

Inline modular analog input terminal, 8 inputs, RTD (resistance temperature detector)

R911338008
Edition 03

Data sheet R-IB IL TEMP 4/8 RTD/EF-PAC

8 analog inputs
2, 3, and 4-wire technology
Degrees Celsius (°C), degrees Fahrenheit (°F)
linear resistance (Ω)

08 / 2020



1 Description

The terminal is designed for use within an Inline station.

This terminal provides an 8-channel input module with three linear resistance ranges for resistance temperature detectors.

The terminal supports all common platinum sensors in accordance with DIN EN 60751 and SAMA, as well as nickel sensors in accordance with DIN 43760.

Cu10, Cu50, and Cu53 sensors as well as KTY81 and KTY84 sensors are also supported.

Communication either takes place via the parameter channel (PCP, all eight measuring channels) or via four process data words (always four channels in multiplex mode).

Features

- Pt, Ni, Cu, KTY sensor types according to DIN and SAMA
- Connection of 8 RTD temperature sensors and linear resistors in 4-wire technology
- High precision and noise immunity
- Temperature stability
- High-resolution temperature and resistance measurement

- Resistance values can be preset separately via parameterization bits
- The channels are parameterized independently of one another via the bus system
- Parameterization of open-circuit detection sensitivity (firmware version 1.10 or later)
- Additional representation in float format according to IEEE754
- Channel scout functionality, for optical channel identification during startup



This data sheet is only valid in association with the "Automation terminals of the Inline product range" application description (DOK-CONTRL-ILSYSINS***-AW...-EN-P, MNR R911317021).



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3 Ordering data

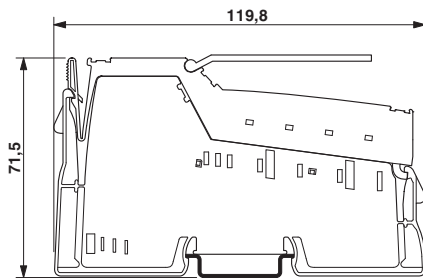
Description	Type	MNR	Pcs./Pkt.
Inline modular analog input terminal; 8 inputs, RTD (resistance temperature detector), 4-conductor connection technology, complete with individually numbered I/O connectors	R-IB IL TEMP 4/8 RTD/EF-PAC	R911173029	1
Documentation	Type	MNR	Pcs./Pkt.
Application description Automation terminals of the Inline product range	DOK-CONTRL-ILSYSINS***- AW..-EN-P	R9111317021	1

Additional ordering data

For additional ordering data (accessories), please refer to the product catalog at www.boschrexroth.com/electrics.

4 Technical data

Dimensions (nominal sizes in mm)



Width	48.8 mm
Height	119.8 mm
Depth	71.5 mm
General data	
Color	gray
Weight	190 g (with connectors)
Operating mode	Process data mode with 5 words/1 word PCP
Ambient temperature (operation)	-25 °C ... 60 °C
Ambient temperature (storage/transport)	-25 °C ... 85 °C
Permissible humidity (operation)	10 % ... 95 % (non-condensing)
Permissible humidity (storage/transport)	10 % ... 95 % (non-condensing)
Air pressure (operation)	70 kPa ... 106 kPa (up to 3000 m above sea level)
Air pressure (storage/transport)	70 kPa ... 106 kPa (up to 3000 m above sea level)
Degree of protection	IP20
Protection class	III (IEC 61140, EN 61140, VDE 0140-1)
Connection data: Inline connector	
Connection method	Spring-cage connection
Conductor cross section solid / stranded	0.2 mm ² ... 1.5 mm ² / 0.2 mm ² ... 1.5 mm ²
Conductor cross section [AWG]	24 ... 16
Stripping length	8 mm

Interface: Inline local bus

Number	2
Connection method	Inline data jumper
Transmission speed	500 kbps

Communications power (U_L)

Supply voltage	7.5 V DC (via voltage jumper)
Current consumption	typ. 95 mA max. 120 mA

Supply of analog modules (U_{ANA})

Supply voltage	24 V DC (via voltage jumper)
Supply voltage range	19.2 V DC ... 30 V DC (including all tolerances, including ripple)
Current consumption	typ. 6 mA max. 15 mA

Power consumption

Power consumption	typ. 0.85 W (entire device)
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Analog RTD inputs

Number of inputs	8 (for resistance temperature detectors)
Connection method	Spring-cage connection
Connection technology	4-wire, shielded
Sensor types (RTD) that can be used	Pt, Ni, KTY, Cu sensors, linear resistors
Linear resistance measuring range	0 Ω ... 500 Ω , 0 Ω ... 5 k Ω , 0 Ω ... 30 k Ω
A/D converter resolution	24 bit
Measuring principle	Sigma/Delta process
Measured value representation	16 bits (15 bits + sign bit)
Data formats	IB IL
Process data update	1.8 s (Up to 3.3 s possible depending on operating mode)
Input filter time	100 ms, 120 ms, 200 ms, 480 ms (adjustable)
Absolute accuracy	typ. ± 0.05 K (Pt 100 with 4-wire connection)
Permissible cable length	max. 250 m (4-wire termination with LiYCY (TP) 2 x 2 x 0.5 mm ²)
Differential non-linearity	typ. 1 ppm / $\pm 0.0001\%$ (in all ranges)
Integral non-linearity	typ. 30 ppm / $\pm 0.003\%$ (Pt 100) typ. 20 ppm / $\pm 0.002\%$ (R_{Lin} 500 Ω) typ. 200 ppm / $\pm 0.02\%$ (R_{Lin} 5000 Ω)
Crosstalk attenuation	typ. 98.6 dB (Channel-channel, Pt 100, resolution: 0.01 K) typ. 100 dB (Channel-channel, R_{Lin} 500 Ω , resolution: 0.01 Ω) typ. 88 dB (Channel-channel, R_{Lin} 5000 Ω , resolution: 0.1 Ω)

Programming data (INTERBUS, local bus)

ID code (hex)	DF
ID code (dec.)	223
Length code (hex)	05
Length code (dec.)	05
Process data channel	80 Bit
Input address area	10 Byte
Output address area	10 Byte
Parameter channel (PCP)	2 Byte
Register length (bus)	96 Bit



For the programming data/configuration data of other bus systems, please refer to the corresponding electronic device data sheet (e.g., GSD, EDS).

Configuration and parameter data in a PROFIBUS system

Required parameter data	31 Byte
Required configuration data	5 Byte

Error messages to the higher level control or computer system

Failure of the internal I/O supply	I/O error message sent to the bus coupler
Failure of or insufficient communications power U_L	I/O error message sent to the bus coupler
User error	Error message in the process data

Electrical isolation/isolation of the voltage areas

Test section	Test voltage
7.5 V supply (bus logic), 24 V supply U_{ANA} / I/O	500 V AC, 50 Hz, 1 min.
7.5 V supply (bus logic), 24 V supply U_{ANA} / functional ground	500 V AC, 50 Hz, 1 min.
I/O/functional ground	500 V AC, 50 Hz, 1 min.

Approvals

For the latest approvals, please visit www.boschrexroth.com/electrics.

5 Additional technical data

Sampling times for different filter times

Filter time	Typical scan repeat time for all eight measuring channels	Typical scan time for each measuring channel
480 ms (default)	3300 ms	482 ms
200 ms	2190 ms	201 ms
120 ms	1874 ms	121 ms
100 ms	1800 ms	100 ms

Common mode rejection with different filter times

Filter time	Optimization of common mode rejection for the interference frequency	Typical common mode rejection for measuring inputs of analog/digital converters (CMRR)
480 ms	50 Hz or 60 Hz	74 dB
120 ms	50 Hz	80 dB
101 ms	60 Hz	90 dB
200 ms	50 Hz or 60 Hz	69 dB

6 Temperature and resistance measuring ranges

Supported measuring ranges

Sensor type	Standard and manufacturer specification	Measuring range	
		Lower limit	Upper limit
Pt sensors (e.g., Pt 100, Pt 500, Pt 1000)	DIN IEC 60751 or SAMA RC 21-4-1966	-200 °C	+850 °C
Ni sensors (e.g., Ni 100, Ni 1000)	DIN 43760	-60 °C	+180 °C
Ni 500 (Viessmann)	(Viessmann)	-60 °C	+250 °C
Ni 1000 (Landis & Gyr)	(Landis & Gyr)	-50 °C	+160 °C
KTY 81-110	(Philips)	-55 °C	+150 °C
KTY 81-210	(Philips)	-55 °C	+150 °C
KTY 84	(Philips)	-40 °C	+300 °C
Cu 10	SAMA RC 21-4-1966	-70 °C	+500 °C
Cu 50	SAMA RC 21-4-1966	-50 °C	+200 °C
Cu 53	SAMA RC 21-4-1966	-50 °C	+180 °C
Linear resistor R_{Lin} 500 Ω (linear range 1)		0 Ω	525 Ω
Linear resistor R_{Lin} 5000 Ω (linear range 2)		0 Ω	5250 Ω
Linear resistance R_{Lin} 30,000 Ω (linear range 3)		0 Ω	31500 Ω

6.1 Tolerances with 4-wire technology at 25°C

Measuring conditions:

- Nominal operation $U_S = 24\text{ V}$
- Connection of sensors in 4-wire technology
- Installation on horizontal DIN rail on the wall

No.	Sensor type	Measuring range		Absolute tolerance		Relative tolerance (with reference to MRFV)	
		Lower limit	Upper limit	Typical	Maximum	Typical	Maximum
1	Pt 100 DIN and SAMA	-200 °C	+200 °C ¹⁾	±0.05 K	±0.19 K	±0.03 % ²⁾	±0.10 % ²⁾
2	Pt 100 DIN and SAMA	-200 °C	+850 °C	±0.09 K	±0.34 K	±0.01%	±0.04 %
3	Pt 1000 DIN and SAMA	-200 °C	+850 °C	±0.29 K	±0.61 K	±0.03%	±0.07%
4	Ni 100	-60 °C	+180 °C	±0.04 K	±0.10%	±0.02%	±0.05 %
5	Ni 1000	-60 °C	+180 °C	±0.09 K	±0.39 K	±0.05 %	±0.22 %
6	Ni 1000 (Landis & Gyr)	-50 °C	+160 °C	±0.09 K	±0.43 K	±0.06%	±0.27%
7	KTY 81-110	-55°C	+150 °C	±0.08 K	±0.34 K	±0.06%	±0.27%
9	KTY 81-210	-55°C	+150 °C	±0.05 K		±0.03%	
13	Linear resistor R_{Lin} 500 Ω (linear range 1)	0 Ω	500 Ω	±0.12 Ω	±2.05 Ω	±0.02%	±0.41 %
14	Linear resistor R_{Lin} 5000 Ω (linear range 2)	0 Ω	5000 Ω	±1.50 Ω	±10.20 Ω	±0.03%	±0.20 %
15	Linear resistance R_{Lin} 30,000 Ω (linear range 3)	0 Ω	30000 Ω	No data	No data	±3.00 %	No data ³⁾

1) Specified separately, since the measuring range of $\pm 200^\circ\text{C}$ is used for many applications.

2) In the more limited measuring range, the relative tolerance is also related to the measuring range final value of $+200^\circ\text{C}$.

3) No data, since this range is not calibrated.

MRFV= Measuring range final value

The data contains the offset error, gain error, and linearity error in the respective default setting (4-wire technology).

To determine the overall tolerance, please also take into consideration the values for temperature drift and where applicable the tolerances influenced by electromagnetic interference (see table below).

Typical tolerance values are measured application values that are based on the maximum variance of all test objects.

The **maximum tolerance values** represent the worst-case measurement inaccuracy. They contain the theoretical maximum possible tolerances in the corresponding measuring ranges as well as the theoretical maximum possible tolerances of the calibration and test equipment. The data is valid for at least 24 months from delivery of the module.

The **percentage tolerances** refer to the positive measuring range final value.

6.2 Additional tolerances influenced by electromagnetic interference

Type of electromagnetic interference	Standard	Level	Additional tolerances of measuring range final value	Criterion
Electromagnetic fields	EN 61000-4-3/ IEC 61000-4-3	10 V/m	< 0.1 %	A
Fast transients (burst)	EN 61000-4-4/ IEC 61000-4-4	1.1 kV	None	A
Conducted interference	EN 61000-4-6/ IEC 61000-4-6	150 kHz ... 80 MHz, 10 V, 80 % (1 kHz)	None	A
Conducted disturbance variables (with parameterized ODS = 3, see note on ODS)	EN 61000-4-6/ IEC 61000-4-6	150 kHz ... 300 MHz, 30 V , 80 % (1 kHz)	None	A

The data was determined under nominal conditions with the following parameterization: Pt 100, resolution: 0.1 K.

The accuracy class of 0.1 is maintained, even under the EMI indicated above.



Slight additional tolerances may occur due to the influence of high-frequency interference caused by wireless transmission systems in the immediate vicinity.

The specifications refer to nominal operation. The modules are directly exposed to interference without the use of additional shielding measures (e.g., steel cabinet).

The above tolerances can be reduced by implementing further shielding measures for the I/O module, e.g., by using a shielded control box/control cabinet, etc.

Please refer to the recommended measures in the DOK-CONTRL-ILSYS-INS***-AW...-DE-P application description.



As of firmware version 1.10, you can activate the "open-circuit detection sensitivity" (ODS) function. If you activate the function, refer to the "Notes on diagnostic behavior in the event of an error".

7 Temperature and drift response



Please also observe the calculation examples at the end of the document.

7.1 Tolerance and temperature response (drift response) for 4-wire connection

Tolerance and temperature response at $T_A = -25\text{ °C}$ to $+55\text{ °C}$ ($+60\text{ °C}$) ¹⁾				
Sensor type	Measuring range		Drift	
	Lower limit	Upper limit	Typical	Maximum
Pt 100 DIN and SAMA	-200 °C	+850 °C	±5 ppm/K	±18 ppm/K
Pt 1000 DIN and SAMA	-200 °C	+850 °C	±20 ppm/K	±65 ppm/K
Ni 100 DIN and SAMA	-60 °C	+180 °C	±5 ppm/K	±20 ppm/K
Ni 1000 DIN and SAMA	-60 °C	+180 °C	±20 ppm/K	±65 ppm/K
Linear resistor R_{Lin} 500 Ω (linear range 1)	0 Ω	500 Ω	±8 ppm/K	±20 ppm/K
Linear resistor R_{Lin} 5000 Ω (linear range 2)	0 Ω	5000 Ω	±25 ppm/K	±80 ppm/K

¹⁾ The temperature of $+60\text{ °C}$ is only valid for the Inline terminal with 500 kbps.

7.2 Absolute tolerances with a Pt 100 sensor at $T_A = -25\text{ °C} \dots +55\text{ °C}$ ($+60\text{ °C}$)¹⁾

Tolerances at $T_A = -25\text{ °C} \dots +55\text{ °C}$					
Sensor type	Measuring range (nominal range)		Connection method	Absolute tolerance	
	Lower limit	Upper limit		Typical	Maximum
Pt 100 DIN and SAMA	-200 °C	+200 °C	4-wire	±0.10 K	±0.37 K

¹⁾ The temperature of $+60\text{ °C}$ is only valid for the Inline terminal with 500 kbps.

8 Internal circuit diagram

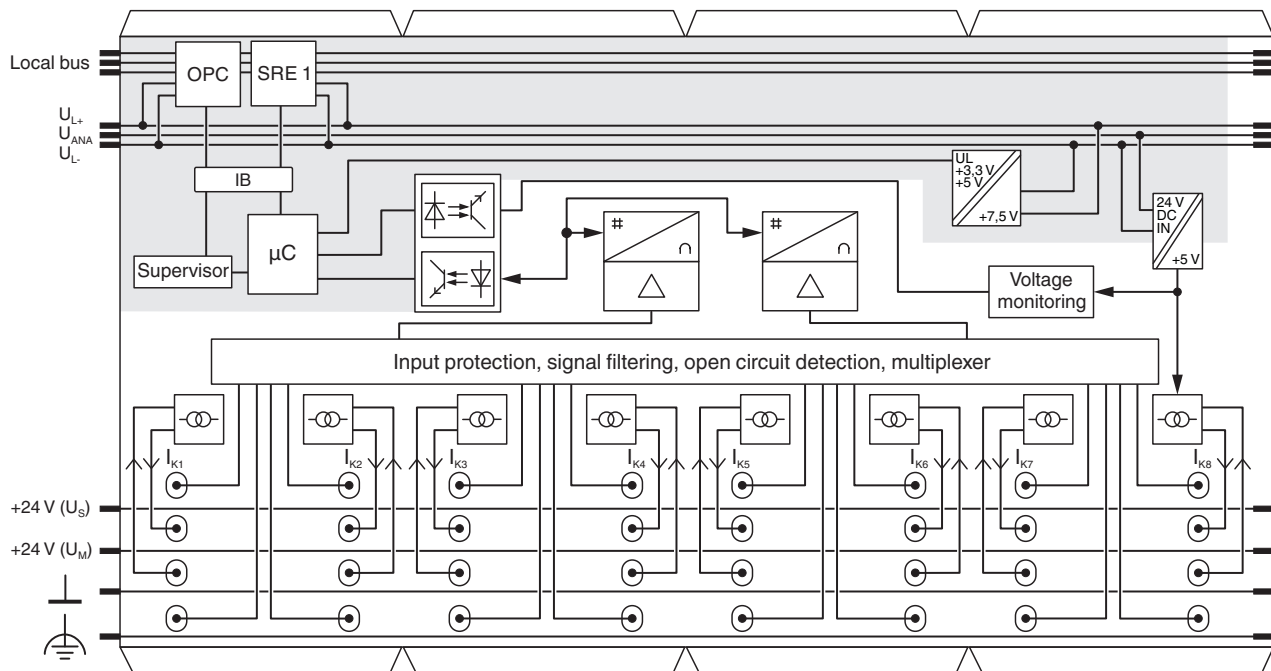








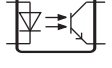


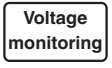



Fig. 1 Internal wiring of the terminal points

Key:

	Protocol chip		Input protection and signal filter, open-circuit detection, multiplexer
	Register expansion		Constant current source
	Protocol chip		Electrically isolated areas
	Microcontroller		
	Hardware monitoring		
	Electrical isolation (optocoupler or isolator)		
	Analog/digital converter		
	Amplifier		
	Voltage monitoring		
	Power supply unit with electrical isolation		



For an explanation of the other symbols used, please refer to the "Automation terminals of the Inline product range" application description (DOK-CONTROL-ILSYSINS***-AW...-EN-P, MNR R911317021).

9 Electrical isolation

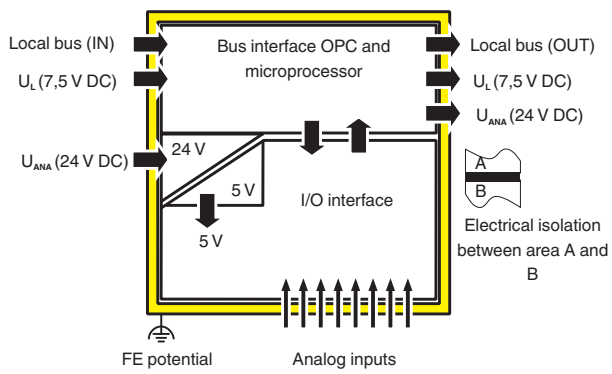


Fig. 2 *Electrical isolation of the individual function areas*

10 Terminal point assignment

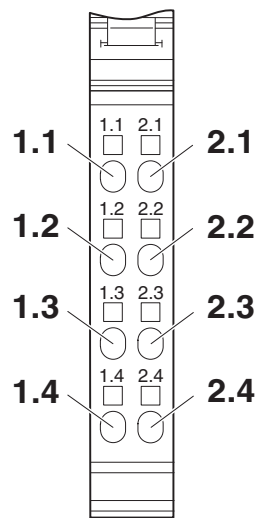


Fig. 3 Terminal point assignment

The printing on the four connectors of the module is identical.

Terminal point assignment for 4-wire termination

Terminal point	Signal				Meaning
	Connector 1	Connector 2	Connector 3	Connector 4	
1.1	U01+	U03+	U05+	U07+	RTD sensor Ux+
1.2	I01+	I03+	I05+	I07+	Constant current supply +
1.3	I01-	I03-	I05-	I07-	Constant current supply -
1.4	U01-	U03-	U05-	U07-	RTD sensor Ux-
2.1	U02+	U04+	U06+	U08+	RTD sensor Uy+
2.2	I02+	I04+	I06+	I08+	Constant current supply +
2.3	I02-	I04-	I06-	I08-	Constant current supply -
2.4	U02-	U04-	U06-	U08-	RTD sensor Uy-



WARNING: danger of electric shock

No isolating voltage for safe isolation is specified between the analog inputs and the local bus.

- Please take this into consideration during configuration.
- If required, provide signals with safe isolation (e.g., for thermistor detection).

11 Connection notes

High current flowing through potential jumpers U_M and U_S leads to a temperature rise in the potential jumpers and inside the terminal. To keep the current flowing through the potential jumpers of the analog terminals as low as possible, always place the analog terminals after all the other terminals at the end of the main circuit (for the sequence of the Inline terminals: see also "Automation terminals of the Inline product range" application description (DOK-CTRL-ILSYSINS***-AW..-EN-P, MNR R911317021).

Always connect the temperature shunts using shielded twisted pair cables.

The connection examples show how to connect the shielding.

Insulate the shielding at the sensor.

Short-circuit unused channels (see connection examples).

11.1 Suppressing error messages for unused channels

If you short-circuit unused channels, this will generate a wire breakage alert.

To suppress these messages, connect unused 4-conductor technology channels with a resistor of, for example, $R = 100 \Omega$.

Example

Install a resistor with the following characteristic values:

Resistor	100 Ω
Tolerance	1 %
Temperature coefficient	50 ppm/K

A value of $0^\circ\text{C} \pm 3 \text{ K}$ will be displayed in the process data.

As an alternative, you can use other resistors in the value range of 33Ω to 330Ω .

It is not necessary to configure the channel in this case. You can work with the default setting.

11.2 Connecting the shield

Connect the cable shield to a central position in the control cabinet.

Only connect the braided shield of the sensor cable at one end!

12 Connection examples



Connect the braided shield of the sensor cable at **one end** only.

For the examples illustrated here, please note that the cable shield must be connected at a central point in the control cabinet. The braided shield can be connected to a shield busbar using a shield clamp, for example.

12.1 4-wire connection

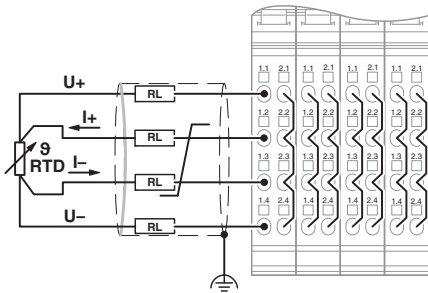


Fig. 4 Connection example: 4-wire connection

Example assignment:

Channel	Connection	Notes
1	4-wire connection	
2 ... 8	Not used	Insert the short-circuit jumpers.

12.2 3-wire connection



Manufacturer's recommendation

To improve the measured results of a 3-wire sensor on long sensor cables, combine the 4-wire termination with the 3-wire sensor.

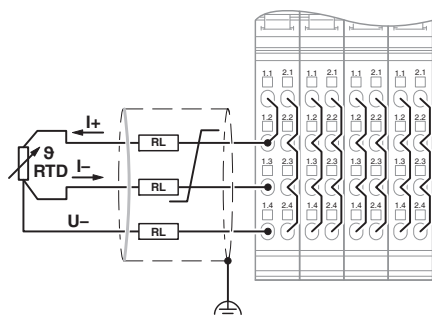


Fig. 5 Connection example: 3-wire connection

12.3 2-wire connection

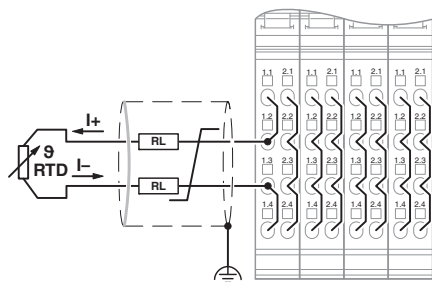


Fig. 6 Connection example: 2-wire connection

12.4 4-wire termination using a sensor in 3-wire technology

In order to also measure 3-wire sensors with very long supply lines without additional tolerances, we also recommend 4-conductor connection technology here.

This compensates for any cable interference, which may be caused by very long sensor cable lengths due, for example, to cable resistance, capacitance, and inductance. In addition, the temperature drift of the connecting cable is eliminated.

Bridge connections Ix- and Ux- on the sensor side.

In this application you can connect sensors with a cable length up to 250 m.

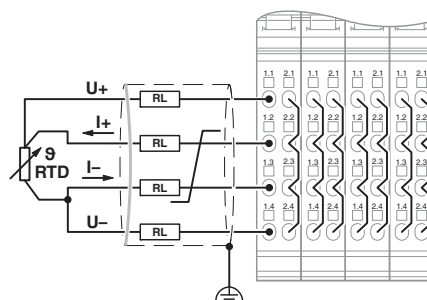


Fig. 7 Connection example: 4-wire connection for 3-wire sensor with very long supply lines (> 100 m)

13 Local diagnostic and status indicators

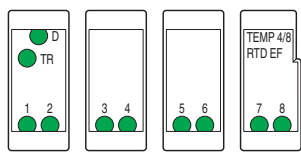


Fig. 8 Local diagnostic and status indicators

Designation	Color	Meaning
D	Green	Diagnostics (bus and logic voltage)
TR	Green	PCP
1 ... 8	Green on	Measuring channel in operation
	Red on	Open circuit, overrange or underrange
	Orange	Channel Scout
	Flashing (0.5 Hz)	Channel chosen for startup purposes and selected using the PCP object (see the "Channel Scout object (0090 _{hex})" section)

14 Diagnostic behavior in the event of an error

The diagnostics detect and indicate single or multiple interrupted sensor wires as well as completely disconnected sensor cables.

14.1 Diagnostic behavior in the event of an error with ODS = 0 or ODS = 1

The following error states are diagnosed and indicated by the terminal. The errors are indicated at the corresponding local diagnostic indicators and, when IB IL format is set, in the IN process data.

Error	Indication in the process data or other messages	Local diagnostic indicators
U_L missing	None, bus error	All LEDs are off
Measured value is above the valid measuring range (e.g., 500 Ω at Pt 100 input)	8001 _{hex} : Measuring range exceeded (overrange) Error bit in IN0 is set	LED of the relevant channel (1 ... 8) lights up red
Sensor connector is not connectorged in, the sensor cable is completely interrupted	8002 _{hex} : Open circuit Error bit in IN0 is set	LED of the relevant channel (1 ... 8) lights up red
Measured value invalid (e.g., during parameterization of a channel)	8004 _{hex} : Measured value invalid Error bit in IN0 is set	LED of the relevant channel (1 ... 8) briefly lights up red
U_{ANA} (24 V) not present or failure of the internal I/O voltages	I/O error message is triggered	D LED flashes green at 2 Hz
Internal component faulty	8040 _{hex} : Device faulty Error bit in IN0 is set	
Measured value is below the valid measuring range (e.g., 5 Ω at Pt 100 input)	8080 _{hex} : Below measuring range (under-range) Error bit in IN0 is set	LED of the relevant channel (1 ... 8) briefly lights up red

14.2 Diagnostic behavior in the event of an error with ODS = 3

For applications with very high EMC requirements (significantly higher than the standard limit values), the ODS function can be set to 3. This deactivates the open-circuit detection function and allows for interference-free measurements even in the case of very high electromagnetic interference.

Error	Indication in the process data or other messages	Local diagnostic indicators
Sensor connector is not connectorged in, the sensor cable is completely interrupted	8001 _{hex} : Measuring range exceeded (overrange) Error bit in IN0 is set	LED of the relevant channel (1 ... 8) lights up red

14.3 Response times for diagnostics in the event of an open circuit

The table below lists the typical response times for diagnostics when the sensor connector is not plugged in and/or the sensor cable is completely interrupted.

Setting for ODS (open-circuit detection sensitivity)		Setting recommended for	Diagnostic message in the process data	Typical response time of all eight channels
0 _{hex}	High sensitivity	Interference coupling within the standard level	8002 _{hex} : Open circuit	2 s ... 5 s
1 _{hex}	Medium sensitivity	Interference coupling slightly above the standard level	8002 _{hex} : Open circuit	6 s
3 _{hex}	Switched off	Interference coupling signifi- cantly higher than the stan- dard level	8001 _{hex} : Measuring range exceeded (overrange)	15 s ... 17 s



The typical response time of the diagnostic messages was determined between the error event and the message in the process data. The time also includes the transmission of the data to the controller/controller board in the test system used.

14.4 Response times for diagnostics if single sensor wires are interrupted

The table below lists the typical response times for diagnostics if single sensor wires are interrupted.

Setting for ODS (open-circuit detec- tion sensitivity)		Setting recommended for	Diagnostic message in the process data	Typical response time of all eight channels
0 _{hex}	High sensitivity	Interference coupling within the standard level	8002 _{hex} : open circuit or 8080 _{hex} : overrange	2 s ... 5 s
1 _{hex}	Medium sensitivity	Interference coupling slightly above the standard level	8002 _{hex} : open circuit or 8080 _{hex} : overrange	2 s ... 5 s
3 _{hex}	Switched off	Interference coupling signifi- cantly higher than the stan- dard level	8001 _{hex} : overrange or 8080 _{hex} : underrange	2 s ... 60 s



If ODS = 3 is parameterized:
Please note that the response time for the
diagnostic message can be up to 60 sec-
onds in your application if a single wire is
broken.
During this time the measured values are
either rising or falling.

15 Parameterization and analog values

You only need to parameterize the terminal if you do not wish to operate the channels with the default values (see "Output word OUT1 (parameter word), value range, and parameter default settings").

You can either parameterize the terminal via process data or via PCP and transmit the analog values accordingly.

If you have parameterized the terminal via PCP, the parameterization can no longer be modified via the process data.

Examples for parameterizing the terminal via process data



For easy terminal configuration, a function block can be downloaded at www.boschrexroth.com/electrics.

16 Process data

The terminal uses five input process data words and five output process data words.

The terminal also has one PCP word.

Order of the PCP word and process data words:

Communication via compact PCP	Process data control	Process data for measured value transfer			
PCP	OUT0 (control word)	OUT1	OUT2	OUT3	OUT4
PCP	IN0 (status word)	IN1	IN2	IN3	IN4
Acyclic request	Cyclic request				

17 OUT process data words

Five OUT process data words are available.

The terminal can be parameterized via the OUT process data.

Word OUT0 contains the command; word OUT1 contains the parameters for this command.

17.1 Output word OUT0 (control word)

	OUT0								
Bit	15 ... 8	7	6	5	4	3	2	1	0
Assignment	Command code	0	0	ODS		0	0	0	0



Set all reserved bits to 0.



ODS is only relevant for commands 4x00_{hex}, 5x00_{hex}, and 6000_{hex}.

Bit 15 to bit 8 (command code):

Bit 15 ... bit 8	OUT0 (hex)	Command function
00000KKK	0x00	Read measured value in IN1 channel-by-channel
00001000	0800	Read measured values of channel 1 ... 4 in IN1 ... IN4
00001001	0900	Read measured values of channel 5 ... 8 in IN1 ... IN4
00010KKK	1x00	Read parameterization in IN1 channel-by-channel
00111100	3C00	Read device data. The firmware version and the device ID are displayed in IN1.
01000KKK	4x00	Parameterize channel. Parameterization in OUT1
01010KKK	5x00	Parameterize channel and read measured value of the channel. Parameterization in OUT1, measured value in IN1
0110 0000	6000	Parameterize entire terminal (all channels). Parameterization in OUT1

KKK Channel number

Channel assignment:

Bit			Channel number
10	9	8	
0	0	0	1
0	0	1	2
0	1	0	3
0	1	1	4
1	0	0	5
1	0	1	6
1	1	0	7
1	1	1	8

For commands 4x00_{hex}, 5x00_{hex}, and 6000_{hex}

Bit 5 and Bit 4:

ODS: open-circuit detection sensitivity, as of firmware 1.10

Bit		ODS: open-circuit detection sensitivity
5	4	
0	0	High sensitivity
0	1	Medium sensitivity
1	0	Reserved
1	1	Switched off



Please also refer to the "Notes on diagnostic behavior in the event of an error" section.

17.2 Output word OUT1 (parameter word)

Specify the parameters for commands $4x00_{hex}$, $5x00_{hex}$, and 6000_{hex} in OUT1. This parameter word is only evaluated for these commands.

	OUT1															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Assignment	0	Filter time		0	R ₀				Resolution		Data format		Sensor type			

R_0 Select the resistance of the sensor at 0°C.
Here, for example, you can select whether Pt 100, Pt 500 or Pt 1000 is to be used for the platinum sensor type.

Resolution Quantization of the measured value, choice between °Celsius or °Fahrenheit

Data format Representation of the measured value in the IN process data

Sensor type Setting for the selected sensor type



Set all unused bits to 0.



If invalid parameters are specified in the parameter word, the command will not be executed. The command is acknowledged in the input words with the set error bit.

Resistance type (R_0):

R_0 (Ω)	Code (bin)	Code (hex)
100	0000	0
10	0001	1
20	0010	2
30	0011	3
50	0100	4
120	0101	5
150	0110	6
200	0111	7
240	1000	8
300	1001	9
400	1010	A
500	1011	B
1000	1100	C
1500	1101	D
2000	1110	E
10000	1111	F

Parameter value ranges and presets

The values displayed in bold are pre-settings.

Filter time:

Filter time	Code (bin)	Code (dec)
480 ms	00	0
120 ms	01	1
101 ms	10	2
200 ms	11	3

Resolution:

Resolution for sensor type					
Temperature sensors	Linear R 0 Ω ... 500 Ω	Linear R 0 Ω ... 5 k Ω	Linear R 0 Ω ... 30 Ω	Code (bin)	Code (dec)
0.1 °C	0.1 Ω	1 Ω	1 Ω	00	0
0.01 °C	0.01 Ω	0.01 Ω	Re-served	01	1
0.1 °F	Reserved			10	2
0.01 °F				11	3

Data format:

Data format	Code (bin)	Code (dec)
IB IL	00	0
Reserved	01	1
S7-compatible	10	2
Reserved	11	3

Sensor type:

Sensor type	Code (bin)	Code (hex)
Pt DIN	0000	0
Pt SAMA	0001	1
Ni DIN	0010	2
Ni SAMA	0011	3
Cu 10	0100	4
Cu 50	0101	5
Cu 53	0110	6
Ni 1000 (L&G)	0111	7
Ni 500 (Viessmann)	1000	8
KTY 81-110	1001	9
KTY 84 (KTY 84-130, KTY 84-150)	1010	A
KTY 81-210	1011	B
Linear R 0 Ω ... 30 Ω	1100	C
Reserved	1101	D
Linear R 0 Ω ... 500 Ω	1110	E
Linear R 0 Ω ... 5 kΩ	1111	F



For the sensor types 0_{hex} to 3_{hex} parameterize the resistance type as well.

18 Process data input words IN**18.1 Input word IN0 (status word)**

Input word IN0 performs the task of a status word.

IN0										
Bit	15	14 ... 8				7	6	5	4	3
Assignment	EB	SP				0	0	0	0	0

EB: Error Bit

EB = 0 No error has occurred.

EB = 1 An error has occurred.

The error bit indicates whether a command could be executed without errors or not.

Possible errors and their effects are listed in Section "Diagnostics".

SP: Mirrored command code

A command code mirrored from the control word. Here, the MSB is suppressed.

18.2 Input words IN1 to IN4

The measured values, parameterization or firmware version are transmitted to the controller board or the computer via process data input words IN1 to IN4 according to the parameterization.

For control word 3C00_{hex}, word IN1 supplies the firmware version and the module ID.

Example: Firmware version 1.23

	IN1															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Assignment (hex)	1				2				3				E			
Meaning	Firmware version 1.23												Module ID			

19 Formats for representing measured values

19.1 IB IL format

The measured value is represented in bits 14 to 0. An additional bit (bit 15) is available as a sign bit.

This format supports extended diagnostics. Values $> 8000_{\text{hex}}$ and $< 8100_{\text{hex}}$ indicate an error.

Measured value representation in IB IL format

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
V	Analog value														

V Sign bit

19.2 Supported error codes in IB IL format

In the IB IL format a diagnostic code is mapped to the input data in the event of an error.

Code (hex)	Cause
8001	Measuring range exceeded (overrange)
8002	Open circuit
8004	Measured value is invalid
8020	Sensor and/or analog supply not present
8040	Device faulty
8080	Below measuring range (underrange)



If the measured value is outside the display range of the process data, the "Overrange" or "Underrange" error message is generated.

19.3 Significant values in IB IL format

Input data		R 0 Ω ... 500 Ω		R 0 Ω ... 5 k Ω		Temperature sensors	
Resolution		0.1 Ω	0.01 Ω	1 Ω	0.1 Ω	0.1°C or 0.1°F	0.01°C or 0.01°F
hex	dec	Ω	Ω	Ω	Ω	°C or °F	°C or °F
8001	Overrange	> 525	> 325.12	> 5250	> 3251.2	$> \text{Limit value}$	$> \text{Limit value}$
0FA0	1000	+100.0	+10.0	+1000.0	+100.0	+100.0	+10.0
0001	1	+0.1	+0.01	+1.0	+0.1	+0.1	+0.01
0000	0	≤ 0	≤ 0	≤ 0	≤ 0	0	0
FFFF	-1					-0.1	-0.01
FC18	-1000					-100.000	-10.0
8080	Underrange					$< \text{Limit value}$	$< \text{Limit value}$

20 PCP communication

20.1 General information

On delivery, the terminal is parameterized according to the default settings (under parameterization). The terminal can be parameterized to suit your application using process data or PCP.

During PCP operation you can parameterize the terminal using the "Config Table" object.

20.2 Object dictionary for PCP communication

Index (hex)	Object type	Data type	A	L	Meaning	Object name	Rights
0018	Record		6		Diagnostic state	DiagState	rd
0080	Array	UINT16	12	2	Parameter table: terminal parameterization	Config Table	rd/wr
0081	Array	UINT16	8	2	Measured value in 16-bit format	Analog Values	rd
0082	Record		8	6	Measured value in extended float format	Measured Value Float	rd
0090		UINT8	1	1	Channel Scout	Channel Scout	rd/wr

A Number of elements

L Length of an element in bytes

rd

Read access permitted

wr

Write access permitted

20.3 Diagnostics state (0018_{hex}: DiagState)

This object is used for a structured message of an error.

Object description:

Object	DiagState		
Access	Read		
Data type	Record	6 elements	
Index	0018 _{hex}		
Subindex	00 _{hex}	Read all elements	
	01 _{hex}	Error Number	UINT16
	02 _{hex}	Priority	UINT8
	03 _{hex}	Channel	UINT8
	04 _{hex}	Error code	UINT16
	05 _{hex}	More follows	UINT8
	06 _{hex}	Text (10 characters)	Visible String
Length (bytes)	11 _{hex}	Subindex 00 _{hex}	
	02 _{hex}	Subindex 01 _{hex}	
	01 _{hex}	Subindex 02 _{hex}	
	01 _{hex}	Subindex 03 _{hex}	
	02 _{hex}	Subindex 04 _{hex}	
	01 _{hex}	Subindex 05 _{hex}	
	0A _{hex}	Subindex 06 _{hex}	
Data	Diagnostic state		

Value range:

Error Number	0 ... 65535 _{dec}	
Priority	Error code = 0000 _{hex}	Prio: 00 _{hex}
	Other	Prio: 02 _{hex}
Channel	Error code = 0000 _{hex}	Channel: 00 _{hex}
	Other	01 _{hex} ... 08 _{hex}
Error code	0000 _{hex}	OK
	8910 _{hex}	Oerrange
	8920 _{hex}	Underrange
	7710 _{hex}	Open circuit
	5160 _{hex}	Power fail
	5010 _{hex}	Hardware fault
More follows	00 _{hex}	
Text (10 characters)	Error code = 0000 _{hex}	Text: Status OK
	Other	Error-specific

20.4 Parameter table (0080_{hex}: Config Table)

Parameterize the terminal using this object.

Object description:

Object	Config Table	
Access	Read, write	
Data type	Array of UINT16	12 x 2 bytes
Index	0080 _{hex}	
Subindex	00 _{hex}	Read/write all elements
	01 _{hex}	Parameterization of channel 1
	02 _{hex}	Parameterization of channel 2
	03 _{hex}	Parameterization of channel 3
	04 _{hex}	Parameterization of channel 4
	05 _{hex}	Parameterization of channel 5
	06 _{hex}	Parameterization of channel 6
	07 _{hex}	Parameterization of channel 7
	08 _{hex}	Parameterization of channel 8
	09 _{hex}	Reserved
	0A _{hex}	ODS
	0B _{hex}	Reserved
	0C _{hex}	Reserved
Length (bytes)	18 _{hex}	Subindex 00 _{hex}
	02 _{hex}	Subindex 01 _{hex} to 0C _{hex}
Data	Parameter table: terminal parameterization	

Element value range

Parameterization of channel x

The "Parameterization of channel x" elements have the following structure:

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Assignment	0	Filter time		0	R ₀				Resolution		Data format		Sensor type			

The value ranges and default values are listed in section "Output word OUT1 (parameter word)".

If an invalid configuration is specified, a negative confirmation is generated with error message 08_{hex}, 00_{hex} or xx30_{hex}. The low byte of the Additional_Error_Code is 30_{hex} (value is out of value range), the high byte contains the number of the element in question.

Example: Config Table is completely written with data (subindex 00) and the entry for channel 2 is invalid. In this case, the Additional_Error_Code is equal to 0230_{hex}.

ODS (as of firmware 1.10)

Bit	15 ... 8	7	6	5	4	3	2	1	0
Assign- ment	0	0	0	ODS	0	0	0	0	0

For commands 4x00_{hex}, 5x00_{hex}, and 6000_{hex}:

Bit 5 and Bit 4:

ODS: open-circuit detection sensitivity, as of firmware 1.10

Bit		ODS: open-circuit detection sensitivity
5	4	
0	0	High sensitivity
0	1	Medium sensitivity
1	0	Reserved
1	1	Switched off

20.5 Analog values of the channels (0081_{hex}: Analog Values)

The elements of this object contain the analog values of the channels in the format that was parameterized for this channel.

Object description:

Object	Analog Values	
Access	Read	
Data type	Array of UINT16	8 x 2 bytes
Index	0081 _{hex}	
Subindex	00 _{hex}	Read all elements
	01 _{hex}	Analog value of channel 1
	02 _{hex}	Analog value of channel 2
	03 _{hex}	Analog value of channel 3
	04 _{hex}	Analog value of channel 4
	05 _{hex}	Analog value of channel 5
	06 _{hex}	Analog value of channel 6
	07 _{hex}	Analog value of channel 7
	08 _{hex}	Analog value of channel 8
Length (bytes)	10 _{hex}	Subindex 00 _{hex}
	02 _{hex}	Subindex 01 _{hex} to 08 _{hex}
Data	Analog values of the channels	

20.6 Measured value in extended float format (0082_{hex}: Measured Value Float)

The elements of this object contain the measured values in the highest accuracy of the terminal.

Object description:

Object	Measured Value Float	
Access	Read	
Data type	Array of Records	8 x 6 bytes
Index	0082 _{hex}	
Subindex	00 _{hex}	Read all elements
	01 _{hex}	Measured value of channel 1 (Record)
	02 _{hex}	Measured value of channel 2 (Record)
	03 _{hex}	Measured value of channel 3 (Record)
	04 _{hex}	Measured value of channel 4 (Record)
	05 _{hex}	Measured value of channel 5 (Record)
	06 _{hex}	Measured value of channel 6 (Record)
	07 _{hex}	Measured value of channel 7 (Record)
	08 _{hex}	Measured value of channel 8 (Record)
Length (bytes)	30 _{hex}	Subindex 00 _{hex}
	06 _{hex}	Subindex 01 _{hex} to 08 _{hex}
Data	Measured value in extended float format	

Extended Float Format is a specially defined format. It consists of the measured value in float format, a status, and a unit.

Status is necessary because the float format defines no patterns providing information on the status of the numerical value.

The status corresponds to the LSB of the diagnostic code in IB IL format (e.g., overrange: status = 01, diagnostic code = 8001_{hex}). If status = 0, the measured value is valid.

Record structure:

Element	Data type	Length in bytes	Meaning
1	Float	4	Measured value in float format according to IEEE 754
2	UINT8	1	Status
3	UINT8	1	Unit

Structure of the float format according to IEEE 754 in the bit representation:

VEEEE EEEE	EMMM MMMM	MMMM MMMM	MMMM MMMM
------------	--------------	--------------	--------------

V 1 sign bit, 0: positive, 1: negative

E 8 bits exponent with offset 7F_{hex}

M 23 bits mantissa

Some example values for conversion from floating point to hexadecimal representation:

Floating point	Hexadecimal representation
1.0	3F 80 00 00
10.0	41 20 00 00
1.03965528	3F 85 13 6D
- 1.0	BF 80 00 00

Unit	Code
°Celsius (°C)	50 (32 _{hex})
°Fahrenheit (°F)	51 (31 _{hex})
Ohms (Ω)	55 (37 _{hex})

Status	Code
Measured value is valid	00 _{hex}
Measured value is invalid	Other

20.7 Channel Scout (0090_{hex})

This object is used to quickly find a channel.



The channel scout functionality is superior to all diagnostic messages of the selected LED and must be disabled separately by the user. The parameterization of a channel automatically causes this functionality to be aborted.

Object description:

Object	Channel Scout	
Access	Read, write	
Data type	UINT8	1 byte
Index	0090 _{hex}	
Subindex	00 _{hex}	Activate or deactivate channel scout
Length (bytes)	01 _{hex}	Subindex 00 _{hex}
Data	Control of the LED for the selected channel	

Value range:

- 0
- Disable all channel scout processes
- 1 ... 8
- Green LED of the channel is flashing at 0.5 Hz (1 second ON, 1 second OFF)

21 Parameterization example

All eight channels of the terminal are preset to a Pt 100 sensor and a filter time of 480 ms.

If you do not wish to work with the factory settings, parameterize the terminal accordingly.

To do this, proceed as follows.

Channel	Filter time	R0 (Ω)	Resolution	Data format	Sensor type	Parameter word (hex)
1	480 ms	100	0.1 °C	IB IL	Pt DIN	0000
2	480 ms	100	0.1 °C	IB IL	Ni DIN	0002
3	480 ms	(100)	0.01 Ω	IB IL	Linear R 0 Ω ... 500 Ω	004E
4	480 ms	(100)	0.1 °C	IB IL	Cu 10	0004
5	480 ms	100	0.01 °C	IB IL	Pt DIN	0040
6	480 ms	1000	0.1 °C	IB IL	Pt DIN	0C00
7	480 ms	500	0.1 °C	IB IL	Ni DIN	0B02
8	480 ms	(100)	1.0 Ω	IB IL	Linear R 0 Ω ... 500 Ω	000F

In the table below, all values for INx and OUTx are hexadecimal values.

Step	Process data	Parameterization
1	OUT0 = 0000, 0800 or 0900	Specify a passive command first
2	Wait until IN0 = OUT0	Wait for confirmation
3	OUT1 = 0000, OUT0 = 4000	Parameterization of channel 1
4	Wait until IN0 = OUT0	Wait for confirmation
5	OUT1 = 0002, OUT0 = 4100	Parameterization of channel 2
6	Wait until IN0 = OUT0	Wait for confirmation
7	OUT1 = 00E4, OUT0 = 4200	Parameterization of channel 3
8	Wait until IN0 = OUT0	Wait for confirmation
9	OUT1 = 0004, OUT0 = 4300	Parameterization of channel 4
10	Wait until IN0 = OUT0	Wait for confirmation
11	OUT1 = 0040, OUT0 = 4300	Parameterization of channel 5
12	Wait until IN0 = OUT0	Wait for confirmation
13	OUT1 = 0C00, OUT0 = 4500	Parameterization of channel 6
14	Wait until IN0 = OUT0	Wait for confirmation
15	OUT1 = 0B02, OUT0 = 4600	Parameterization of channel 7
16	Wait until IN0 = OUT0	Wait for confirmation
17	OUT1 = 000F, OUT0 = 4700	Parameterization of channel 8
18	Wait until IN0 = OUT0	Wait for confirmation
19	Wait 4 seconds	Wait until all channels have settled
20	OUT0 = 0800	Request measured values of channels 1 ... 4
21	Wait until IN0 = OUT0	Wait for confirmation
22	Measured value channel 1 = IN1 Measured value channel 2 = IN2 Measured value channel 3 = IN3 Measured value channel 4 = IN4	Read measured values of channels 1 ... 4
23	OUT0 = 9000	Request measured values of channels 5 ... 8
24	Wait until IN0 = OUT0	Wait for confirmation
25	Measured value channel 5 = IN1 Measured value channel 6 = IN2 Measured value channel 7 = IN3 Measured value channel 8 = IN4	Read measured values of channels 5 ... 8

22 Measuring ranges depending on the resolution (IB IL format)

Resolution		Temperature sensors
Code (bin)	Meaning	
00	0.1 °C	-273 °C ... +3276.8 °C
01	0.01°C	-273 °C ... +327.68 °C
10	0.1°F	-459 °F ... +3276.8 °F
11	0.01°F	-459 °F ... +327.68 °F



Temperature values in °C can be converted to °F using the following formula:
 $T [^{\circ}\text{F}] = T [^{\circ}\text{C}] \times 9/5 + 32$

Where:

- T [°F] Temperature in °F
- T [°C] Temperature in °C

23 Measuring errors caused by connecting cables

23.1 4-wire system

Sensors in 4-wire technology can be connected to the terminal on all channels. The terminal supports a maximum connection length of 250 meters per sensor. Additional measuring tolerances caused by the cable length do not occur here.

23.2 Systematic errors during temperature measurement using 2-wire technology

Diagram 1

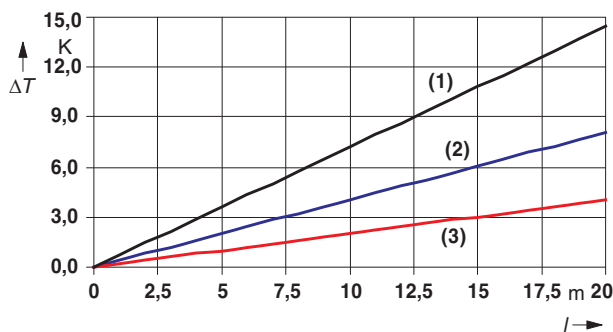


Fig. 9 Systematic temperature measuring error ΔT depending on the cable length l

Curves depending on cable cross section A

- 1 Temperature measuring error for $A = 0.14 \text{ mm}^2$
- 2 Temperature measuring error for $A = 0.25 \text{ mm}^2$
- 3 Temperature measuring error for $A = 0.50 \text{ mm}^2$

(Measuring error valid for: copper cable $\chi = 57 \text{ m}/\Omega\text{mm}^2$, $T_A = 25^\circ\text{C}$ and Pt 100 sensor)

Diagram 2

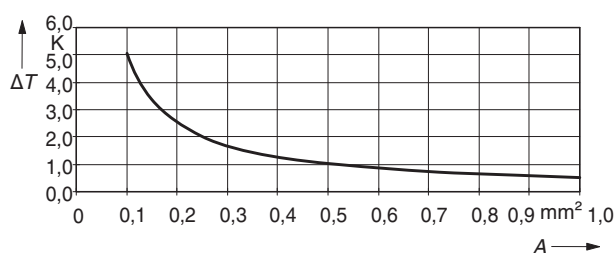


Fig. 10 Systematic temperature measuring error ΔT depending on the cable cross section A

(Measuring error valid for: copper cable $\chi = 57 \text{ m}/\Omega\text{mm}^2$, $T_A = 25^\circ\text{C}$, $l = 5 \text{ m}$, and Pt 100 sensor)

Diagram 3

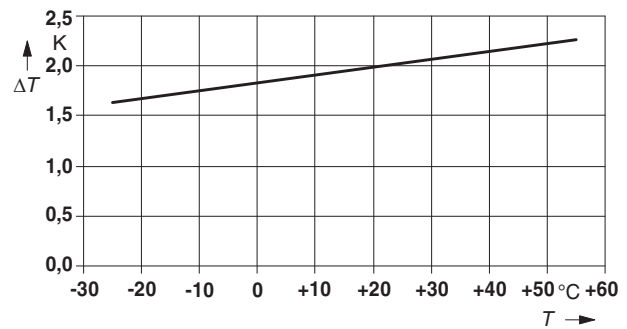


Fig. 11 Systematic temperature measuring error ΔT depending on the cable temperature T

(Measuring error valid for: copper cable $\chi = 57 \text{ m}/\Omega\text{mm}^2$, $T_A = 25^\circ\text{C}$, $l = 5 \text{ m}$, $A = 0.25 \text{ mm}^2$, and Pt 100 sensor)

Conclusion

All diagrams show that the increase in cable resistance causes the measuring error.

A considerable improvement is made when Pt 1000 sensors are used. Due to the 10-fold higher temperature coefficient α ($\alpha = 0.385 \Omega/\text{K}$ for Pt 100 to $\alpha = 3.85 \Omega/\text{K}$ for Pt 1000) the effect of the cable resistance on the measurement is decreased by factor 10. All errors in the diagrams above would be reduced by factor 10.

Diagram 1 clearly shows the effect of the cable length on the cable resistance and therefore on the measuring error. The solution is to use the shortest possible sensor cables.

Diagram 2 shows the influence of the cable diameter on the cable resistance. It can be seen that cables with a diameter of less than 0.5 mm^2 cause the error to increase exponentially.

Diagram 3 shows the influence of the ambient temperature on the cable resistance. This parameter is of minor importance and can hardly be influenced. It is mentioned here only for the sake of completeness.

The formula for calculating the cable resistance is as follows:

$$R_L = R_{L20} \times \left(1 + 0,0039 \frac{1}{K} \times (T - 20^{\circ}\text{C}) \right)$$

$$R_L = \frac{l}{\chi \times A} \times \left(1 + 0,0039 \frac{1}{K} \times (T - 20^{\circ}\text{C}) \right)$$

Where:

R_L	Cable resistance in Ω
R_{L20}	Cable resistance at 20°C in Ω
l	Cable length in m
χ	Specific electrical resistance of copper in $\text{m}/\Omega\text{mm}^2$
A	Cable cross section in mm^2
0.0039 1/K	Temperature coefficient for copper (percentage purity of 99.9%)
T	Ambient temperature (cable temperature) in $^{\circ}\text{C}$

Since there are two cable resistances in the measuring system (forward and return), the value must be doubled. The absolute measuring error in Kelvin [K] is provided for platinum detectors according to DIN using the average temperature coefficient χ ($\chi = 0.385 \text{ } \Omega/\text{K}$ for Pt 100; $\chi = 3.85 \text{ } \Omega/\text{K}$ for Pt 1000).

24 Calculation examples

24.1 Typical temperature behavior

Task setting:

Temperatures of up to +45°C are achieved in the control cabinet.

1. What typical drift values of the measuring inputs are to be expected for temperature measurement with a Pt 100 sensor using 4-wire technology at a measuring temperature of +180°C for this device?
2. What typical measuring tolerance is to be expected at +45°C?

Calculation:

The temperature difference is calculated using the formula (1):

$$\Delta T_U = T_S - 25^\circ\text{C} \quad (1)$$

Where:

ΔT_U Temperature difference (difference between current switch cabinet temperature and reference temperature of +25°C)

T_S Current temperature in the switch cabinet

Value for this example:

$T_S = 45^\circ\text{C}$

According to formula (1)

$$\begin{aligned} \Delta T_U &= T_S - 25^\circ\text{C} \\ &= 45^\circ\text{C} - 25^\circ\text{C} \\ &= 20\text{ K} \end{aligned}$$

The temperature drift of the Pt 100 sensor is calculated according to formula (2):

$$T_{\text{Drift}} = \Delta T_A \times T_K \times T_M \quad (2)$$

Where:

T_{Drift} Temperature drift of the Pt 100 measuring input

ΔT_U Temperature difference; from formula (1)

T_K Temperature coefficient

T_M Measuring range final value

Values for this example:

$\Delta T_U = 20\text{ K}$

$T_K = \pm 5\text{ ppm/K}$ (typical drift)

$T_M = 180^\circ\text{C}$

According to formula (2)

$$\begin{aligned} T_{\text{Drift}} &= \Delta T_A \times T_K \times T_M \\ &= 20\text{ K} \times \pm 5\text{ ppm/K} \times 180^\circ\text{C} \\ &= 20 \times \pm 5 \times 10^{-6} \times 180^\circ\text{C} \\ &= \pm 0.018\text{ K} \\ T_{\text{Drift}} &= \pm 0.02\text{ K} \end{aligned}$$

Solution:

Under these marginal conditions, a typical temperature drift of $\pm 0.02\text{ K}$ is to be expected.

Calculation of the typical measuring tolerance:

The measuring tolerance is calculated using the formula (3):

$$\Delta T_{\text{Tot}} = \Delta T_{25} + T_{\text{Drift}} \quad (3)$$

Where:

ΔT_{Tot} Total tolerance

ΔT_{25} Typical tolerance at 25°C

T_{Drift} Drift at 45°C; from formula (2)

Values for this example:

$\Delta T_{25} = \pm 0.05\text{ K}$

$T_{\text{Drift}} = \pm 0.02\text{ K}$

According to formula (3)

$$\begin{aligned} \Delta T_{\text{Tot}} &= \Delta T_{25} + T_{\text{Drift}} \\ &= \pm 0.05\text{ K} + 0.02\text{ K} \\ \Delta T_{\text{Tot}} &= \pm 0.07^\circ\text{K} \end{aligned}$$

Solution:

At an ambient temperature of +45°C, a typical measuring tolerance of $\pm 0.07\text{ K}$ is to be expected.

24.2 Maximum temperature behavior (worst case)

Task setting:

Temperatures of up to +40°C are achieved in the control cabinet.

What typical drift values of the measuring inputs are to be expected for temperature measurement with a Pt 100 sensor using 4-wire technology at a measuring temperature of +200°C for this device?

Calculation:

The measuring tolerance is calculated using the formula (3):

$$\Delta T_{\text{Tot}} = \Delta T_{25} + T_{\text{Drift}} \quad (3)$$

Values for this example:

$$\Delta T_{25} = \pm 0.19 \text{ K}$$

$$T_{\text{Drift}} \text{ Must be calculated}$$

To calculate the drift, proceed as described in the example for the typical temperature response.

The temperature difference is calculated using the formula (1):

$$\Delta T_U = T_S - 25 \text{ °C} \quad (1)$$

Value for this example:

$$T_S = 40 \text{ °C}$$

According to formula (1)

$$\begin{aligned} \Delta T_U &= T_S - 25 \text{ °C} \\ &= 40 \text{ °C} - 25 \text{ °C} \\ &= 15 \text{ K} \end{aligned}$$

The maximum temperature drift of the Pt 100 sensor is calculated according to formula (2):

$$T_{\text{Drift}} = \Delta T_A \times T_K \times T_M \quad (2)$$

Values for this example:

$$\Delta T_U = 15 \text{ K}$$

$$T_K = \pm 18 \text{ ppm/K (maximum drift)}$$

$$T_M = 200 \text{ °C}$$

According to formula (2)

$$\begin{aligned} T_{\text{Drift}} &= \Delta T_A \times T_K \times T_M \\ &= 15 \text{ K} \times \pm 18 \text{ ppm/K} \times 200 \text{ °C} \\ &= 15 \times \pm 18 \times 10^{-6} \times 200 \text{ °C} \\ &= \pm 0.054 \text{ K} \\ T_{\text{Drift}} &= \pm 0.05 \text{ K} \end{aligned}$$

According to formula (3)

$$\begin{aligned} \Delta T_{\text{Tot}} &= \Delta T_{25} + T_{\text{Drift}} \\ &= \pm 0.19 \text{ K} + \pm 0.05 \text{ K} \\ \Delta T_{\text{Tot}} &= \pm 0.24 \text{ K} \end{aligned}$$

Solution:

At an ambient temperature of +40°C, a maximum worst-case measuring tolerance of ±0.24 K should be expected for a measuring temperature of +200°C.