# Inline terminal with two inputs for thermocouples

**R911170518**
Edition 02

## Data sheet R-IB IL TEMP 2 UTH-PAC

2 analog inputs
Connecting thermocouples

08 / 2019

## 1 Description

The terminal is designed for use within an Inline station.
This terminal can be used to acquire signals from standard thermocouples.
It supports 13 different types of thermocouples according to DIN EN 60584-1 and DIN 43710, as well as a linear voltage input of -15 mV to +85 mV.

### Features

- 2 differential inputs for thermocouples or linear voltage
- 1 input for an external cold junction, Pt 1000 or Ni 1000
- The channels are parameterized independently of one another via the bus system
- Internal detection and compensation of cold junction temperature (can be parameterized)
- Absolute and differential temperature measurement (can be parameterized)
- Pt 1000 sensor in the vicinity of the connection terminal blocks of the thermocouple inputs for internal measurement of the cold junction temperature
- Measured values can be represented in three different formats

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).

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

## 2 Table of contents

# 3 Ordering data

| Description | Type | MNR | Pcs./Pkt. |
|---|---|---|---|
| Inline terminal with two analog input channels for the connection of thermocouples; complete with accessories (male connector and marking field) | R-IB IL TEMP 2 UTH-PAC | R911170431 | 1 |

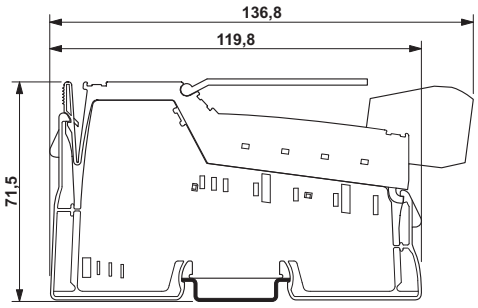
| Documentation | Type | MNR | Pcs./Pkt. |
|---|---|---|---|
| Application description<br>Automation terminals of the Inline product range | DOK-CONTRL-ILSYSINS***-AW..-EN-P | R911317021 | 1 |

**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 | 12.2 mm |
| Height | 136.8 mm |
| Depth | 71.5 mm |
| Note on dimensions | Housing dimensions |

| General data | |
|---|---|
| Weight | 67 g (with connector) |
| Operating mode | Process data operation with 2 words |
| Ambient temperature (operation) | -25 °C ... 55 °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 draw | typ. 43 mA<br>max. 60 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 draw | typ. 11 mA<br>max. 18 mA |

| Power consumption | |
|---|---|
| Power consumption | typ. 587 mW<br>max. 882 mW |

| Analog UTH inputs | |
|---|---|
| Number of inputs | 2 (Thermocouples or linear voltage) |
| Connection method | Inline connector |
| Connection technology | 2-wire, Shielded compensating line for TC with encapsulated sensors |
| Sensor types that can be used (TC) | U, T, L, J, E, K, N, S, R, B, C, W, HK |
| A/D conversion time | typ. 120 µs (per channel) |
| Measuring principle | Successive approximation |
| Measured value representation | 16 bits (15 bits + sign bit) |
| Process data update | max. 30 ms (For both channels) |
| Absolute accuracy | typ. ± 0.6 K (Sensor type K) |
| Permissible cable length | < 30 m (For shielded cable) |
| Surge protection (TC channels) | up to ±40 V |
| Limit frequency (3 dB) | 48 Hz |

| Programming data (INTERBUS, local bus) | |
|---|---|
| ID code (hex) | 7F |
| ID code (dec.) | 127 |
| Length code (hex) | 02 |
| Length code (dec.) | 02 |
| Process data channel | 32 Bit |
| Input address area | 4 Byte |
| Output address area | 4 Byte |
| Parameter channel (PCP) | 0 Byte |
| Register length (bus) | 32 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 | 6 Byte |
| Required configuration data | 4 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 |
| Peripheral fault | Error message in the process data |
| User error | Error message in the process data |

| Electrical isolation/isolation of the voltage areas | |
|---|---|
| **Test section** | **Test voltage** |
| 7.5 V supply (bus logics)/24 V analog supply (analog I/O) | 500 V AC, 50 Hz, 1 min. |
| 7.5 V supply (bus logics) / functional earth ground | 500 V AC, 50 Hz, 1 min. |
| 24 V analog supply (analog I/O) / functional earth ground | 500 V AC, 50 Hz, 1 min. |

**Approvals**

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

# 5 Tolerance and temperature response

All **percentage tolerance values** refer to the relevant positive measuring range final value.

Unless stated otherwise, nominal operation is used as the basis.
Nominal operation: nominal voltage, preferred mounting position, default format, identical measuring range setting for channels
The tolerance values refer to the operating temperature range specified in the tables. The operable range outside this temperature range is not taken into consideration.

Please also observe the values for temperature drift and the tolerances under influences of electromagnetic interferences.

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.

## 5.1 Tolerances of the measuring inputs at $T_A$ = +25°C

All **percentage tolerance values** refer to the relevant positive measuring range final value.

* Below the indicated range, more errors are to be expected because of the very low sensitivity of the sensor elements.

The tolerance values of the TC sensors refer to a differential temperature measurement without cold junction compensation.
The tolerances of the sensor element and the cold junction must also be taken into consideration (see corresponding table).

| No. | Input | Sensor type | Measuring range for tolerance value | | | Absolute tolerance | | Relative tolerance (with reference to MRFV) | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Lower limit | Upper limit | | Typical | Maximum | Typical | Maximum |
| 1 | Thermocouples | B | +500°C | +1820 °C | * | ±4.2 K | ±16.7 K | ±0.23 % | ±0.92 % |
| 2 | | E | -226 °C | +1000 °C | * | ±0.4 K | ±1.6 K | ±0.04 % | ±0.15 % |
| 3 | | J | -210 °C | +1200 °C | | ±0.5 K | ±1.9 K | ±0.04 % | ±0.15 % |
| 4 | | K | -200 °C | +1372 °C | * | ±0.6 K | ±2.4 K | ±0.04 % | ±0.17 % |
| 5 | | N | -200 °C | +1300 °C | * | ±1.0 K | ±3.7 K | ±0.07% | ±0.29% |
| 6 | | R | -50°C | +1768 °C | | ±2.5 K | ±10.0 K | ±0.14 % | ±0.57 % |
| 7 | | S | -50°C | +1768 °C | | ±2.5 K | ±10.0 K | ±0.14 % | ±0.57 % |
| 8 | | T | -270 °C | +400 °C | | ±0.7 K | ±2.5 K | ±0.16 % | ±0.63 % |
| 9 | | C | -18 °C | +2316 °C | | ±1.7 K | ±6.7 K | ±0.07% | ±0.29% |
| 10 | | W | -18 °C | +2316 °C | | ±2.1 K | ±8.4 K | ±0.09 % | ±0.36 % |
| 11 | | HK | -200 °C | +800 °C | | ±0.4 K | ±1.5 K | ±0.05 % | ±0.18 % |
| 12 | | L | -200 °C | +900 °C | | ±0.5 K | ±1.9 K | ±0.05 % | ±0.21 % |
| 13 | | U | -200 °C | +600 °C | | ±0.7 K | ±2.5 K | ±0.11 % | ±0.42 % |
| 14 | Internal cold junction | Pt 1000 | -25 °C | +85 °C | | ±0.3 K | ±1.9 K | ±0.04 % | ±0.22 % |
| 15 | Voltage input | Linear voltage | -15 mV | +85 mV | | ±25 µV | ±100 µV | ±0.03% | ±0.12 % |

MRFV= Measuring range final value

### 5.2 Tolerances of the measuring inputs at $T_A$ = -25°C to +55°C

All percentage tolerances refer to the relevant measuring range final value.

* Below the indicated range, more errors are to be expected because of the very low sensitivity of the sensor elements.

The tolerance values of the TC sensors refer to a differential temperature measurement without cold junction compensation.
The tolerances of the sensor element and the cold junction must also be taken into consideration (see corresponding table).

| No. | Input | Sensor type | Measuring range for tolerance value | | | Absolute tolerance | | Relative tolerance (with reference to MRFV) | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Lower limit | Upper limit | | Typical | Maximum | Typical | Maximum |
| 1 | Thermocouples | B | +500°C | +1820 °C | * | ±10.0 K | ±25.0 K | ±0.55 % | ±1.37% |
| 2 | | E | -226 °C | +1000 °C | * | ±0.9 K | ±2.3 K | ±0.09 % | ±0.23 % |
| 3 | | J | -210 °C | +1200 °C | | ±1.1 K | ±2.8 K | ±0.09 % | ±0.23 % |
| 4 | | K | -200 °C | +1372 °C | * | ±1.4 K | ±3.6 K | ±0.10% | ±0.26% |
| 5 | | N | -200 °C | +1300 °C | * | ±2.2 K | ±5.6 K | ±0.17 % | ±0.43% |
| 6 | | R | -50°C | +1768 °C | | ±6.0 K | ±15.0 K | ±0.34% | ±0.85% |
| 7 | | S | -50°C | +1768 °C | | ±6.0 K | ±15.0 K | ±0.34% | ±0.85% |
| 8 | | T | -270 °C | +400 °C | | ±1.5 K | ±3.8 K | ±0.38 % | ±0.95% |
| 9 | | C | -18 °C | +2316 °C | | ±4.0 K | ±10.0 K | ±0.17 % | ±0.43% |
| 10 | | W | -18 °C | +2316 °C | | ±5.0 K | ±12.5 K | ±0.22 % | ±0.54% |
| 11 | | HK | -200 °C | +800 °C | | ±0.9 K | ±2.2 K | ±0.11 % | ±0.28 % |
| 12 | | L | -200 °C | +900 °C | | ±1.1 K | ±2.8 K | ±0.12 % | ±0.31% |
| 13 | | U | -200 °C | +600 °C | | ±1.5 K | ±3.8 K | ±0.25% | ±0.63 % |
| 14 | Internal cold junction | Pt 1000 | -25 °C | +85 °C | | ±0.4 K | ±2.0 K | ±0.05 % | ±0.24% |
| 15 | Voltage input | Linear voltage | -15 mV | +85 mV | | ±60 µV | ±150 µV | ±0.07% | ±0.18 % |

### 5.3 Temperature response

| No. | Input | Sensor type | Measuring range | | Drift | |
|---|---|---|---|---|---|---|
| | | | Lower limit | Upper limit | Typical | Maximum |
| 15 | Voltage input | Linear voltage | -15 mV | +85 mV | 15 ppm/K | 35 ppm/K |

### 5.4 Tolerances of the internal cold junction

**Operation at an ambient temperature of $T_A$ = -25°C to +55°C**

| Error type | Typical | Maximum |
|---|---|---|
| Sensor tolerance Pt 1000 ($T_A$ = 25°C) | ±0.2 K | ±0.43 K |
| Temperature distribution error for channel 1 and 2 | - | - |
| Linearity error | ±0.01 K | ±0.01 K |
| **Total cold junction error at $T_A$ = 25°C** | **±0.3 K** | **±1.9 K** |
| **Total cold junction error at $T_A$ = -25°C to +55°C** | **±0.4 K** | **±2.0 K** |

After applying the supply voltage, the warm-up phase lasts 30 minutes.

Immediately after switch-on, the tolerances of the cold junction can be increased by the typical tolerance.

The curve in the figure below shows the transient response.

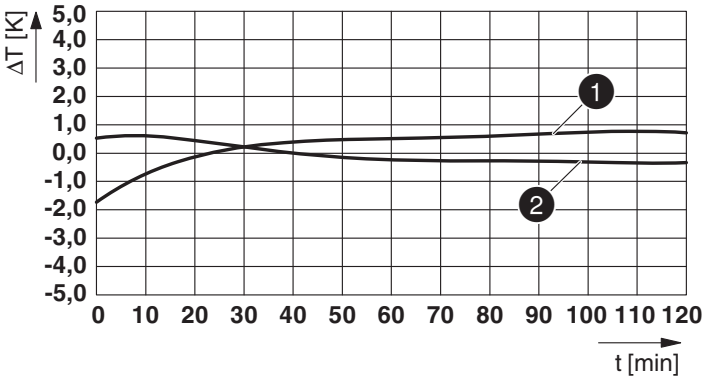



*Fig. 1 Transient response*

Key:

t [min] Time after switch-on in minutes

ΔT [K] Temperature deviation from the measured value in Kelvin (absolute tolerance)
The total system tolerance for an absolute temperature measurement shown in the diagram is made up of the sensor tolerance, the device tolerance, and the cold junction tolerance.

(1) Curve for channel 1

(2) Curve for channel 2

## 5.5 Tolerances due to linearization

| No. | Input | Sensor type | Standard | Measuring range (software-supported) | | Maximum tolerance due to linearization |
|---|---|---|---|---|---|---|
| | | | | Lower limit | Upper limit | |
| 1 | Thermocouples | B | EN 60584-1 (DIN EN 60584-1) | +50 °C | +1820 °C | ±0.05 K |
| 2 | | E | | -270 °C | +1000 °C | ±0.05 K |
| 3 | | J | | -210 °C | +1200 °C | ±0.05 K |
| 4 | | K | | -270 °C | +1372 °C | ±0.05 K |
| 5 | | N | | -270 °C | +1300 °C | ±0.05 K |
| 6 | | R | | -50°C | +1768 °C | ±0.05 K |
| 7 | | S | | -50°C | +1768 °C | ±0.05 K |
| 8 | | T | | -270 °C | +400 °C | ±0.05 K |
| 9 | | C | | -18 °C | +2316 °C | ±0.1 K |
| 10 | | W | | -18 °C | +2316 °C | ±0.1 K |
| 11 | | HK | | -200 °C | +800 °C | ±0.1 K |
| 12 | | L | DIN 43710 | -200 °C | +900 °C | ±0.05 K |
| 13 | | U | | -200 °C | +600 °C | ±0.05 K |
| 14 | Internal cold junction | Pt 1000 | | -200 °C | +850 °C | ±0.01 K |
| 15 | Voltage input | Linear voltage | | - | - | - |

### 5.6 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 | Channel 1: ±9.6%, channel 2: ±5.0% | A |
| Conducted interference | EN 61000-4-6/ IEC 61000-4-6 | Class 3 (test voltage 10 V) | Channel 1: ±4.2%, channel 2: ±2.5% | A |
| Fast transients (burst) | EN 61000-4-4/ IEC 61000-4-4 | Class 3 | - | B |
| Transient overvoltage | EN 61000-4-5/ IEC 61000-4-5 | | - | B |
| Electrostatic discharge (ESD) | EN 61000-4-2/ IEC 61000-4-2 | 6 kV contact discharge / 6 kV air discharge | - | B |

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

The listed values refer to operation in the presetting (TC type K with cold junction compensation) for direct electromagnetic interference of the components without the use of additional shielding measures such as a steel cabinet, etc.

The above tolerances can be reduced by additional shielding measures for the I/O module. For example, you can use a shielded control box or control cabinet. Please refer to the recommended measures in the Inline system manual.

## 6 Internal circuit diagram

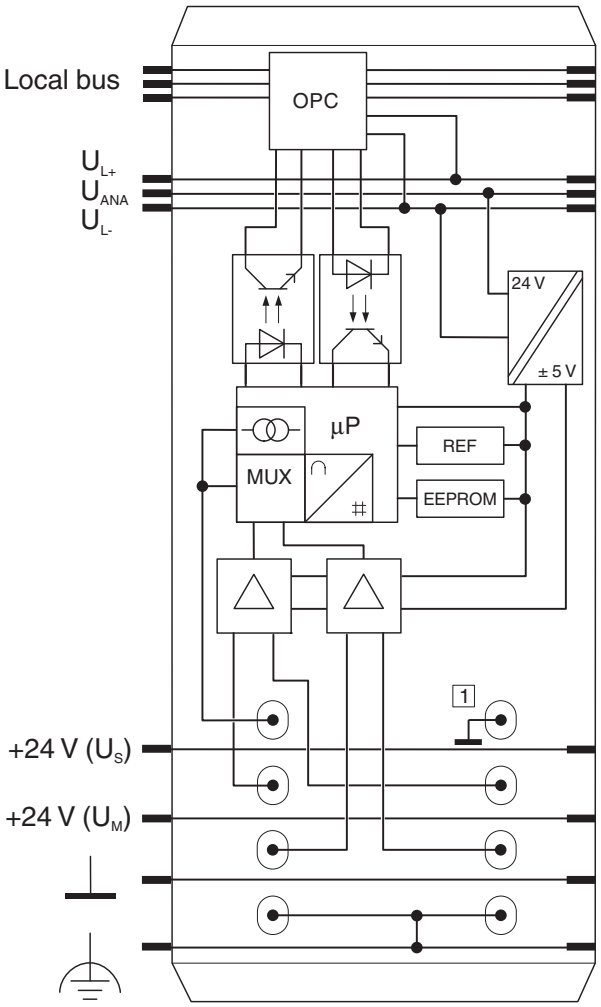
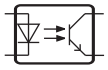



*Fig. 2 Internal wiring of the terminal points*

Key:


Protocol chip



Optocoupler

Power supply unit with electrical isolation


Microprocessor with multiplexer, power source for the cold junction and analog-to-digital converter


Reference voltage source


Electrically erasable programmable read-only memory

Input amplifier

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

## 7 Electrical isolation

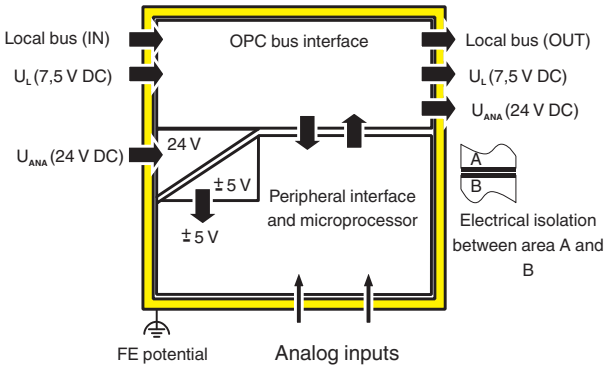



*Fig. 3 Electrical isolation of the individual function areas*

## 8 Terminal point assignment

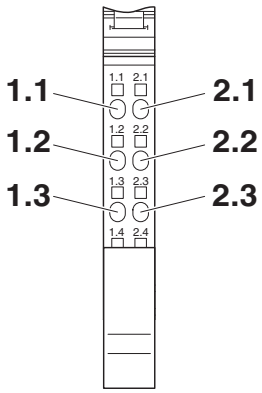



*Fig. 4 Terminal point assignment*

| Terminal point | Signal | Assignment | |
|---|---|---|---|
| 1.1 | - | Not used | |
| 2.1 | - | Not used | |
| 1.2 | TC2+ | Thermocouple | Positive input channel 2 |
| 2.2 | TC2- | Thermocouple | Channel 2 minus input |
| 1.3 | TC1+ | Thermocouple | Positive input channel 1 |
| 2.3 | TC1- | Thermocouple | Negative input channel 1 |
| 1.4, 2.4 | Shield | Shield connection | Channel 1 and 2 |

## 9 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. 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-CONTRL-ILSYSINS***-AW..-EN-P, MNR R911317021).

Please note for this terminal that due to potential routing the current always distorts the temperature of the internal cold junction. Therefore, position this terminal after all of the other terminals to minimize the current flowing through all potential jumpers.

## 10 Connection notes

### Connecting the thermocouples

Always connect the thermocouples using twisted pair equalizing conductors.

Use encapsulated thermocouples.

Use suitable thermocouple terminal blocks for extending the thermoelectric cables.

### Connecting the shield

Connect the shielding to only one side of the Inline terminal using the shield connection clamp.

In this way, the creation of ground loops that might occur when connecting the shielding to PE on both sides can be prevented.

The clamp connects the shield directly to FE on the module side. Additional wiring is not required.

Insulate the shielding at the sensor.

# 11 Connection examples

When connecting the shield at the terminal, you must insulate the shield on the sensor side.

Use a connector with overall shielding braid when installing the sensors. The figures below illustrate the connection (without overall shielding braid).

## 11.1 Absolute temperature measurement

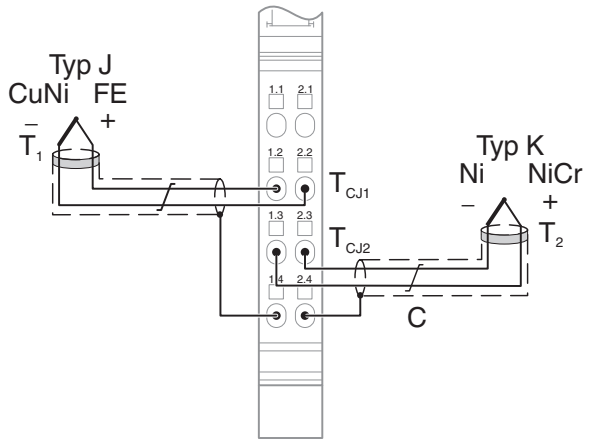



*Fig. 5 Absolute temperature measurement on two channels*

For absolute temperature measurement, the measuring temperature of T1 or T2 is determined by means of cold junction compensation (TCJ1, TCJ2).

## 11.2 Differential temperature measurement

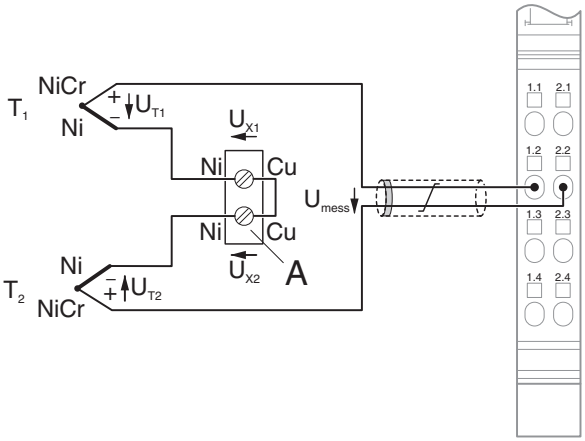



*Fig. 6 Differential temperature measurement with two type K thermocouples*

$U_{meas} = U_{T1} - U_{X1} + U_{X2} - U_{T2} = U_{T1} - U_{T2}$

If both terminal points (A) are at the same temperature level, the absolute values of $U_{X1}$ and $U_{X2}$ are equal. Both voltages cancel each other out. The difference between $U_{T1}$ and $U_{T2}$ remains.

### 11.3 Extension of the compensating line

When connecting the shield to a central grounding point, insulate the shield on the opposite side (shown in gray in the figure).

Use a plug with shield connection when connecting the sensors. The figure shows the connection schematically (without shield connecting plug).

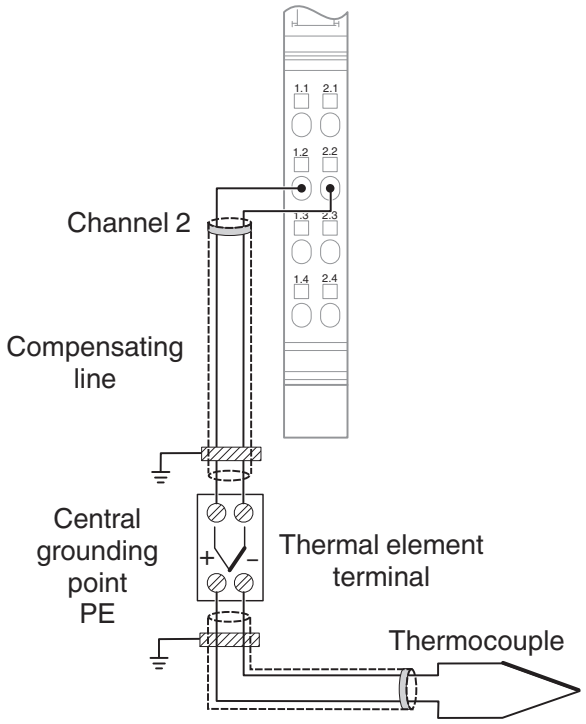



*Fig. 7 Extending the compensating line with thermocouple terminal blocks*

### 11.4 Improved interference suppression

The figure below shows an application for improved interference suppression. The bridges reduce interference caused by coupling in 50 Hz or 60 Hz frequencies and their electromagnetic fields (e.g., at heating cartridges).

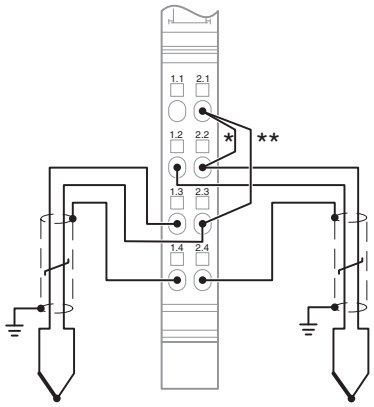



*Fig. 8 TC two-channel operation at high interference voltages*

* External bridge between 2.1 and 2.2 for improved interference suppression at channel 1

** External bridge between 2.1 and 2.3 for improved interference suppression at channel 2

In this application, TC1- is connected to TC2-.

### 11.5 Signal conditioner

The figure below shows an application for high noise immunity in an environment subjected to electromagnetic interference with electrical isolation between the channels of adjacent modules.

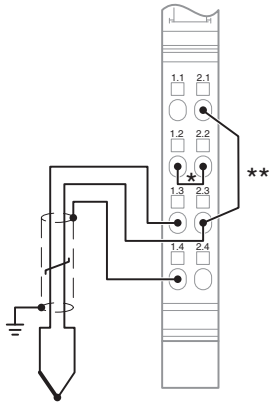



*Fig. 9 TC operation on channel 1 at high interference voltages*

* External bridge between 2.1 and 2.2

** External bridge between 2.1 and 2.3

You can only use channel 1 in this application.

## 12 Local diagnostic indicator

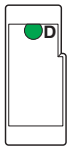



*Fig. 10 Local diagnostic indicator*

| Designation | Color | Meaning |
|---|---|---|
| D | Green | Diagnostics (bus and logic voltage) |

For more detailed information on diagnostics, please refer to the “Automation terminals of the Inline product range” application description (DOK-CONTRL-IL-SYSINS***-AW..-EN-P, MNR R911317021).

**Function identification**

Green

## 13 Process data

The terminal uses two words of IN process data and two words of OUT process data.

Each channel is mapped to a word.

The analog values are transmitted via the input process data.

The terminal can be parameterized via the OUT process data.

### 13.1 OUT process data

You can parameterize each channel independently of the other channels. Parameterize the first channel via the first output word and the second channel via the second output word.

The following parameterization options are available:

- Sensor type selection
- Resolution setting
- Selecting the formats for representing measured values
- Cold junction selection

The parameterization is not saved. Transmit the parameterization in each bus cycle.

After applying voltage (power up) to the Inline station, the message "Measured value invalid" (error code $8004_{hex}$) appears in the process data input words. After a maximum of one second, the preset parameterization is accepted and the first measured value is available.

If you change the parameterization, the corresponding channel is re-initialized.
The message "Measured value invalid" (error code $8004_{hex}$) appears in the process data output words for maximum 100 ms.

The following values are preset on the terminal:

| | |
|---|---|
| Sensor type | TC type K |
| Resolution | 0.1°C (1 µV) |
| Format | IB IL |
| Cold junction | Internal |

Order of the process data words:

| Output process data (parameter words) | |
|---|---|
| Word 0 | Word 1 |
| Channel 1 | Channel 2 |

Assignment of the parameter words

| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Parame-terization | Reserved | | | | Cold junction | | | Resolution | | Format | | Sensor type | | | |

**Bit 15**

| Code | | Parameterization |
|---|---|---|
| dec | bin | |
| **0** | **0** | **Default** |
| 1 | 1 | Parameterization |

When bit 15 = 0, the preset (default) is active.

In order to parameterize the terminal, set bit 15 to 1.

**Bits 14 ... 11**

These bits are reserved. Set these bits to 0.

**Bit 10 ... 8**

| Code | | Cold junction compensation |
|---|---|---|
| dec | bin | |
| **0** | **000** | **Internal cold junction active, TC measurement with internal cold junction compensation** |
| 1 | 001 | Internal cold junction inactive, TC differential measurement without cold junction compensation |
| 2 | 010 | External cold junction Pt 1000, TC measurement with external cold junction compensation at an isothermal block (for laboratory applications only) |
| 3 | 011 | External cold junction Ni 1000, TC measurement with external cold junction compensation at an isothermal block (for laboratory applications only) |
| Other | | Reserved |

**Bit 7 ... 6**

| Code | | Resolution based on IB IL format |
|---|---|---|
| dec | bin | |
| **0** | **00** | **0.1°C (1 µV)** |
| 1 | 01 | 1°C (10 µV) |
| 2 | 10 | 0.1°F |
| 3 | 11 | 1°F |

**Bit 5 ... 4**

| Code | | Format |
|---|---|---|
| dec | bin | |
| **0** | **00** | **IB IL (15 bits + sign bit, default)** |
| 1 | 01 | IB ST (12 bits + sign bit + 3 diagnostic bits) |
| 2 | 10 | IB RT (15 bits + sign bit) |
| 3 | 11 | Reserved |

See “Measured value representation in the different formats”.

**Bit 3 ... 0**

| Code | | Sensor type |
|---|---|---|
| dec | bin | |
| **0** | **0000** | **TC type K** |
| 1 | 0001 | TC type J |
| 2 | 0010 | TC type E |
| 3 | 0011 | TC type R |
| 4 | 0100 | TC type S |
| 5 | 0101 | TC type T |
| 6 | 0110 | TC type B |
| 7 | 0111 | TC type N |
| 8 | 1000 | TC type U |
| 9 | 1001 | TC type L |
| 10 | 1010 | TC type C |
| 11 | 1011 | TC type W |
| 12 | 1100 | TC type HK |
| 13 | 1101 | Cold junction (CJ) |
| 14 | 1110 | U: linear voltage (-15 mV ... +85 mV) |
| 15 | 1111 | Reserved |

Use IB IL format to represent the measured values of sensor type 14 (linear voltage).

If you select cold junction as the sensor type, the input data word displays the cold junction temperature (terminal temperature). In addition, the channel parameterized in this way will not be evaluated within the measuring cycle. This shortens the update time for the terminal.

### 13.2 IN process data

The measured values and diagnostic messages (in the IB IL format) are transmitted channel-by-channel to the controller via the process data input words.

Order of the process data words:

| Input process data | |
|---|---|
| Word 0 | Word 1 |
| Channel 1 | Channel 2 |

### 13.3 Assignment of the terminal points to IN process data

| (Word.bit) view | Word | Word x | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Bit | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Channel 1 | Signal | Terminal point 1.3 | | | | | | | | | | | | | | | |
| | Signal reference | Terminal point 2.3 | | | | | | | | | | | | | | | |
| | Shielding | Terminal point 1.4, 2.4 | | | | | | | | | | | | | | | |
| Channel 2 | Signal | Terminal point 1.2 | | | | | | | | | | | | | | | |
| | Signal reference | Terminal point 2.2 | | | | | | | | | | | | | | | |
| | Shielding | Terminal point 1.4 | | | | | | | | | | | | | | | |

| Word x | Channel |
|---|---|
| 0 | 1 |
| 1 | 2 |

# 14 Formats for representing measured values

Bosch Rexroth recommends format IB IL for all controllers, as this format contains the most comprehensive diagnostic codes.

The other formats are only intended for simplifying reconfiguration on IB IL analog modules in existing projects.

## 14.1 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 > $8000_{hex}$ indicate an error.

### Supported error codes

| Code (hex) | Error |
|---|---|
| 8001 | Measuring range exceeded (overrange) |
| 8002 | Open circuit |
| 8004 | Measured value invalid or no valid measured value available |
| 8008 | Cold junction defective |
| 8010 | Configuration invalid |
| 8040 | Device faulty |
| 8080 | Below measuring range (underrange) |

### 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

### Significant measured values

| Sensor type (bits 3 ... 0) | | TC and CJ sensor (0 ... 13) | Linear voltage (14) |
|---|---|---|---|
| Resolution (bits 7 ... 6) | | $00_{bin}$ or $10_{bin}$ | $00_{bin}$ |
| Process data item (= analog value) | | 0.1°C or 0.1°F | 1 µV |
| hex | dec | °C or °F | µV |
| 8002 | - | Open circuit | - |
| 8001 | - | Measuring range exceeded (over-range) | > 32768 |
| 2710 | 10000 | 1000.0 | 10000 |
| 000A | 10 | 1.0 | 10 |
| 0001 | 1 | 0.1 | 1 |
| 0000 | 0 | 0 | 0 |
| FFFF | -1 | -0.1 | -1 |
| FC18 | -1000 | -100.0 | -1000 |
| C568 | -15000 | - | -15000 |
| 8080 | | Below measuring range (under-range) | < -15000 |

| Sensor type (bits 3 ... 0) | | TC and CJ sensor (0 ... 13) | Linear voltage (14) |
|---|---|---|---|
| Resolution (bits 7 ... 6) | | $01_{bin}$ or $11_{bin}$ | $01_{bin}$ |
| Process data item (= analog value) | | 1°C or 1°F | 10 µV |
| hex | dec | °C or °F | µV |
| 8002 | - | Open circuit | - |
| 8001 | - | Measuring range exceeded (over-range) | > 85000 |
| 2134 | 8500 | - | 85000 |
| 03E8 | 1000 | 1000 | 10000 |
| 0001 | 1 | 1 | 10 |
| 0000 | 0 | 0 | 0 |
| FFFF | -1 | -1 | -10 |
| FF9C | -100 | -100 | -1000 |
| FA24 | -1500 | - | -15000 |
| 8080 | | Below measuring range (under-range) | < -15000 |

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

The “open circuit” error message is only generated in TC operation.

### 14.2 IB ST format

The measured value is represented in bits 14 to 3.

An additional bit (bit 15) is available as a sign bit.

Bits 2 to 0 are available as measuring range and error bits.

IB ST format corresponds to the data format used on INTERBUS ST modules.

**Measured value representation in IB ST format**

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

V Sign bit
0 Reserved
OC Open circuit
BÜ Overrange

**Significant measured values**

| **Sensor type (bits 3 ... 0)** | | **TC and CJ sensor (0 ... 13)** | |
|---|---|---|---|
| **Resolution (bits 7 ... 6)** | | **$00_{bin}$ or $10_{bin}$** | **$01_{bin}$ or $11_{bin}$** |
| **Process data item (= analog value)** | | **0.1°C or 0.1°F** | **1°C or 1°F** |
| **hex** | **dec** | **°C or °F** | **°C or °F** |
| xxxx xxxx xxxx $xxx1_{bin}$ | | Overrange (AV = positive final value for the measuring range) | |
| 2710 | 10000 | 1000 | - |
| 03E8 | 1000 | 100 | 1000 |
| 0008 | 8 | 0.8 | 8 |
| 0000 | 0 | 0 | 0 |
| FFF8 | -8 | -0.8 | -8 |
| FC18 | -1000 | -100 | - |
| xxxx xxxx xxxx $xxx1_{bin}$ | | Underrange (AV = negative final value for the measuring range) | |
| xxxx xxxx xxxx $xx1x_{bin}$ | | Open circuit/short circuit (AV = negative final value for the measuring range) | |

AV Analog value
x Can have the value 0 or 1

If the measured value is outside the display range of the process data, bit 0 is set to 1.

In the event of an open circuit, bit 1 is set to 1.

### 14.3 IB RT format

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

IB RT format corresponds to the data format used on INTERBUS RT modules.

**Measured value representation in IB RT format**

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

V Sign bit

**Significant measured values**

| **Sensor type (bits 3 ... 0)** | | **TC and CJ sensor (0 ... 13)** |
|---|---|---|
| **Resolution (bits 7 ... 6)** | | **$00_{bin}$ or $10_{bin}$** |
| **Process data item (= analog value)** | | **0.1°C or 0.1°F** |
| **hex** | **dec** | **°C or °F** |
| Upper limit value + 1 LSB | | Measuring range exceeded (overrange) |
| 7D00 | 32000 | - |
| 2710 | 10000 | 1000.0 |
| 000A | 10 | 1 |
| 0001 | 1 | 0.1 |
| 0000 | 0 | 0 |
| FFFF | -1 | -0.1 |
| FC18 | -1000 | -100.0 |
| Lower limit value - 1 LSB | | Below measuring range (underrange) |
| Lower limit value - 2 LSB | | Open circuit |

| **Sensor type (bits 3 ... 0)** | | **TC and CJ sensor (0 ... 13)** |
|---|---|---|
| **Resolution (bits 7 ... 6)** | | **$01_{bin}$ or $11_{bin}$** |
| **Process data item (= analog value)** | | **1°C or 1°F** |
| **hex** | **dec** | **°C or °F** |
| Upper limit value + 1 LSB | | Measuring range exceeded (overrange) |
| 6400 | 25600 | - |
| 03E8 | 1000 | 1000 |
| 0001 | 1 | 1 |
| 0000 | 0 | 0 |
| FFFF | -1 | -1 |
| FF9C | -100 | -100 |
| ED40 | -4800 | - |
| Lower limit value - 1 LSB | | Below measuring range (underrange) |
| Lower limit value - 2 LSB | | Open circuit |

# 15 Measuring ranges

## 15.1 Measuring ranges depending on the resolution

### IB IL and IB RT format

| Resolution (bits 7 ... 6) | Thermocouples | | Linear voltage sensors | |
|---|---|---|---|---|
| | Resolution | Measuring range | Resolution | Measuring range |
| 00 | 0.1 °C | -273 °C ... +3276.8 °C | 1 µV | -15 mV ... +32.768 mV |
| 01 | 1 °C | -273 °C ... +32768 °C | 10 µV | -15 mV ... +85 mV |
| 10 | 0.1°F | -459 °F ... +3276.8 °F | | |
| 11 | 1°F | -459 °F ... 32760 °F | | |

### IB ST format

| Resolution (bits 7 ... 6) | Thermocouples | |
|---|---|---|
| | Resolution | Measuring range |
| 00 | 0,8 °C | -272.8 °C ... +3276.0 °C |
| 01 | 8 °C | -272 °C ... +32760 °C |
| 10 | 0,8 °F | -459,2 °F ... 3276 °F |
| 11 | 8 °F | -456 °F ... +32760 °F |

Temperature values in °C can be converted to °F using the following formula:

T [°F] = T [°C] x 9/5 +32

Where:

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

### 15.2 Input measuring ranges

| No. | Input | Sensor type | Standard | Measuring range (software-supported) | |
|---|---|---|---|---|---|
| | | | | Lower limit | Upper limit |
| 1 | Thermocouples | B | EN 60584-1 (DIN EN 60584-1) | +50 °C | +1820 °C |
| 2 | | E | | -270 °C | +1000 °C |
| 3 | | J | | -210 °C | +1200 °C |
| 4 | | K | | -270 °C | +1372 °C |
| 5 | | N | | -270 °C | +1300 °C |
| 6 | | R | | -50°C | +1768 °C |
| 7 | | S | | -50°C | +1768 °C |
| 8 | | T | | -270 °C | +400 °C |
| 9 | | C | | -18 °C | +2316 °C |
| 10 | | W | | -18 °C | +2316 °C |
| 11 | | HK | | -200 °C | +800 °C |
| 12 | | L | DIN 43710 | -200 °C | +900 °C |
| 13 | | U | | -200 °C | +600 °C |
| 14 | Internal cold junction | Pt 1000 | DIN IEC 60751 | -200 °C | +850 °C |
| 15 | Voltage input | Linear voltage | | -15 mV | +85 mV |

In the event of an underrange or overrange of the specified measuring range limits, the terminal outputs the “Underrange” or “Overrange” error message in IB IL format.

## 16 Process data update time

The process data update time is the response time of the terminal for the output of the required channel address with the corresponding measured value.

| Action | Time | Number of bus cycles |
|---|---|---|
| Refreshing the measured value in the process data with a constant process data output word (e.g., PD OUT = $0000_{hex}$) | < 30 ms | = time/cycle time |

The time is the response time of the module electronics up to the point in time when the valid values are present in the process data output words.

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