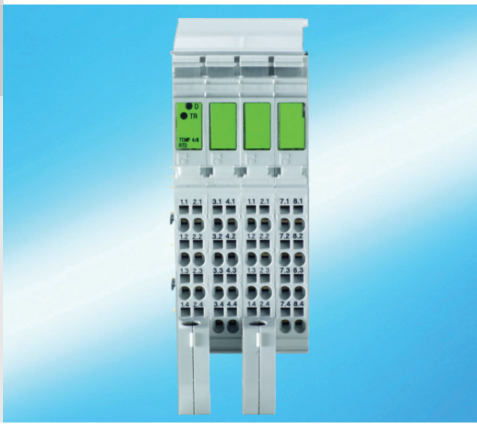
Rexroth Inline terminal with eight resistive temperature sensor inputs

R911170513
Edition 01

R-IB IL TEMP 4/8 RTD(-2MBD)-PAC



8 analog input channels
for resistive temperature shunts
2 and 3-wire technology

09/2008

1 Description

The terminal is designed for use within an Inline station. This terminal provides an 8-channel input module for resistive temperature sensors.
There are two options for data exchange:

- Via process data (**four** inputs each in one bus cycle, multiplex mode)
- Via PCP (all **eight** inputs in the "Analog Values" PCP object)

This terminal supports:

- Platinum and nickel sensors, e.g., Pt100, Pt1000, Ni1000 according to standard DIN EN 60751 and the SAMA guideline, as well as various other sensors
- KTY81 and KTY84 sensors
- The sensor type Pt10000 especially for building automation

The measuring temperature is represented by standardized 16-bit values.

Features

- Eight inputs for resistive temperature sensors and linear resistors up to 20 kΩ
- Connection of sensors in 2 and 3-wire technology
- Communication either via process data or via parameter channel (PCP)
- Channels are configured independently of one another using the bus system
- Rugged inputs, ideal for use in harsh industrial environments with high electromagnetic interference
- Diagnostic indicators
- Temperature and resistance measurement within just a few milliseconds

This data sheet is only valid in association with the application descriptions for the Rexroth Inline system (see "Documentation" on page 4).

Make sure you always use the latest documentation.
It can be downloaded at www.boschrexroth.com.

Table of contents

2 Ordering data

Products

Description	Type	MNR	Pcs./ Pkt.
Rexroth Inline terminal with eight resistive Temperature sensor inputs; complete with accessories (connectors and labeling fields); transmission speed of 500 kbps	R-IB IL TEMP 4/8 RTD-PAC	R911170428	1
Rexroth Inline terminal with eight resistive Temperature sensor inputs; complete with accessories (connectors and labeling fields); transmission speed of 2 Mbps	R-IB IL TEMP 4/8 RTD-2MBD-PAC	R911170429	1

Documentation

Description	Type	MNR	Pcs./ Pkt.
"Automation terminals of the Rexroth Inline product range" application description	DOK-CONTRL-ILSYSINS***-AW..-EN-P	R911317021	1
"Configuring and installing the Rexroth Inline product range for INTERBUS" application description	DOK-CONTRL-ILSYSPRO***-AW..-EN-P	R911317023	1

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

3 Technical data

General data	
Housing dimensions (width x height x depth)	48.8 mm x 120 mm x 72 mm
Weight	190 g (with connectors)
Operating mode	Process data mode with 5 words/1 word PCP
Connection method for sensors	2 and 3-wire technology
Permissible temperature (operation)	-25°C to +55°C
Permissible temperature (storage/transport)	-25°C to +85°C
Permissible humidity (operation/storage/transport)	10% to 95% according to DIN EN 61131-2
Permissible air pressure (operation/storage/transport)	70 kPa to 106 kPa (up to 3000 m above sea level)
Degree of protection	IP20 according to IEC 60529
Class of protection	Class 3 according to VDE 0106, IEC 60536
Connection data for Inline connector	
Connection method	Spring-cage terminals
Conductor cross-section	0.08 mm^2 to 1.5 mm^2 (solid or stranded), 28 - 16 AWG

Interface	
Local bus	Data routing

Transmission speed	
R-IB IL TEMP 4/8 RTD-PAC	500 kbps
R-IB IL TEMP 4/8 RTD 2MBD-PAC	2 Mbps

Power consumption	500 kbps	2 Mbps
Communications power U_L	7.5 V DC	7.5 V DC
Current consumption from U_L	75 mA, typical	100 mA, typical
I/O supply voltage U_{ANA}	24 V DC	24 V DC
Current consumption at U_{ANA}	28 mA, typical	41 mA, typical
Total power consumption	1.24 W, typical	1.75 W, typical

Supply of the module electronics and I/O through bus coupler/power terminal	
Connection method	Potential routing

Analog inputs	
Number	Eight inputs for resistive temperature sensors
Connection of signals	2 or 3-wire, shielded sensor cable
Sensor types that can be used	Pt, Ni, Cu, KTY, linear resistors
Standards for characteristic curves	According to DIN EN 60751: 07/1996/ according to SAMA RC 21-4-1966
Conversion time of the A/D converter	5 μs, typical; 10 μs, maximum
Process data update	Depends on the connection method

Additional tolerances influenced by electromagnetic fields		
Type of electromagnetic interference	**Typical deviation of the measuring range final value**	
	Relative for the input area linear R 0 to 400 Ω	**Relative for the input area linear R 0 to 20 kΩ**
Electromagnetic fields; field strength 10 V/m according to EN 61000-4-3/IEC 61000-4-3	< ±4.8%	< ±0.5%
Conducted interference Class 3 (test voltage 10 V) according to EN 61000-4-6/IEC 61000-4-6	< ±3.5%	< ±0.3%

Tolerances at TA = +25°C						
Sensor type	**Range**		**TA = +25°C**		**TA = +25°C**	
	Lower limit	**Upper limit**	**Absolute deviation**		**Relative deviation**	
			Typical	**Maximum**	**Typical**	**Maximum**
Pt100 DIN and SAMA (3-wire connection)	-200°C	+850°C	±0.50°C	±2.13°C	±0.06%	±0.25%
Pt100 DIN and SAMA (2-wire connection)	-200°C	+850°C	±1.22°C	±5.64°C	±0.16%	±0.55%
Pt10000 DIN and SAMA (2 and 3-wire connection)	0°C	+70°C	±0.60°C	±1.80°C	±0.86%	±2.57%
Pt10000 DIN and SAMA (2 and 3-wire connection)	-200°C	+180°C	±1.24°C	±3.10°C	±1.11%	±1.72%
Rlin400 (3-wire connection)	0 Ω	400 Ω	±0.20 Ω	±0.83 Ω	±0.05%	±0.21%
Rlin400 (2-wire connection)	0 Ω	400 Ω	±0.48 Ω	±2.20 Ω	±0.16%	±0.55%
Rlin20k (2 and 3-wire connection)	0 Ω	20000 Ω	±150 Ω	±200 Ω	±0.75%	±1.00%

The data contains the offset error, gain error, and linearity error in the relevant basic setting. The data is related to nominal operation (preferred mounting position, U_S = 24 V) with preset 32-sample filter. Please also observe the values for temperature drift and the tolerances under EMI.
All errors indicated as a **percentage** are related to the positive measuring range final value.
The **maximum** tolerance values represent the worst case measurement inaccuracy. They contain the theoretical maximum possible tolerances in the corresponding measuring ranges. In the same way, the theoretical maximum possible tolerances of the calibration and test equipment have been taken into account. This data is valid for at least twelve months.

Temperature and drift response				
Sensor type	**Range**		**TA = -25°C to +55°C**	
	Lower limit	**Upper limit**	**Drift (related to the measuring range final value)**	
			Typical	**Maximum**
Pt100 DIN and SAMA	-200°C	+850°C	60 ppm/K	220 ppm/K
Pt1000 DIN and SAMA	-200°C	+850°C	150 ppm/K	500 ppm/K
Pt10000 DIN and SAMA	-200°C	+180°C	390 ppm/K	1200 ppm/K
Rlin400	0 Ω	400 Ω	60 ppm/K	250 ppm/K
Rlin20k	0 Ω	20000 Ω	280 ppm/K	900 ppm/K

Safety equipment	
Short-circuit protection for each input	Yes

Electrical isolation	
Common potentials	
24 V main voltage U_M, 24 V segment voltage U_S, and GND have the same potential. FE is a separate potential area.	
Separate potentials in the terminal	
Test distance	**Test voltage**
7.5 V supply (bus logic)/ ±15 V, ±5 V analog supply (analog I/O)	500 V AC, 50 Hz, 1 min.
7.5 V supply (bus logic)/functional earth ground	500 V AC, 50 Hz, 1 min.
±15 V, ±5 V analog supply (analog I/O)/functional earth ground	500 V AC, 50 Hz, 1 min.

Error messages to the higher-level control or computer system	
Failure of the internal I/O power supply	Yes, I/O error message sent to the bus coupler
Failure of or insufficient communications power U_L	Yes, I/O error message sent to the bus coupler

Error messages via process data	
I/O error/user error	Yes (see page 15)

Approvals
For the latest approvals, please visit www.boschrexroth.com.

4 Internal basic circuit diagram

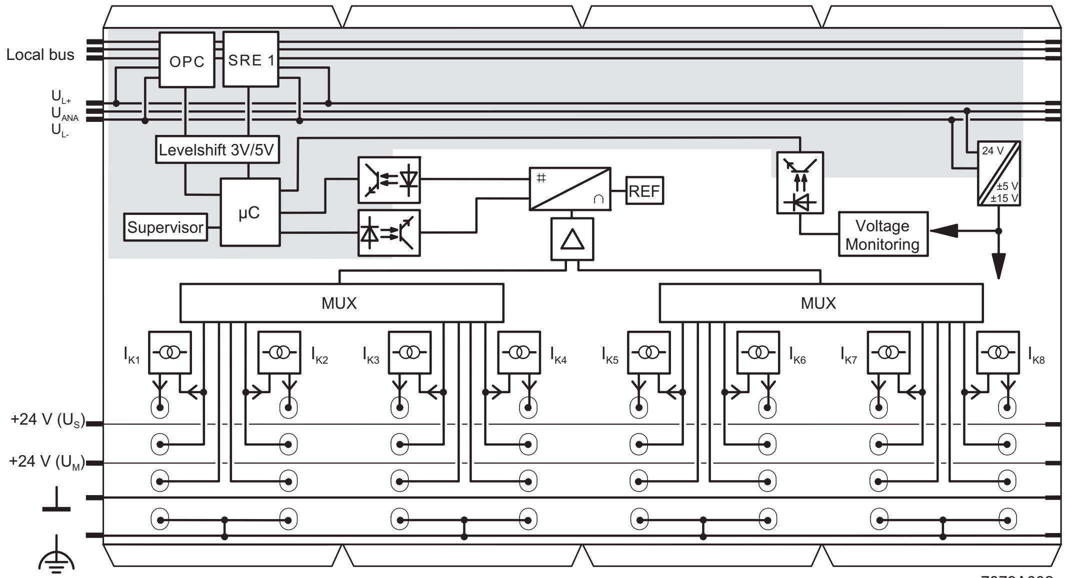


Fig. 1 *Internal wiring of the terminal points*

Key:

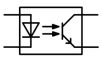
Protocol chip

Register expansion

Level adaptation

Hardware monitoring

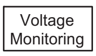
Microcontroller


Optocoupler


Analog/digital converter

Reference voltage


Amplifier



Voltage monitoring


DC/DC converter
with electrical isolation

Multiplexer


Constant current source

Other symbols used are explained in the application descriptions for the Rexroth Inline system or the application description for your bus system.

5 Local diagnostic and status indicators and terminal point assignment

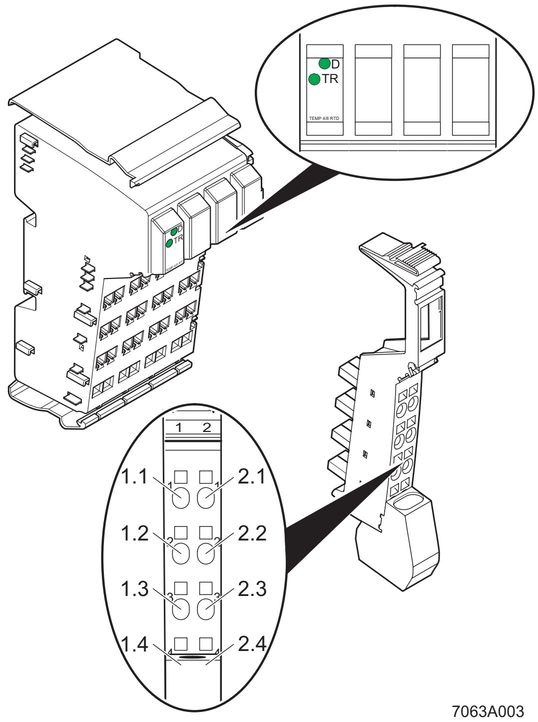


Fig. 2 Terminal with an appropriate connector

5.1 Local diagnostic and status indicators

Des.	Color	Meaning
D	Green	Diagnostics
TR	Green	PCP active

5.2 Function identification

Green

2 Mbps: White stripe in the vicinity of the D LED

5.3 Terminal point assignment for 2-wire connection

Terminal points	Signal	Assignment
1.1	I_1+/U_1+	RTD sensor 1
1.2	I_1-/U_1-	I: Constant current supply U: Measuring input
1.3	–	–
2.1	I_2+/U_2+	RTD sensor 2
2.2	I_2-/U_2-	I: Constant current supply U: Measuring input
2.3	–	–
1.4, 2.4	–	FE

5.4 Terminal point assignment for 3-wire connection

Terminal points	Signal	Assignment
1.1	I_1+/U_1+	RTD sensor 1
1.2	I_1-	Constant current supply
1.3	U_1-	Measuring input sensor 1
2.1	I_2+/U_2+	RTD sensor 2
2.2	I_2-	Constant current supply
2.3	U_2-	Measuring input sensor 2
1.4, 2.4	–	FE

6 Safety note

CAUTION

During configuration, ensure that no isolating voltage for safe isolation is specified between the analog inputs and the bus. During thermistor detection this, for example, means that the user has to provide signals with **safe isolation**, if applicable.

7 Installation instructions

High current flowing through potential jumpers U_M and U_S leads to a temperature rise in the potential jumpers and inside the terminal. Observe the following instructions to keep the current flowing through the potential jumpers of the analog terminals as low as possible:

CAUTION

Create a separate main circuit for the analog terminals

If this is not possible in your application and if you are using analog terminals in a main circuit together with other terminals, place the analog terminals after all the other terminals at the end of the main circuit.

8 Electrical isolation

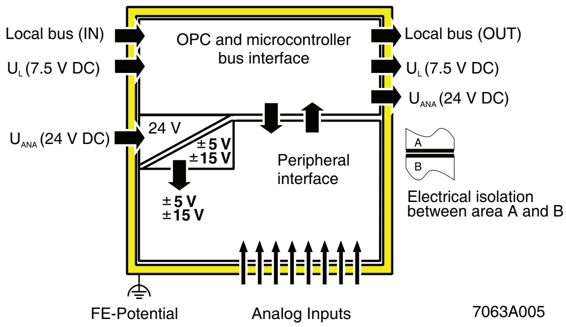


Fig. 3 Electrical isolation of the individual function areas

9 Connection notes

Connecting the resistance temperature detectors

Always connect temperature shunts using shielded, twisted-pair cables.

Connecting the shield

The connection examples show how to connect the shield (Fig. 4).
Insulate the shield at the sensor.

Unused channels

Short circuit unused channels (see Fig. 4 on page 9, channels 2 to 7).

10 Connection example

When connecting the shield before the terminal, insulate the shield on the sensor side (shown in gray in Fig. 4). Fig. 4 shows the connection schematically.

Connection of passive sensors

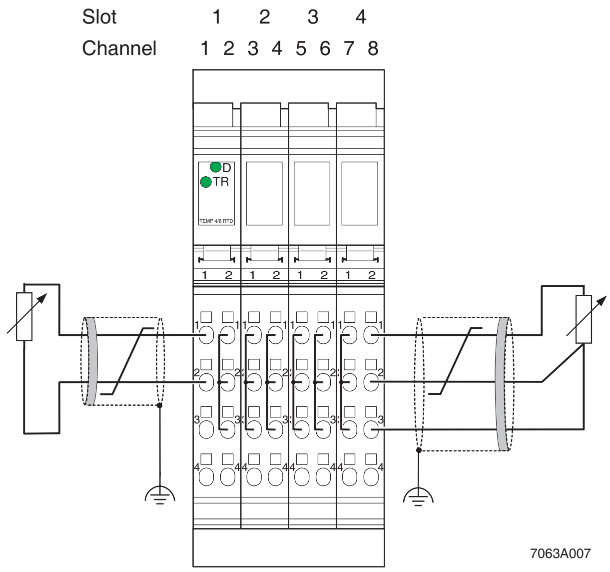


Fig. 4 Connection of sensors in 2 and 3-wire technology with shield connection

Channel 1: 2-wire technology; channel 8: 3-wire technology
Other channels: Not used (with short-circuit jumpers)

11 Programming data/configuration data

Local bus

ID code	DF_{hex} (223_{dec})
Length code	05_{hex}
Process data channel	80 bits
Input address area	5 words
Output address area	5 words
Parameter channel (PCP)	1 word
Register length (bus)	6 words

Other bus systems

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

12 Process data

The terminal has five process data words and one PCP word.

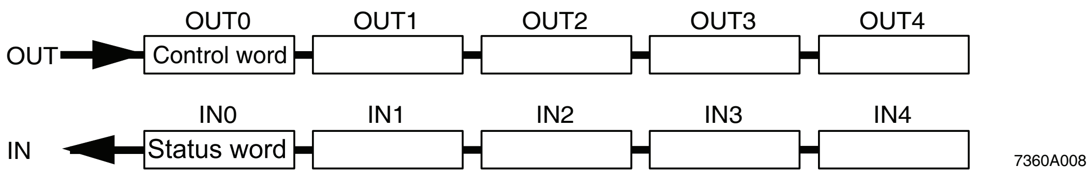


Fig. 5 Order of the process data words

13 Process data output words (OUT)

Five process data output words are available.

Configure the terminal channels via process data output words OUT0 and OUT1. In this context, output word OUT0 contains the command and output word OUT1 contains the parameters belonging to this command.

The following configurations are possible:

Configuration	**Short designation**	**Default**
Selection of mean-value generation (filtering)	Filter	16-sample mean value
Connection type of the sensor	Connection	3-wire technology
Value of reference resistance R_0	R_0	100 Ω
Resolution setting	Resolution	0.1°C
Selection of the format for representing measured values	Format	IB IL format
Sensor type setting	Sensor type	Pt100 (DIN)

Configuration errors are indicated in the status word. The configuration settings are stored in a volatile memory only.

If you change the configuration, the message "Measured value invalid" appears (diagnostic code 8004_{hex}), until new measured values are available.

Please note that extended diagnostics is only possible if IB IL format is configured as the format for representing the measured values. As this format is preset on the terminal, it is available as soon as the voltage is applied.

13.1 Output word OUT0 (control word)

	OUT0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Assignment	Command code								0	0	0	0	0	0	0	0

Bit 15 to bit 8 (command code):

Bit 15 to bit 8								**OUT0**	**Command function**
0	0	0	0	0	**C**	**C**	**C**	0x00$_{hex}$	Read measured value in IN1 channel-by-channel
0	0	0	0	1	0	0	0	0800$_{hex}$	Read measured values of channel 1 to 4 in IN1 to IN4
0	0	0	0	1	0	0	1	0900$_{hex}$	Read measured values of channel 5 to 8 in IN1 to IN4
0	0	0	0	1	0	1	0	0A00$_{hex}$	Read measured values of channel 1 to 4 in IN1 to IN4; Conversion of these channels only (shorter conversion times)
0	0	0	1	0	**C**	**C**	**C**	1x00$_{hex}$	Read configuration in IN1 channel-by-channel
0	0	1	1	1	1	0	0	3C00$_{hex}$	Read firmware version and module ID in IN1
0	1	0	0	0	**C**	**C**	**C**	4x00$_{hex}$	Configure channel, configuration in OUT1
0	1	0	1	0	**C**	**C**	**C**	5x00$_{hex}$	Configure channel and read measured value of the channel; Configuration in OUT1, measured value in IN1
0	1	1	0	0	0	0	0	6000$_{hex}$	Configure entire terminal (all channels); Configuration in OUT1

CCC = channel number

13.2 Output word OUT1 (parameter word)

For commands 4x00$_{hex}$, 5x00$_{hex}$, and 6000$_{hex}$ the parameters must be specified 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		2/3	R_0				Resolution		Format		Sensor type			

Filter	Selects mean-value generation. After every conversion, the measured value is saved in a mean-value memory via which the mean value is generated. The memory size can be selected with the filter option. E.g., for a 16-sample mean value, the mean value is generated using the last 16 measured values.
2/3	Connection method, 2-wire or 3-wire
R_0	Selection of sensor resistance at 0°C. Here, for example, you can select whether Pt100, Pt500, Pt1000 or Pt10000 are to be used for the platinum sensor type.
Resolution	Quantization of the measured value, choice between °Celsius or °Fahrenheit
Format	Represents the measured value in the IN process data
Sensor type	Sets the selected sensor type

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.

13.3 Parameters for configuration

The values displayed in **bold** are default settings.

Bit 14 and bit 13:

Code		Filter
dec	bin	
0	00	**16-sample mean value**
1	01	No mean value
2	10	4-sample mean value
3	11	32-sample mean value

Bit 12:

Code		Connection method (2/3)
dec	bin	
0	0	**3-wire**
1	1	2-wire

Bit 11 to bit 8

Code			R_0 [Ω]
dec	bin	hex	
0	**0000**	**0**	**100**
1	0001	1	10
2	0010	2	20
3	0011	3	30
4	0100	4	50
5	0101	5	120
6	0110	6	150
7	0111	7	200

Code			R_0 [Ω]
dec	bin	hex	
8	1000	8	240
9	1001	9	300
10	1010	A	400
11	1011	B	500
12	1100	C	1000
13	1101	D	1500
14	1110	E	2000
15	1111	F	10000

Bit 7 and bit 6:

Code		Resolution for sensor type			
dec	bin	0 to 11	13 (Potentiometer [%])	14 (Linear R: 0 to 400 Ω)	15 (Linear R: 0 to 20000 Ω)
0	**00**	**0.1°C**	**1%**	**0.1 Ω**	**1 Ω**
1	01	0.01°C	0.1%	0.01 Ω	0.1 Ω
2	10	0.1°F	Reserved	Reserved	Reserved
3	11	0.01°F			

Bit 5 and bit 4:

Code		Format
dec	bin	
0	**00**	**IB IL format (15 bits + sign bit with extended diagnostics)**
1	01	IB ST format (12 bits + sign bit + 3 diagnostic bits)
2	10	S7-compatible format (15 bits + sign bit)
3	11	Reserved

Bit 3 to bit 0:

Code		Sensor type
dec	bin	
0	**0000**	**Pt DIN**
1	0001	Pt SAMA
2	0010	Ni DIN
3	0011	Ni SAMA
4	0100	Cu10
5	0101	Cu50
6	0110	Cu53
7	0111	Ni1000 (Landis & Gyr)

Code		Sensor type
dec	bin	
8	1000	Ni500 (Viessmann)
9	1001	KTY81-110
10	1010	KTY84
11	1011	KTY81-210
12	1100	Reserved
13	1101	Potentiometer [%]
14	1110	Linear R: 0 to 400 Ω
15	1111	Linear R: 0 to 20000 Ω

Example of parameterization

Pt1000 DIN sensor

	OUT1															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Assignment	0	Filter		2/3	R_0				Resolution		Format		Sensor type			
Assignment	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0

14 Process data input words (IN)

14.1 Input word IN0 (status word)

Input word IN0 performs the task of a status word.

	IN0															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Assignment	EB	Mirrored command code							0	0	0	0	0	0	0	0

EB: Error bit

EB = 0	No error has occurred.
EB = 1	An error has occurred.

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

14.2 Input words IN1 to IN4

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

For control word **$3C00_{hex}$**, 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_{hex}			
Meaning	Firmware Version 1.23												Module ID			

Basically there are three formats available for representing measured values. For more detailed information about the formats, please refer to "Formats for representing measured values" on page 15.

MSB															LSB	
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
SB	Analog value															IB IL format, S7-compatible format

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
SB	Analog value												0	OC	OR	IB ST format

MSB Most significant bit
LSB Least significant bit
SB Sign bit
AV Analog value
0 Reserved
OC Open circuit/short circuit
OR Overrange

Open circuit detection:
The following table shows how an open circuit is detected:

Faulty sensor cable	2-wire	3-wire
I+/U+	Yes	Yes
I-	Yes	Yes
U-	–	No

Yes Open circuit is detected.
– For this connection method a cable is not connected.
No Open circuit is not detected.

15 Formats for representing measured values

15.1 IB IL format (default setting)

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_{hex} and < 8100_{hex} indicate an error.

The following diagnostic codes are possible:

Code (hex)	Error
8001	Overrange
8002	Open circuit
8004	Measured value invalid/no valid measured value available (e.g., because the channel has not been configured)
8010	Invalid configuration
8020	I/O supply voltage faulty
8040	Terminal faulty
8080	Underrange

Measured value representation in IB IL format, 15 bits

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

SB Sign bit

Typical analog values depending on the resolution

Sensor type		**All temperature sensors**	**Potentiometer**	**Linear 0 to 400 Ω**	**Linear 0 to 20 kΩ**
Sensor/code		**0 to 11**	**13**	**14**	**15**
Resolution (bits 7 and 6)		**00_{bin}/10_{bin}**	**00_{bin}**	**00_{bin}**	**00_{bin}**
Process data item (= analog value)		**0.1°C/0.1°F [°C]/[°F]**	**1% [%]**	**0.1 Ω [Ω]**	**1 Ω [Ω]**
hex	**dec**				
8002	–	Open circuit	–	–	–
8001	–	Overrange (see table on page 23)	– See note below	> 400.0	> 20000
2710	10000	1000.0	10000 (100 x R_0)	–	10000
0FA0	4000	400.0	4000 (40 x R_0)	400.0	4000
00A0	10	1.0	10 (0.10 x R_0)	1.0	10
0001	1	0.1	1 (0.01 x R_0)	0.1	1
0000	0	0	0	0	0
FFFF	-1	-0.1	–	–	–
FC18	-1000	-100.0	–	–	–
8080		Underrange (see table on page 23)	–	–	–

This sensor type (potentiometer) does not have defined upper limits for the measuring range. Depending on the gain, however, an open circuit is detected at approximately 400 Ω or at approximately 20000 Ω.
Please note for the potentiometer (No. 13) and linear resistor (No. 14 and 15) sensor types that below 0.8% of the nominal range (e.g., 0 Ω to 3 Ω for the "linear R: 0 to 400 Ω" type) the diagnostic messages "Overrange" and "Underrange" can be generated.

Sensor type		**All temperature sensors**	**Potentiometer**	**Linear 0 to 400 Ω**	**Linear 0 to 20 kΩ**
Sensor/code		**0 to 11**	**13**	**14**	**15**
Resolution (bits 7 and 6)		**$01_{bin}/11_{bin}$**	**01_{bin}**	**01_{bin}**	**01_{bin}**
Process data item (= analog value)		**0.01°C/0.01°F [°C]/[°F]**	**0.1% [%]**	**0.01 Ω [Ω]**	**0.1 Ω [Ω]**
hex	**dec**				
8002	–	Open circuit	–	–	–
8001	–	> 325.12 Overrange (see page 23)	– 3251.2	325.12	3251.2
2710	10000	100.00	1000.0 (10 x R0) –	100.00	1000.0
0FA0	4000	40.00	400.0 (4 x R_0)	40.00	400.0
000A	10	0.1	1 (0.01 x R_0)	0.1	1
0001	1	0.01	0.1 (0.001 x R_0)	0.01	0.1
0000	0	0	0	0	0
FFFF	-1	-0.01	–	–	–
FC18 (-1000)	-10	-10	–	–	–
D8F0	-10000	-100.00	–	–	–
8080		Underrange (see page 23)	–	–	–

If the measured value is outside the representation range of the process data, the "Overrange" or "Underrange" error message is generated.
Please note for the potentiometer (No. 13) and linear resistor (No. 14 and 15) sensor types that below 0.8% of the nominal range (e.g., 0 Ω to 3 Ω for the "linear R: 0 to 400 Ω" type) the diagnostic messages "Overrange" and "Underrange" can be generated.

15.2 IB ST format

The measured value is represented in bits 14 to 3.
The remaining 4 bits are sign and error bits.

Measured value representation in IB ST format; 12 bits

MSB LSB

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

SB	Sign bit
0	Reserved
OC	Open circuit/short circuit
OR	Overrange

Typical analog values depending on the resolution

Sensor type		**RTD sensor**	
Sensor code		**(0 to 11)**	
Resolution (bits 7 and 6)		**$00_{bin}/10_{bin}$**	**$01_{bin}/11_{bin}$**
Process data item (= analog value)		**0.1°C/0.1°F [°C]/[°F]**	**0.01°C/0.01°F [°C]/[°F]**
hex	**dec**		
xxxx xxxx xxxx xxx1$_{bin}$		Overrange (AV = positive final value from the table on page 23)	
2710	10000	1000.0	100.00
03E8	1000	100.0	10.00
0008	8	0.8	0.08
0000	0	0	0
FFF8	-8	-0.8	-0.08
FC18	-1000	-100.0	-10.00
xxxx xxxx xxxx xxx1$_{bin}$		Underrange (AV = negative final value from the table on page 23)	
xxxx xxxx xxxx xx1x$_{bin}$		Open circuit/short circuit (AV = negative final value from the table on page 23)	

AV	Analog value
x	Can have value 0 or 1

If the measured value is outside the representation range of the process data, bit 0 is set to 1.
In the event of an open circuit/short circuit, bit 1 is set to 1.

15.3 S7-compatible format

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

Measured value representation in S7-compatible format; 15 bits

MSB LSB

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

SB Sign bit

AV Analog value

IB input data word (two's complement) (hex)	All temperature sensors Resolution 0.1°C or 0.1°F (°C) or (°F)	All temperature sensors Resolution 0.01°C or 0.01°F (°C) or (°F)
7FFF	Overrange	Overrange
2710 (10000)	1000.0	100.0
03E8 (1000)	100.0	10.00
0008 (8)	0.8	0.08
0000	0	0
FFF8 (-8)	-0.8	-0.08
FC18 (-1000)	-100.0	-10
8000	Underrange	Underrange

16 PCP communication

By default upon delivery, the terminal is configured according to the default settings on page 10.

The terminal can be configured using process data or PCP to suit your application.

In PCP mode, the terminal is configured with the "Config Table" object.

16.1 Object dictionary

Index	Data type	N	L	Meaning	Object name	Rights
0080_{hex}	Array of unsigned 16	12	2		Config Table	rd/wr
0081_{hex}	Array of unsigned 16	8	2		Analog Values	rd

N: Number of elements

L: Length of an element in bytes

rd: Read access permitted

wr: Write access permitted

16.2 Object description

Config Table object
Configure the terminal using this object.

Object description:

Object	Config Table	
Access	Read, write	
Data type	Array of unsigned 16	12 x 2 bytes
Index	0080_{hex}	
Subindex	00_{hex}	Write all elements
	01_{hex}	Configuration channel 1
	02_{hex}	Configuration channel 2
	03_{hex}	Configuration channel 3
	04_{hex}	Configuration channel 4
	05_{hex}	Configuration channel 5
	06_{hex}	Configuration channel 6
	07_{hex}	Configuration channel 7
	08_{hex}	Configuration channel 8
	09_{hex}	Reserved
	$0A_{hex}$	Reserved
	$0B_{hex}$	Reserved
	$0C_{hex}$	Reserved
Length (bytes)	18_{hex}	Subindex 00_{hex}
	02_{hex}	Subindex 01_{hex} to $0C_{hex}$
Data	Terminal configuration	

Element value range

The "**Configuration channel x**" elements are structured as follows:

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Assignment	0	Filter		2/3	R_0				Resolution		Format		Sensor type			

For the value ranges for the individual parameters, please refer to "Parameters for configuration" on page 12.

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 range), the high byte contains the number of the affected element.

Example: Config Table is completely filled with data (subindex 00) and the entry for channel 6 is invalid. In this case, the additional error code equals 0630_{hex}.

Analog Values object

The elements of this object contain the analog values of the channels in a format that has been selected for this channel.

Object description:

Object	Analog Values	
Access	Read	
Data type	Array of unsigned 16	8 x 2 bytes
Index	0081_{hex}	
Subindex	00_{hex} 01_{hex} 02_{hex} 03_{hex} 04_{hex} 05_{hex} 06_{hex} 07_{hex} 08_{hex}	Read all elements Analog value channel 1 Analog value channel 2 Analog value channel 3 Analog value channel 4 Analog value channel 5 Analog value channel 6 Analog value channel 7 Analog value channel 8
Length (bytes)	10_{hex} 02_{hex}	Subindex 00_{hex} Subindex 01_{hex} to 08_{hex}
Data	Analog values of the channels	

17 Configuration and analog values

The terminal only needs to be configured if the channels are not to be operated with the preset default values (see "Parameters for configuration" on page 12).

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

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

Examples for terminal configuration via process data

Example 1

All channels are to be configured as Ni1000 in 3-wire technology with 16-sample mean value generation.
IB IL Temp is used as the format with a resolution of 0.1°C. The configuration value is therefore $0C02_{hex}$.

Step	Process data	Meaning
1	OUT2 = $0C02_{hex}$ OUT1 = 6000_{hex}	Specify configuration
2	Wait until IN0 = 6000_{hex}	Wait for confirmation
3	OUT0 = 0800_{hex}	Request the measured values of channels 1 to 4
4	Wait until IN0 = 0800_{hex}	Wait for confirmation
5	Measured value channel 1 = IN1, ..., measured value channel 4 = IN4 if measured value = $80xx_{hex}$, an error message is sent, otherwise temperature in °C = measured value x 10	Read measured values
6	OUT0 = 0900_{hex}	Request the measured values of channels 5 to 8
7	Wait until IN0 = 0900_{hex}	Wait for confirmation
8	Measured value of channel 5 = IN1, ..., measured value of channel 8 = IN4	Read measured values

Example 2

Each channel is configured differently.

Step	Process data	Meaning
1	OUT1 = configuration for channel 1 OUT0 = 4000_{hex}	Specify configuration K1
2	Wait until IN0 = 4000_{hex}	Wait for confirmation
3	OUT1 = configuration for channel 2 OUT0 = 4100_{hex}	Specify configuration K2
4	Wait until IN0 = 4100_{hex}	Wait for confirmation
5	OUT1 = configuration for channel 3 OUT0 = 4200_{hex}	Specify configuration K3
6	Wait until IN0 = 4200_{hex}	Wait for confirmation
...	...	...
15	OUT1 = configuration for channel 8 OUT0 = 4700_{hex}	Specify configuration K8
16	Wait until IN0 = 4700_{hex}	Wait for confirmation

18 Measuring ranges

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

Resolution	Temperature sensors
00	-273°C to +3276.8°C Resolution: 0.1°C
01	-273°C to +327.68°C Resolution: 0.01°C
10	-459°F to +3276.8°F Resolution: 0.1°F
11	-459°F to +327.68°F Resolution: 0.01°F

Temperature values can be converted from °C to °F with this formula:

$$T\,[°F] = T\,[°C] \times \frac{9}{5} + 32$$

Where:

T [°F] Temperature in °F

T [°C] Temperature in °C

18.2 Input measuring ranges

No.	Input	Sensor type		Measuring range	
				Lower limit	Upper limit
0	Temperature sensors	Pt R_0 10 Ω to 2000 Ω	According to DIN EN 60751: 07/ 1996	-200°C	+850°C
0		Pt10000		-200°C	+180°C
1		Pt R_0 10 Ω to 2000 Ω	According to SAMA	-200°C	+850°C
1		Pt10000		-200°C	+180°C
2		Ni R_0 10 Ω to 2000 Ω	According to DIN EN 60751: 07/1996	-60°C	+180°C
3		Ni R_0 10 Ω to 2000 Ω	According to SAMA	-60°C	+180°C
4		Cu10	According to SAMA	-70°C	+500°C
5		Cu50	According to SAMA	-50°C	+200°C
6		Cu53	According to SAMA	-50°C	+180°C
7		Ni1000 L&G		-50°C	+160°C
8		Ni500 (Viessmann)		-60°C	+250°C
9		KTY81-110		-55°C	+150°C
10		KTY84		-40°C	+300°C
11		KTY81-210		-55°C	+150°C
12	Reserved				
13	Relative potentiometer range			0%	R0 (100%)
14	Linear resistance measuring range			0 Ω	400 Ω
15				0 Ω	20000 Ω

The number (No.) corresponds to the code of the sensor type in bit 3 to bit 0 of the parameter word (see "Sensor type" on page 12).
Please note for the potentiometer (No. 13) and linear resistor (No. 14 and 15) sensor types that below 0.8% of the nominal range (e.g., 0 Ω to 3 Ω for the "linear R: 0 to 400 Ω" type) the diagnostic messages "Overrange" and "Underrange" can be generated.

19 Measuring errors

19.1 Systematic measuring errors during temperature measurement using resistance thermometers

When measuring temperatures with resistance thermometers, systematic measuring errors are often the cause of incorrect measured results.

The sensors can be connected in 2 or 3-wire technology.

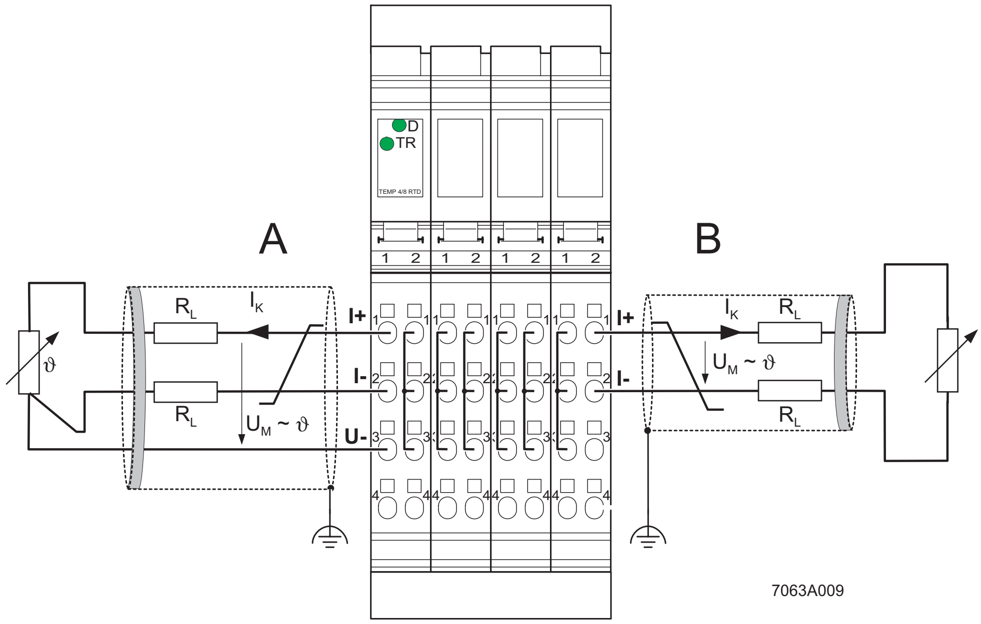


Fig. 6 Connecting the resistance thermometers in 3-wire technology (A) and 2-wire technology (B)

In **3-wire technology** the effect of the cable resistance on the measured result within the terminal is eliminated or minimized by multiple measuring of the temperature-related voltage and corresponding calculations.

2-wire technology is a cost-effective connection method. The U+ and U- cables are no longer needed. The temperature-related voltage is not directly measured at the sensor and therefore falsified by both cable resistances (R_L). This connection method is particularly suitable for sensors with high R_0 (e.g., Pt1000, Pt10000, Ni1000).

The measuring errors that occur if R_0 is low can make the entire measurement unusable (see diagrams in Fig. 7 to Fig. 9). However, these diagrams show at which points in the measurement system measures can be taken to minimize these errors.

19.2 Systematic errors during temperature measurement using 2-wire technology

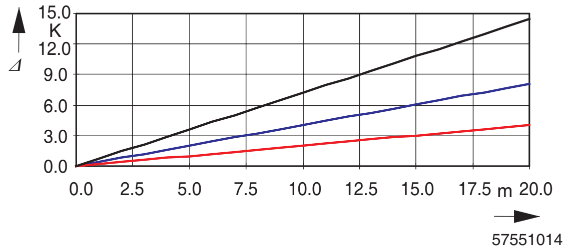


Fig. 7 *Systematic temperature measuring error ΔT depending on the cable length l*

Curves depending on cable cross-section A

(1) Temperature measuring error for A = 0.14 mm^2
(2) Temperature measuring error for A = 0.25 mm^2
(3) Temperature measuring error for A = 0.50 mm^2

(Measuring error valid for: copper cable χ = 57 m/Ωmm^2, T_A = 25°C and Pt100 sensor)

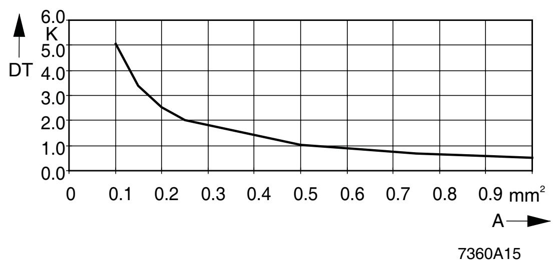


Fig. 8 *Systematic temperature measuring error ΔT depending on the cable cross-section A*

(Measuring error valid for: copper cable χ = 57 m/Ωmm^2, T_A = 25°C, l = 5 m and Pt100 sensor)

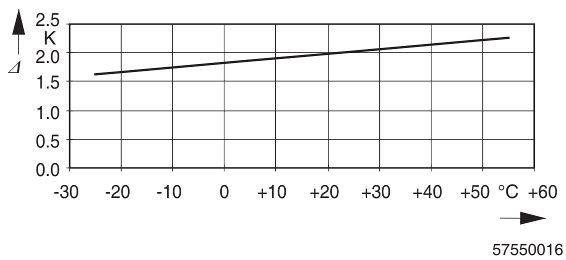


Fig. 9 *Systematic temperature measuring error ΔT depending on the cable temperature T_A*

(Measuring error valid for: copper cable χ = 57 m/Ωmm^2, l = 5 m, A = 0.25 mm^2 and Pt100 sensor)

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

A considerable improvement is made through the use of Pt1000 sensors. Due to the 10 times higher temperature coefficient α (α = 0.385 Ω/K for Pt100 to α = 3.85 Ω/K for Pt1000) 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.

Fig. 7 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.

Fig. 8 shows the effect of the cable cross-section on the cable resistance. It can be seen that cables with a cross-section of less than 0.5 mm^2 cause errors to increase exponentially.

Fig. 9 shows the effect of the ambient temperature on the cable resistance. This parameter is of minor importance and can hardly be influenced. It is mentioned here only in the interest of completeness.

The formula for calculating the cable resistance is as follows:

$$R_L = R_{L20} \times (1 + 0.0039 \frac{1}{K} \times (T_U - 20°C))$$

$$R_L = \frac{l}{c \times A} \times (1 + 0.0039 \frac{1}{K} \times (T_U - 20°C))$$

Fig. 10 *shows the effect of the ambient temperature on the cable resistance.*

Where:

R_L	Cable resistance in Ω
R_{L20}	Cable resistance at 20°C in Ω
l	Cable length in m
χ	Specific electrical conductivity of copper in m/Ωmm^2
A	Cable cross-section in mm^2
0.0039 1/K	Temperature coefficient for copper (percentage purity of 99.9%)
T_A	Ambient temperature (cable temperature) in °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] according to DIN can be obtained for platinum sensors using the average temperature coefficient α (α = 0.385 Ω/K for Pt100; α = 3.85 Ω/K for Pt1000).

20 General notes and recommendations for the signal/ noise ratio

Optimizing the signal/noise ratio in RTD applications using the terminal.

Background:

The terminal used has very high dynamics and can also detect the smallest changes in resistance or temperature. In practice, however, a Pt100 sensor in air immediately passes on even the smallest changes. Temperature fluctuations due to air circulation are measured immediately and are transmitted to the higher-level PLC.

Remedy:

High dynamics are not required for all applications. In order to obtain more stable measured values, set the internal filtering parameter to 32-sample filtering. Moreover, an additional application filter can improve the signal/noise ratio. As far as noise levels are concerned, 2-wire operation is more favorable than 3-wire operation.

The thermal system at the sensor should be made to react more slowly. This can be achieved, for example, by installing it on a body with a high thermal storage capacity. This could be, for example, a metal block of aluminum or steel. The signal/noise ratio will be influenced positively.

Overview of the recommended measures for temperature measurements with minimized noise:

No.	Sensor type	Filter	Connection	Remarks	Other
1	Pt100 Ni100	32	2/3	With regard to the signal/noise ratio it is much better to use a 2-wire connection instead of a 3-wire connection when operating the terminal. Check the tolerances for each measuring task.	• Short circuit unused channels. • Enlarge the sensor ground (connect sensor ground to, e.g., a metal block). • If required, use an additional application filter.
2	Pt1000 Ni1000	32	2	Check the tolerances for each measuring task.	
3	Pt10000	32	2	Due to the high R_0, a 2-wire connection is recommended, ideally with long supply lines. In addition, when using a 2-wire connection, the signal/noise ratio is more favorable. (Example: In order to keep the influence of the cable resistance at a value of <0.1 K, the copper cable may be up to 110 m long with a cross-section of 0.25 mm^2.)	

21 Step response

The step response is the time when a step of the analog input variables (temperature, resistance) is available as a measured value in the IN process data.

It consists of several time parts.

(Basic value + 3-wire additional time + transient period) x filter x number of channels = step response

The 3-wire additional time is only required for 3-wire measurements.

Basic value	3-wire additional time	Transient period	Filter	Number of channels
1.5 ms	0.3 ms	0 ms or 3 ms	16-sample: 16 No mean value generation: 1 4-sample: 4 32-sample: 32	Normal: 8 Convert only 4 channels (command 0A): 4

The transient period depends on the sensor type.

Transient period 0 ms per channel for the following sensor types:	Transient period 3 ms per channel for the following sensor types:
• Pt10 to Pt100 • Ni10 to Ni100 • Cu10, Cu50, Cu53 • Potentiometer [%] • Linear R: 0 to 400 Ω	• Ni1000 (Landis & Gyr) • Ni500 (Viessmann) • KTY81-110 • KTY84 • KTY81-210 • Linear R: 0 to 20000 Ω

Examples:

Configuration	Basic value	3-wire additional time	Transient period	Filter	Number of channels	Time
0000_{hex} = Default: Pt100, 3-wire, 16-sample mean-value generation	1.5 ms	0.3 ms	0 ms	16	8	**230 ms**
$4C02_{hex}$: Ni1000, 2-wire, 4-sample mean-value generation	1.5 ms	0 ms	3 ms	4	8	**144 ms**
2000_{hex}: Pt100, 3-wire, no mean-value generation, convert only four channels	1.5 ms	0.3 ms	0 ms	1	4	**7.2 ms**
3000_{hex}: Pt100, 2-wire, no mean-value generation, convert only four channels	1.5 ms	0 ms	0 ms	1	4	**6 ms**

The local bus runtimes and the time between sending a command and sending the next command are not included in the calculations.

Notes:

Bosch Rexroth AG
Electric Drives and Controls
Postfach 13 57
97803 Lohr, Germany
Bgm.-Dr.-Nebel-Str. 2
97816 Lohr, Germany
Tel. +49-(0) 93 52 - 40-50 60
Fax. +49-(0) 93 52 - 40-49 41
service.svc@boschrexroth.de
www.boschrexroth.com