs at switching threshold = 50% supply voltage	
Software	Default 1 ms, configurable between 0 and 25 ms in 0.2 ms increments	
Input resistance	10 kΩ	
Input delay	<0.5 ms (at 200 µs sampling rate)	
Switching threshold	Fixed or ratiometric, configurable	
Analog inputs		
Quantity	0 to 4, depends on the use of multifunction inputs/outputs	0 to 8, depends on the use of multifunction inputs/outputs
Input	0 to 10 V / 0 to 32 V or 0 to 20 mA	
Digital converter resolution	12-bit	
Conversion time	200 µs	
Output format		
Data type	INT	
Voltage	0 to 10 V: INT 0x0000 - 0x7FFF / 1 LSB = 0x0008 = 3.1 mV. 0 to 32 V: INT 0x0000 - 0x7FFF / 1 LSB = 0x0008 = 9.8 mV	
Current	INT 0x0000 - 0x7FFF / 1 LSB = 0x0008 = 6.1 µA	
Input impedance in signal range		
Voltage	100 kΩ	
Current	-	
Load		
Voltage	-	
Current	<300 Ω	
Open-circuit detection	From the application	
Reverse polarity protection	Yes	
Input signal		
Nominal	0 to 10 V / 0 to 32 V or 0 to 20 mA	
Permissible input signal		
Voltage	±36 V	
Current	±50 mA	
Output of digital value during overload		
Undershoot		
Voltage	0x0000	
Current	0x0000	
Overshoot		
Voltage	0x7FFF	
Current	0x7FFF	
Max. error at 25°C	<1% [1]	
Max. gain drift		
Voltage	<0.03%/°C [2]	
Current	<0.06%/°C [2]	

Table 2: X90AT910.04-00, X90AT910.08-00 - Technical data

Model number	X90AT910.04-00	X90AT910.08-00
Max. offset drift		
Voltage	<0.007%/°C [1]	
Current	<0.02%/°C [1]	
Crosstalk between channels	-70 dB	
Nonlinearity		
Voltage	0.2% [1]	
Current	0.2% [1]	
Input filter		
Cutoff frequency	Voltage: 400 Hz Current: 230 Hz	
Slope	Voltage: 20 dB Current: 40 dB	
Software	Filter level configurable in software, 30 Hz to 3 kHz	
Resistance measurement temperature inputs		
Quantity	0 to 4, depends on the use of multifunction inputs/outputs	0 to 8, depends on the use of multifunction inputs/outputs
Digital converter resolution	12-bit	
Filter time	Configurable	
Conversion time	200 µs for all channels	
Output format	INT	
Output format		
Temperature	-800 to 2700, 0.1°C increments	
Resistance	0 to 2000, 1 Ω increments	
Sensor	PT1000	
Temperature measurement range	-80 to 270°C	
Resistance measurement range	0 to 2000 Ω	
Temperature sensor resolution	1 LSB <0.5°C	
Resistance measurement resolution	1 LSB <2 Ω	
Linearization method	Internal	
Measurement current	Max. 1.7 mA (temperature measurement) Max. 2.3 mA (resistance measurement)	
Reference	1980 Ω ±0.1%	
Permissible input signal	Max. 32 V	
Max. error at 25°C	<1% [1][3]	
Max. gain drift	0.015%/°C [2]	
Max. offset drift	0.009%/°C [1]	
Nonlinearity	<0.25%	
Crosstalk between channels	-70 dB	
Input filter		
Cutoff frequency	230 Hz	
Slope	40 dB	
Software	Filter level configurable in software	
PWM output		
Quantity	0 to 4, depends on the use of multifunction inputs/outputs	0 to 8, depends on the use of multifunction inputs/outputs
Nominal voltage	12 / 24 VDC	
Switching voltage	9 to 32 V	
Voltage drop	Max. 3.5 V	
Nominal current	10 mA	
Switching delay		
0 → 1	<1 µs	
1 → 0	<1 µs	
Switching frequency		
Resistive load	Max. 1 kHz	
Output circuit	Source	
Output protection	Thermal current limiting at 50 mA on short circuit	
Variant	High-side FET	
Leakage current when the output is switched off	<5 µA	
Residual voltage	<2.5 V at 10 mA nominal current	
Peak short-circuit current	250 mA	
Operating conditions		
Mounting orientation		
Any	Yes	
Degree of protection per EN 60529	Up to IP69K [4]	
Ambient conditions		
Temperature		
Operation		
Horizontal mounting orientation	-40 to 85°C housing surface [4]	
Vertical mounting orientation	-40 to 85°C housing surface [4]	
Storage	-40 to 85°C	
Transport	-40 to 85°C	

Table 2: X90AT910.04-00, X90AT910.08-00 - Technical data

Model number	X90AT910.04-00	X90AT910.08-00
Relative humidity		
Operation	5 to 100%, condensing	
Storage	5 to 100%, condensing	
Transport	5 to 100%, condensing	
Mechanical properties		
Dimensions		
Width	47 mm	
Length	95 mm	

Table 2: X90AT910.04-00, X90AT910.08-00 - Technical data

1) Based on the maximum measurement range.
2) Based on the current measured value.
3) At least filter level 16 (fg = 50 Hz) must be configured in order to guarantee that values are observed.
4) Depends on the mainboard. For additional details, see the data sheet for the mainboard.

4 Operating and connection elements

4.1 X2X Link interface

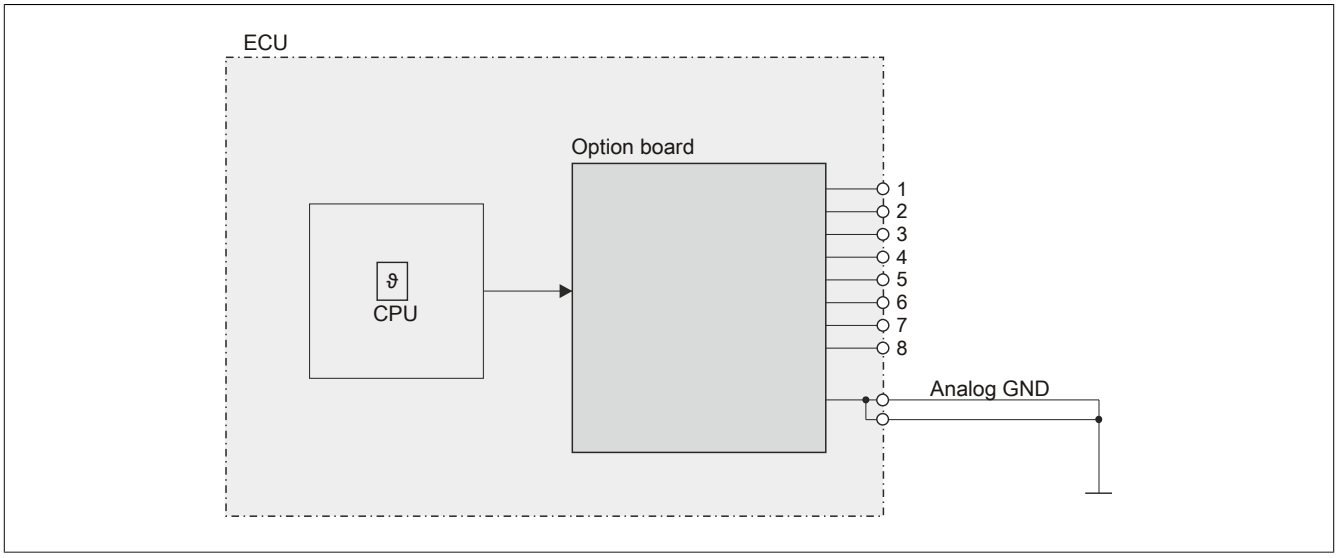
Communication between the option board and mainboard is implemented using X2X Link.

5 Pinout

Channel	Pinout
1	MF-AT
2	MF-AT
3	MF-AT
4	MF-AT
5[1)]	MF-AT
6[1)]	MF-AT
7[1)]	MF-AT
8[1)]	MF-AT
9	Analog GND
10	Analog GND

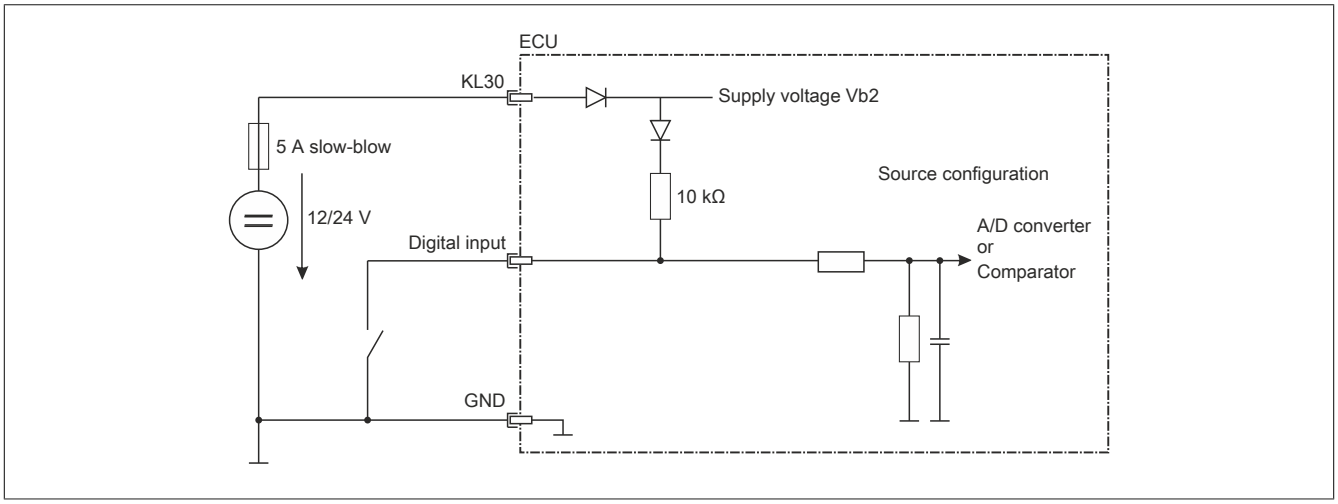
1) Only on modules with 8 channels.

6 Block diagram

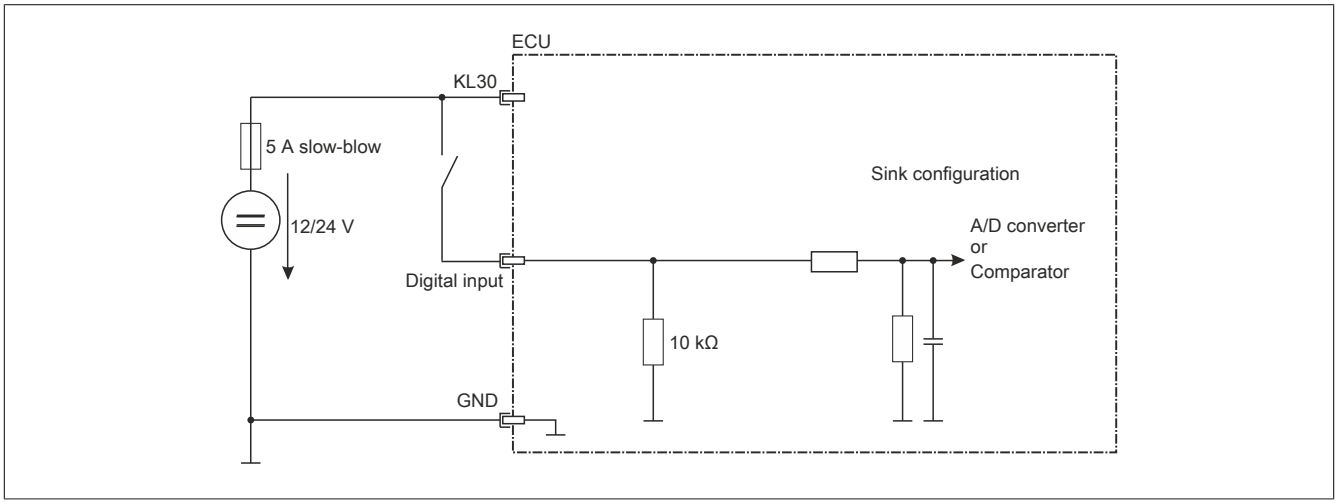


6.1 Input circuit diagram

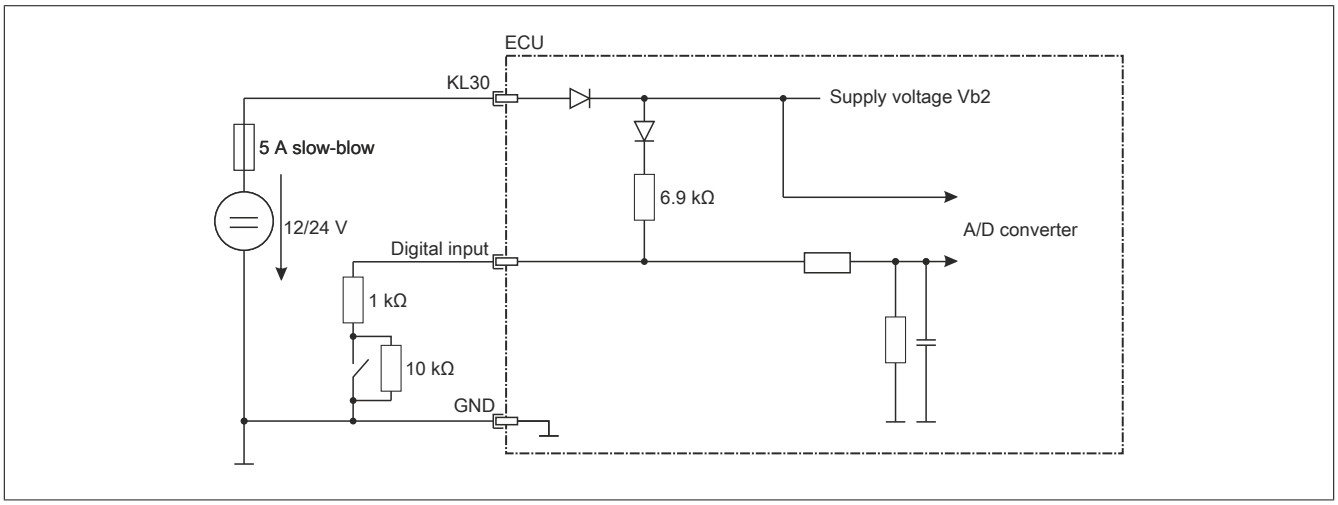
Digital input, negative switching



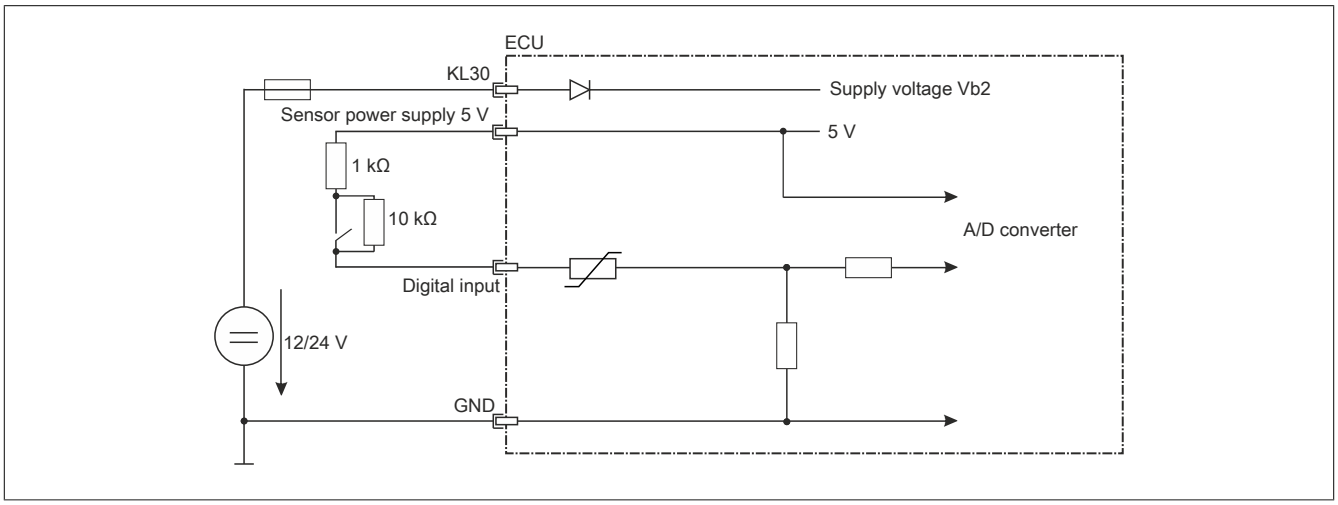
Digital input, positive switching



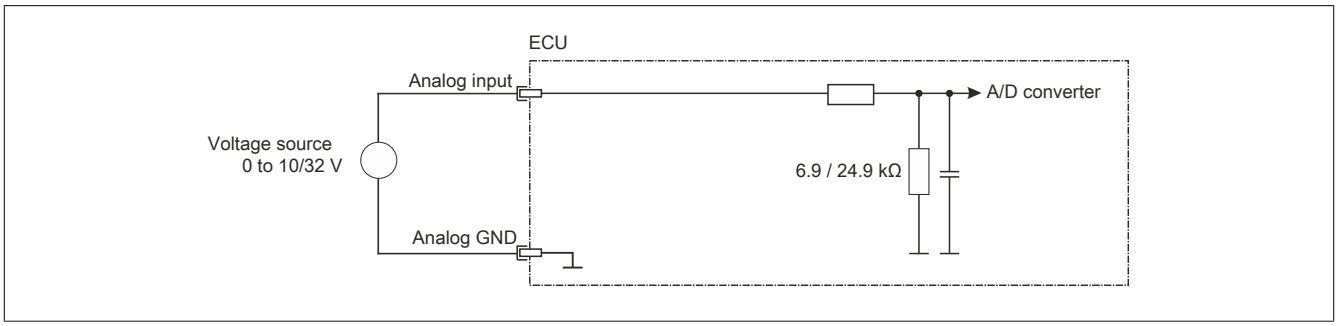
Diagnostics-capable digital voltage input



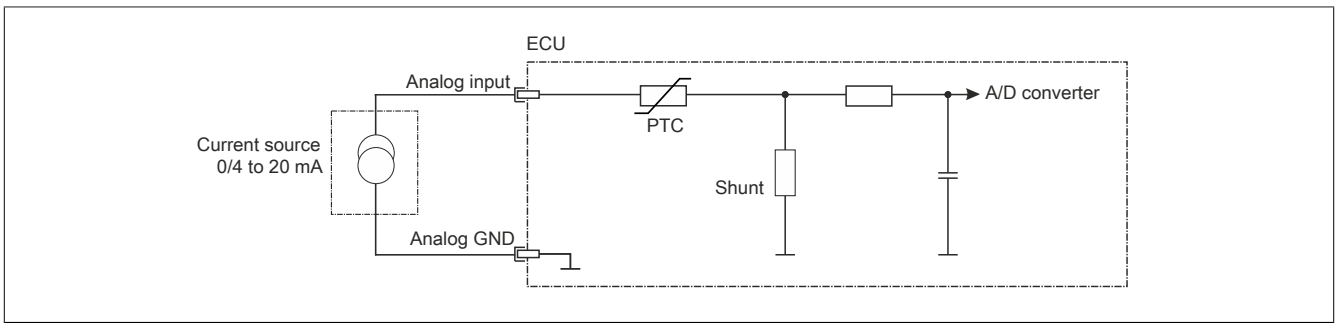
Diagnostics-capable digital current input



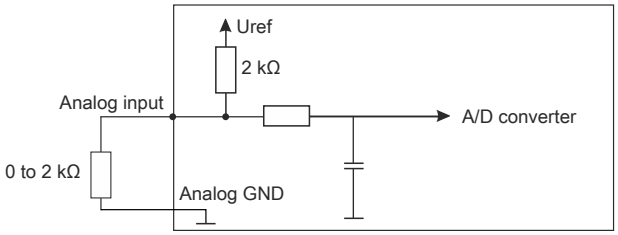
Analog voltage input



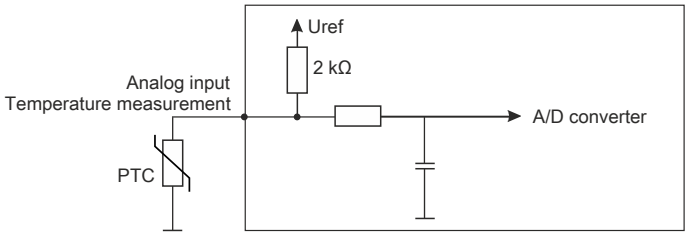
Analog current input



Analog input for resistance measurement

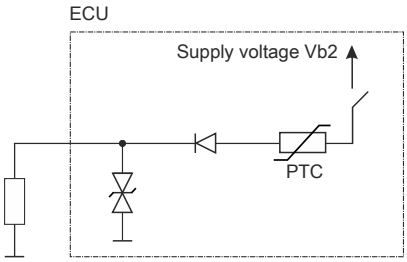


Analog input for temperature measurement



6.2 Output circuit diagram

PWM output, source circuit



7 Register description

7.1 System requirements

The following minimum versions are recommended to generally be able to use all functions:

- Automation Studio 4.3
- Automation Runtime 4.3

7.2 Number of inputs and outputs

Information:

All values in the register description correspond to the maximum hardware variant. Gaps in the registers result from smaller hardware variants.

	X90AT910.04-00	X90AT910.08-00
Digital inputs	1 to 4	1 to 8
Diagnostics-capable digital inputs	1 to 4	1 to 8
Analog inputs	1 to 4	1 to 8
Pulse width modulation (PWM)	1 to 4	1 to 8

7.3 Overview of registers

Register	Name	Data type	Read		Write	
			Cyclic	Acyclic	Cyclic	Acyclic
Communication - Digital inputs						
2	Input state of the digital inputs	USINT	•			
	DigitalInput01	Bit 0				
	...	...				
	DigitalInput08	Bit 7				
Communication - Analog inputs						
6 + (N-1) * 4	AnalogInput0N (index N = 1 to 8)	INT	•			
Communication - Measurement range overshoot						
37	Status of the analog inputs	USINT	•			
	OutOfRangeAnalogInput0	Bit 0				
	...	...				
	OutOfRangeAnalogInput08	Bit 7				
Communication - Lower limit value undershot						
39	Status of the analog inputs	USINT	•			
	UnderflowAnalogInput01	Bit 0				
	...	...				
	UnderflowAnalogInput08	Bit 7				
Communication - Upper limit value overshot						
41	Status of the analog inputs	USINT	•			
	OverflowAnalogInput01	Bit 0				
	...	...				
	OverflowAnalogInput08	Bit 7				
Communication - Open circuit						
43	Open circuit	USINT	•			
	WireBreakDigitalInput01	Bit 0				
	...	...				
	WireBreakDigitalInput08	Bit7				
Communication - Short circuit						
45	Short circuit	USINT	•			
	ShortCircuitDigitalInput01	Bit 0				
	...	...				
	ShortCircuitDigitalInput08	Bit 7				
Communication - Module information						
1538	SupplyVoltage01	UINT	•			
1542	Temperature	INT	•			
Communication - PWM period duration						
2 + (N-1) * 4	PWMPeriod0N (index N = 1 to 8)	UINT			•	
Communication - PWM duty cycle						
33 + (N-1) * 2	PWMOutput0N (index N = 1 to 8)	USINT			•	
Configuration - Filter time of the digital inputs						
1025 + (N-1) * 2	cfgDigiralFilter0N (index N = 1 to 8)	USINT		•		•
Configuration - Pin configuration						
1041 + (N-1) * 2	cfgPinMode0N (index N = 1 to 8)	USINT		•		•
Configuration - Switching threshold of the digital inputs						
1058 + (N-1) * 4	cfgThreshold0N (index N = 1 to 8)	UINT		•		•
Configuration - Hysteresis of the digital inputs						
1090 + (N-1) * 4	cfgHysteresis0N (index N = 1 to 8)	UINT		•		•
Configuration - Filter level of the analog inputs						
1121 + (N-1) * 2	cfgAnalogFilter0N (index N = 1 to 8)	USINT		•		•
Configuration - Lower limit value of the analog inputs						
1138 + (N-1) * 4	cfgAnalogLowerLimit0N (index N = 1 to 8)	INT		•		•
Configuration - Upper limit value of the analog inputs						
1170 + (N-1) * 4	cfgAnalogUpperLimit0N (index N = 1 to 8)	INT		•		•
Configuration - Threshold value configuration						
1201	cfgThresholdMode	USINT		•		•

7.4 Physical configuration of I/O channels

These registers define the function of the channels. Depending on the desired configuration, the following assignments can be made with respect to the existing software and hardware:

- One physical configuration as input or output
- Configuration as digital channel, analog channel or channel capable of temperature measurement
- Configuration as a PWM output

7.4.1 Physical configuration

Name:
cfgPinMode01 to cfgPinMode08

These registers configure the function of the channels.

Data type	Values	Information
USINT	30	Digital input, source
	31	Digital input, sink
	40	Digital input for diagnostics-capable voltage measurement
	41	Digital input for diagnostics-capable current measurement
	80	Analog input 0 to 10 V
	81	Analog input 0 to 32 V
	82	Analog input 0 to 20 mA
	83	Analog input for resistance
	84	Analog input for PT1000
	90	PWM output

7.5 Digital inputs

This module is equipped with 8 digital inputs for 1-wire connections. The inputs of the module are designed for sink and source circuits.

Topics in this section:

- Filter time
- Threshold value / Hysteresis
- Input values of the digital inputs

Input impedance is tightly defined by the physical configuration.

7.5.1 Digital input filter

Name:
cfgDigitalFilter01 to cfgDigitalFilter08

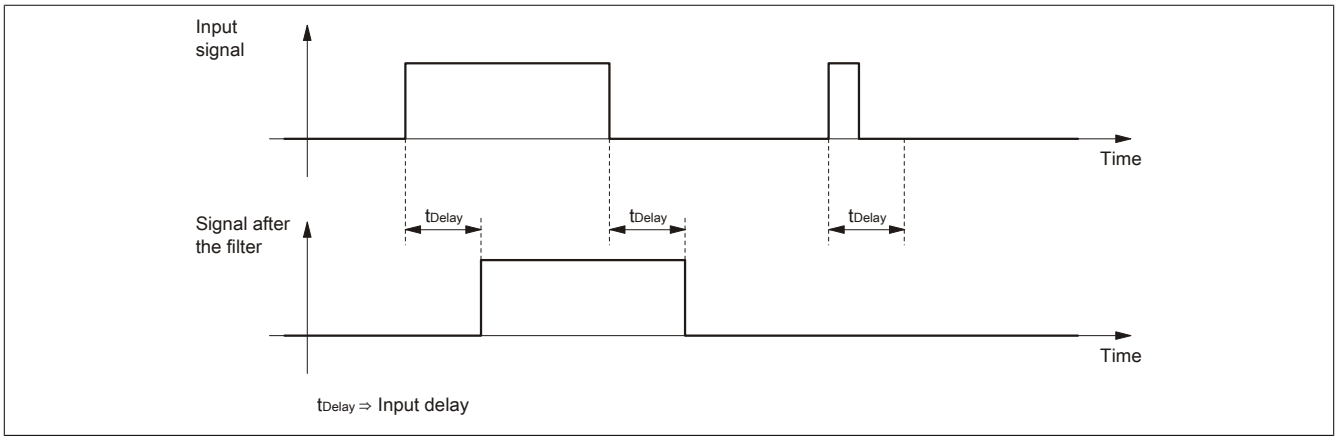
This register can be used to specify the filter value for all digital inputs.

The filter value can be configured in steps of 100 µs.

Data type	Values
USINT	See the bit structure.

Bit structure:

Data type	Values	Information
USINT	0	No software filter
	1	0.1 ms
	...	
	10	1 ms (default)
	...	
	255	25.5 ms



7.5.2 Input state of the digital inputs

Name:
DigitalInput01 to DigitalInput08

The input state of digital inputs 1 to 8 is mapped in this register.

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0	DigitalInputxx[1)]	0 or 1	Input state of digital input x
...	...	...	...
7	DigitalInputxx + 7	0 or 1	Input state of digital input x + 7

1) For xx, see the name of the register.

7.5.3 Configurable switching threshold

Name:
cfgTresholdMode
cfgThreshold01 to cfgThreshold08
cfgHysteresis01 to cfgHysteresis08

If the pin is configured as a digital input, this register can be used to set the switching threshold in mV or percent. When taking into account the configured hysteresis, a voltage level under the threshold value results in "0" on the corresponding bit; a voltage level above the threshold value results in "1".

Register cfgTresholdMode:

This register specifies whether the values of cfgThreshold or cfgHysteresis are to be specified in mV or percent.

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0	cfgThresholdMode	0	Threshold and hysteresis are specified in mV.
		1	Threshold and hysteresis are specified ratiometrically.
1 to 17			Reserved

Registers cfgThreshold01 to cfgThreshold08:

Data type	Values	Information
UINT	0 to 32767	mV, corresponds to 0 to 32.767 V
	0 to 1000	Ratiometric, corresponds to 0.0 to 100.0%

Example:

Desired level: 16 V, corresponds to configuration value 16000

Registers cfgHysteresis01 to cfgHysteresis08:

If the pin is configured as a digital input, this register can be used to set the hysteresis in mV or percent in order to avoid frequent state changes in the measurement range near the threshold value. When taking into account the configured threshold value, a voltage level under threshold value "Threshold – Hysteresis" results in "0" on the corresponding bit; a voltage level above threshold value "Threshold + Hysteresis" results in "1".

Data type	Values	Information
UINT	0 to 15000	mV, corresponds to 0 to 15.00 V
	0 to 1000	Ratiometric, corresponds to 0.0 to 100.0%

Example:

Desired hysteresis range: ±5 V, corresponds to configuration value 5000

7.6 Diagnostics-capable digital inputs

Modes "Digital input for diagnostics-capable voltage measurement" and "Digital input for diagnostics-capable current measurement" are equipped with open circuit and short circuit detection. For this, the sensor needs to be connected to resistors accordingly.

In addition to the digital input functions, this also allows the following states to be monitored:

- Open circuit
- Short circuit

The unfiltered analog value is additionally output in register AnalogInput (0 to 32 V corresponds to 0 to 32767). Status and configuration bits for analog measurement are ignored.

7.6.1 Open circuit

Name:
WireBreakDigitalInput01 to WirebreakDigitalInput08

This register specifies whether the connected sensor indicates an open circuit or no sensor is connected.

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0	WirebreakDigitalInput01	0	No open circuit
		1	Open circuit or no sensor connected
...	...	...	...
7	WirebreakDigitalInput08	0	No open circuit
		1	Open circuit or no sensor connected

7.6.2 Short circuit

Name:
ShortCircuitDigitalInput01 to ShortCircuitDigitalInput08

This register specifies whether there is a short circuit on the sensor line.

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0	ShortCircuitDigitalInput01	0	No short circuit
		1	Short circuit
...	...	...	...
7	ShortCircuitDigitalInput08	0	No short circuit
		1	Short circuit

7.7 Analog inputs

The module is equipped with 8 analog inputs for 1-wire connections.

7.7.1 Analog input filter

Name:
cfgAnalogFilter01 to cfgAnalogFilter08

A filter can be defined to prevent large input jumps. This filter is used to bring the input value closer to the actual analog value over a period of several system cycles. Filtering takes place after input ramp limitation if this is performed.

Bit structure:

Bit	Description	Value	Information
0 to 3	Filter level	0	Disabled (default)
		1	Filter level 2
		2	Filter level 4
		3	Filter level 8
		4	Filter level 16
		5	Filter level 32
		6	Filter level 64
		7	Filter level 128
4 to 7	Input ramp limitation	0	Disabled (default)
		1	Limit value = 16383
		2	Limit value = 8191
		3	Limit value = 4095
		4	Limit value = 2047
		5	Limit value = 1023
		6	Limit value = 511
		7	Limit value = 255

Formula for the evaluation of the input value:

$$Value_{New} = Value_{Old} - \frac{Value_{Old}}{Filter\ level} + \frac{Input\ value}{Filter\ level}$$

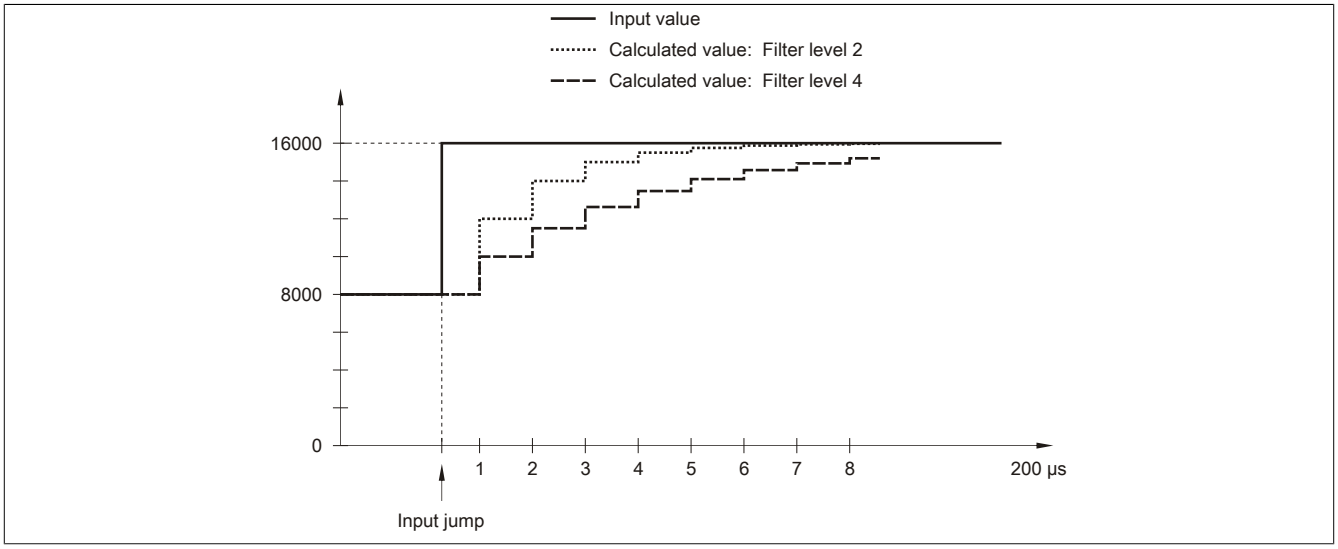


Figure 1: Calculated value during input jump

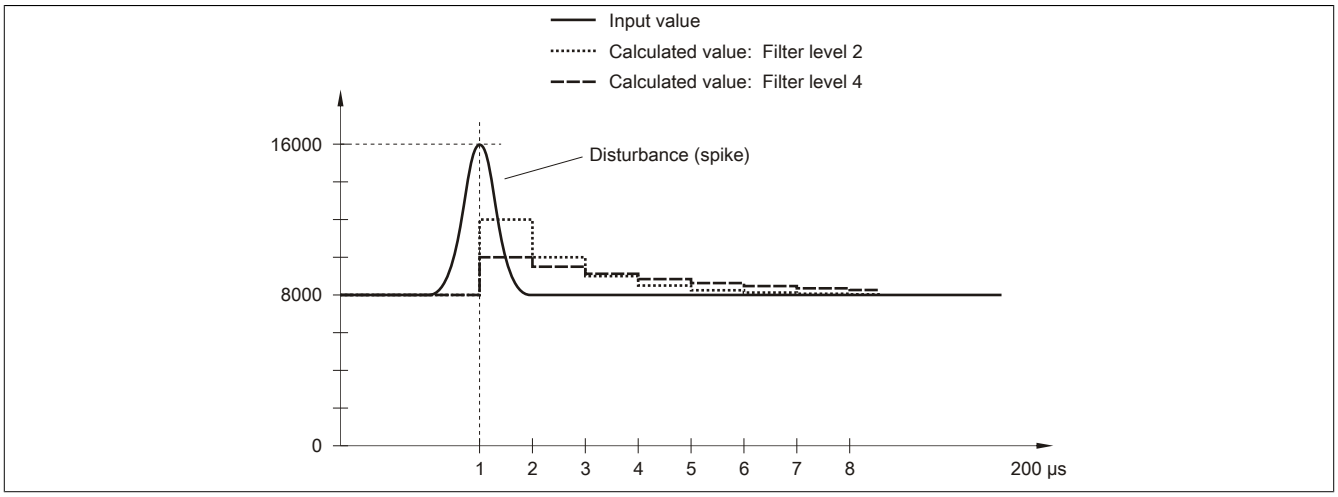


Figure 2: Calculated value during disturbance

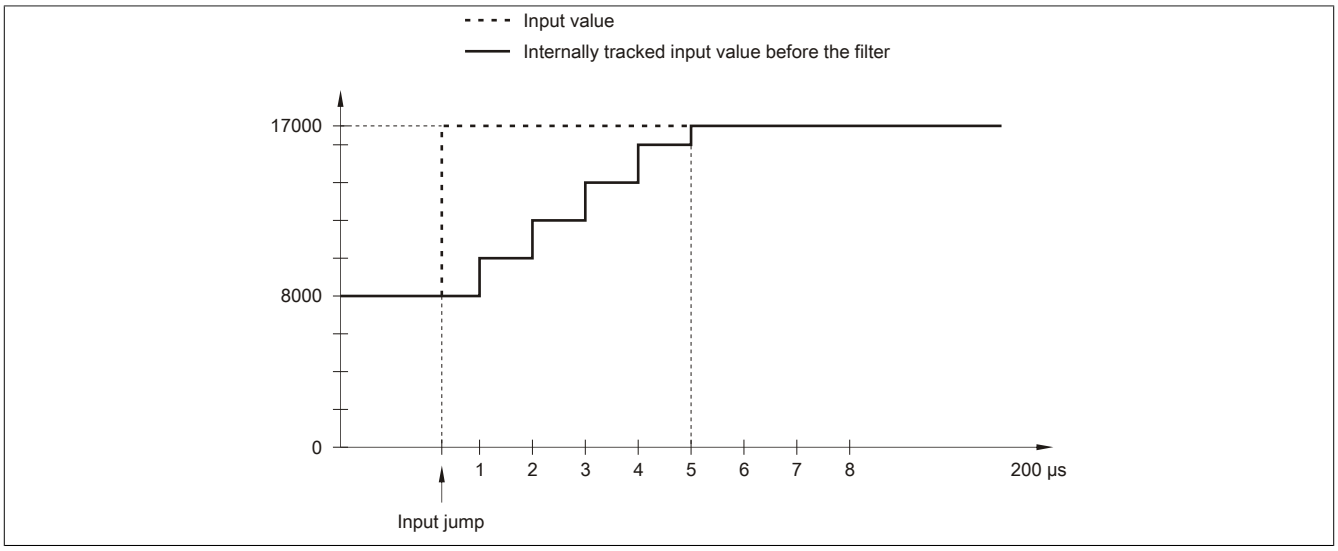


Figure 3: Tracked input value for input jump

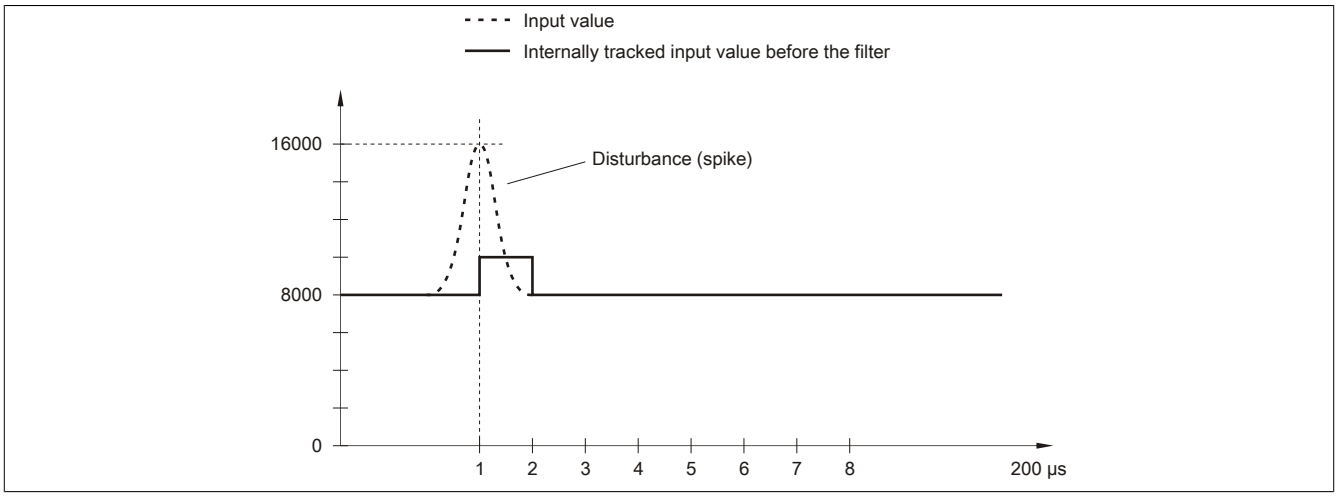


Figure 4: Adjusted input value for disturbance

7.7.2 Analog input - Upper and lower limit value

Name:
cfgAnalogUpperLimit01 to cfgAnalogUpperLimit08
cfgAnalogLowerLimit01 to cfgAnalogLowerLimit08

The lower/upper limit value of the analog value is set in these registers. If the analog value goes above or below the respective limit value, it is frozen at this value and the corresponding error status bits are set.

Data type	Values	Information
INT	0 to 32767	Upper/Lower limit value of the associated analog input

7.7.3 Input values of analog inputs

Name:
AnalogInput01 to AnalogInput08

The analog input value is mapped in these registers depending on the configured operating mode.

Data type	Values	Information
INT	0 to 32767	0 to 10 VDC, 3.1 mV resolution
		0 to 32 VDC, 9.8 mV resolution
		0 to 20 mA, 6.1 µA resolution
	0 to 2000	0 to 2000 Ω
	-800 to 2700	-80 to 270°C

Example:

In mode 0 to 32 VDC, value "8" corresponds to a voltage value of 9.8 mV.

7.7.4 Status of the analog inputs

Name:
UnderflowAnalogInput01 to UnderflowAnalogInput08
OverflowAnalogInput01 to OverflowAnalogInput08
OutOfRangeAnalogInput01 to OutOfRangeAnalogInput08

The state of the analog inputs is stored in these registers. The following states are monitored:

- Overflow
- Underflow
- Out of range

Bit structure:

Bit	Description	Value	Information
0	State of input 01	0	No limit value underflow or overflow
		1	Limit value underflow or overflow
...	...	...	...
7	State of input 08	0	No limit value underflow or overflow
		1	Limit value underflow or overflow

Advice:

If mode "0 to 20 mA" is configured, the analog input is cut off after the upper measurement range of the A/D converter is overshot for 0.5 s (ramp filter). After 5 s, the AI (shunt) is switched back on. During the cutoff time, the corresponding measurement range overshoot bit is set and the maximum analog value is output.

Advice:

If mode "Resistance" or "PT1000" is configured, the analog input is cut off after the upper measurement range of the A/D converter is overshot for 0.5 s (ramp filter). Afterwards, the pending analog value is continuously measured and monitored. If the analog value undershoots the maximum measurement range of the A/D converter for at least 0.5 s (ramp filter), then the analog input is switched back on. During the cutoff time, the corresponding measurement range overshoot bit is set and the maximum analog value is output.

7.8 Pulse width modulation (PWM)

The channels can be configured as PWM outputs. 2 data points are available per channel for controlling the PWM signal.

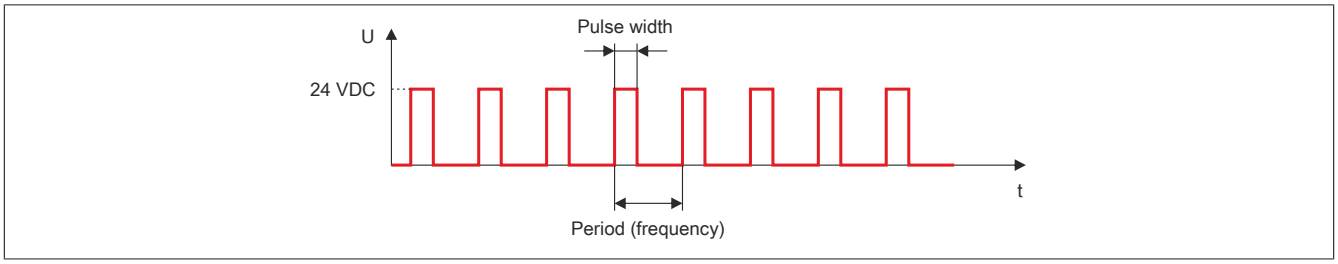


Figure 5: The PWM signal is controlled by setting the pulse width and period duration

Topics in this section:

- Period duration of the PWM outputs
- Duty cycle of the PWM outputs

7.8.1 Period duration of the PWM outputs

Name:
PWMPeriod01 to PWMPeriod08

These registers define the period duration, i.e. the time base for the respective PWM output. This time represents the 100% value, which can be incremented in 1% steps through the duty cycle.

Data type	Values	Information
UINT	1000 to 65535	Period duration in µs

The minimum period duration is 1000 [µs] (1 kHz). A PWM signal is not output for smaller values.

7.8.2 Duty cycle of the PWM outputs

Name:
PWMOutput01 to PWMOutput08

These registers output the ratio of switch on/off time (duty cycle) of the respective PWM output at 1% resolution in relation to the period duration.

Data type	Values	Information
UINT	0 to 100	Duty cycle of the output in 0 to 100%

Example

Period duration T = 4000 [µs] with a duty cycle of 25% equals a switch-on time t_1 of 1000 [µs].

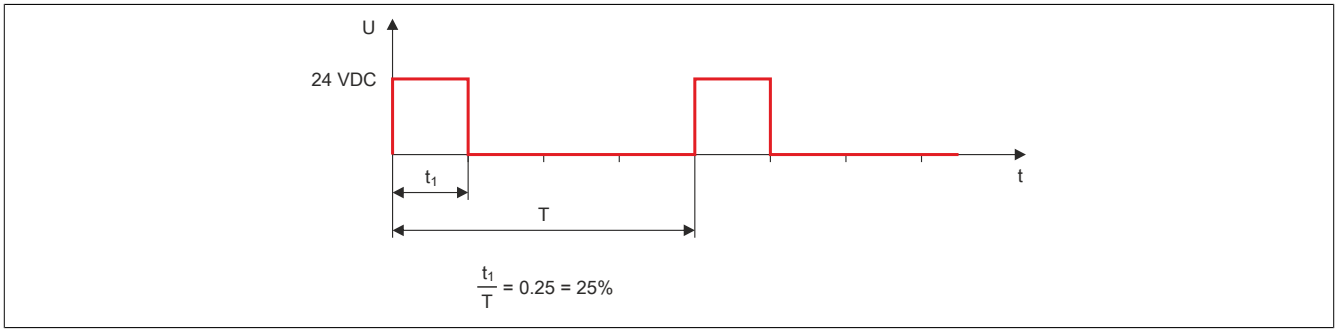


Figure 6: Switch-on time depending on the period duration and duty cycle

7.9 Module information

7.9.1 Measuring the operating voltage

Name:
SupplyVoltage01

The module voltage can be read out in this register.

Data type	Values	Information
UINT	0 to 32767	Voltage in [mV] from 0 V to 32.767 V

7.9.2 Measuring operating temperature

Name:
Temperature

The module temperature can be read out in this register.

Data type	Values	Information
INT	-550 to 1250	Temperature measurement [°C] from -55 to 125°C