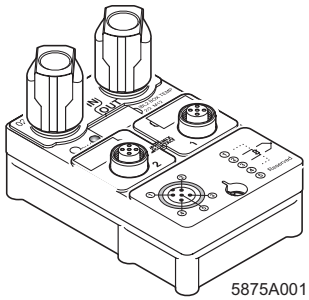
IB L2 BOX TEMP 2/2 M12

INTERBUS Loop Input Module With 2 Analog Input Channels for Measuring Temperature Signals



Data Sheet 5875A 12/1999

This data sheet is intended to be used in conjunction with the “INTERBUS Loop 2 System Manual”, IB L2 SYS PRO UM E.

Function

With this module, you can detect values of analog resistance temperature detectors (RTDs) and thermocouples. The cold junction compensation can be switched off to allow absolute and differential temperature measurement with thermocouples. Additional sensors (e.g, potentiometer and mV voltages) can be networked because of the linear resistance and voltage measurement ranges.

Features

- Two analog signal inputs to detect temperature signals
- Configuration of the channels with INTERBUS
- Internal detection of the cold junction temperature (configurable)
- Absolute or differential temperature measurement (configurable)
- Diagnostic indicators

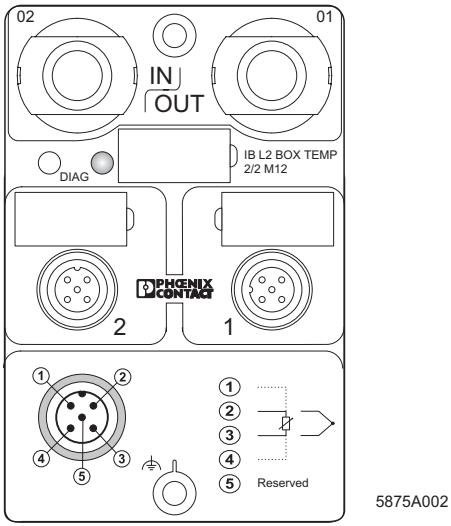


Figure 1 IB L2 BOX TEMP 2/2 M12 module

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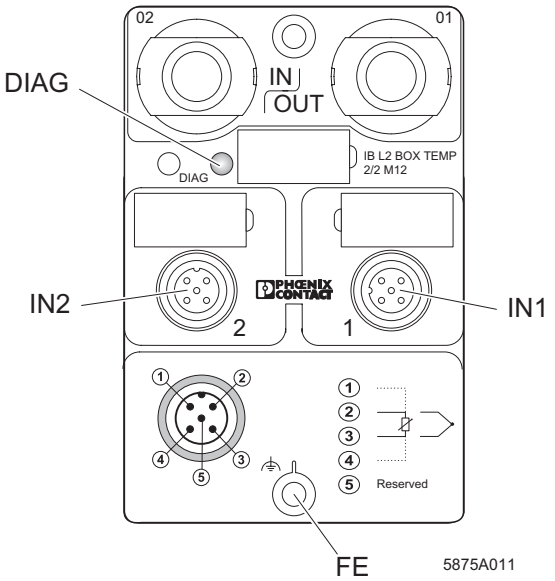

Figure 2 Local diagnostic indicators and pin assignment of the module

Local Diagnostic and Status Indicators

Des.	Color	Meaning
DIAG	Green	Bus active

Pin Assignment

Connection	Signal
IN	Incoming INTERBUS Loop 2
OUT	Outgoing INTERBUS Loop 2
1	Input 1
2	Input 2

Internal Circuit Diagram

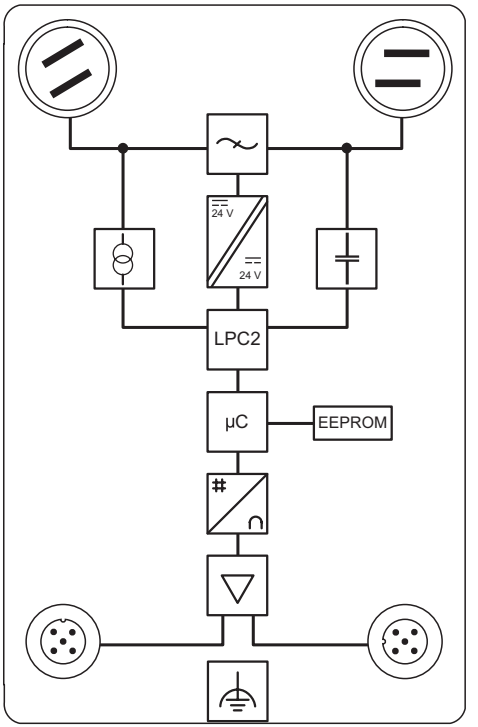

Figure 3 Internal wiring of the terminals

Key:

INTERBUS Loop 2 connection	Microprocessor
Filter	Electrically erasable programmable read-only memory
DC/DC converter with electrical isolation	Analog digital converter
INTERBUS protocol chip	Amplifier
Transformer	M12 sensor socket
Capacitor	Functional earth ground connection (FE) for sensor cables; electrically isolated from the module electronics

Safety Note

Make sure there is no isolating voltage specified between the analog inputs and INTERBUS Loop when configuring the system. That means, for example, that the user must provide signals with **safe isolation** for thermistor detection, if necessary.

Installation and Connection Instructions

Defined module operation can be affected by EMI. Therefore, operate the module only at sites without interference.

Do not operate the device unless the cable shield is connected to ground potential.

Always connect the thermocouples and cable extensions with **shielded thermocouple extension wires**.

Always connect encapsulated sensors using shielded cables.

Ensure a large surface connection when connecting the shield with ground potential. Note the instructions on page 8.

To prevent compensating currents from flowing over the shield, connect the shield to ground potential at only one point.

Cover unused sensor sockets with protective caps (accessories) to ensure IP 65 and IP 67 protection.

Sensor Connection

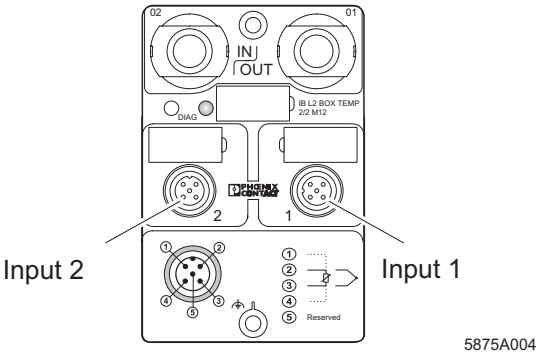

Figure 4 Location of the sensor sockets

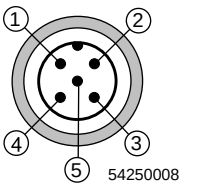

Figure 5 General pin assignment of the 5-pos. sensor sockets

1 Sensor supply
2 Sensor input signal +
3 Sensor input signal -
4 Analog ground
5 Reserved

Pin assignment of the sensor sockets - **Resistance temperature detectors** (RTDs)

Pin	Input 2	Input 1
1	I_{out}+ as 3- and 4-wire connection	I_{out}+ as 3- and 4-wire connection
2	U_{sensor}+	U_{sensor}+
3	U_{sensor}-	U_{sensor}-
4	I_{out}- as 4-wire connection	I_{out}- as 4-wire connection
5	Reserved	Reserved

Pin assignment of the sensor sockets - **Thermocouples (TC) and voltage signals**

Pin	Input 2	Input 1
1	–	–
2	U_{IN}+	U_{IN}+
3	U_{IN}-	U_{IN}-
4	–	–
5	Reserved	Reserved

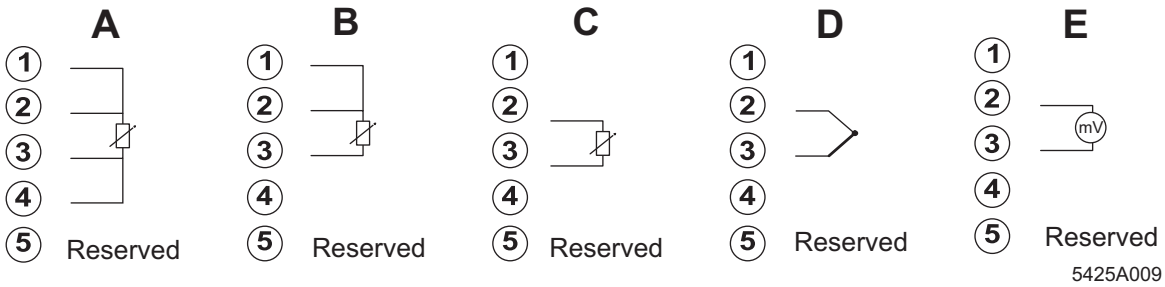

Figure 6 Examples for the connection of 2-, 3-, and 4-wire sensors

A 4-wire RTDs

B 3-wire RTDs

C 2-wire RTDs

D Thermocouples

E Voltage signals

Connection of the Shield

There are two ways of connecting the shield:

Phoenix Contact recommends connecting the shield using the **IB L2 SHIELD shield plate**. This shield plate is installed as default upon delivery.

Connect the sensor using a shielded sensor cable and a M12 metal connector. Preassembled and shielded connection cables from the SAC program are available for RTDs and linear voltages (see ordering data on page 35).

The grounding of the shield plate is shown in Figure 7. Shielding signal cables with a shield plate is shown in Figure 8.

You can also connect the shield by using **shield terminal blocks (SK),** or **shield clamps,** from Phoenix Contact. This is shown in Figure 9.

Thermal element terminal blocks (MTKD... type from Phoenix Contact) are available for the connection of the thermocouple extension wires (see Figure 10 on page 10).

Grounding Signal Cables Using a Shield Plate

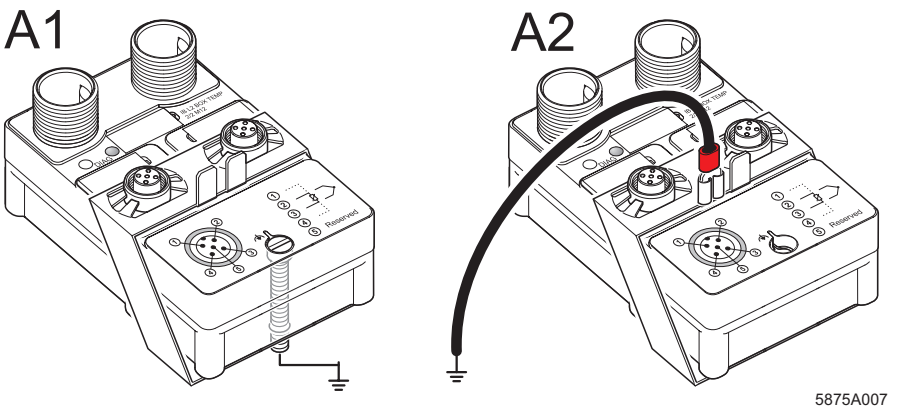

Figure 7 Installing the shield plate

Do the following to ground the shield plate:

- Install the module onto a grounded mounting plate. The shield plate is automatically grounded (Figure 7, A1).
- If it is not possible to fasten the module on a grounded mounting plate, connect the shield plate with a grounding point by means of a separate cable (Figure 7, A2). Use a cable lug to connect the cable with the shield plate.

The shield of the sensor cable is connected with the shield plate by means of the M12 metal connector.

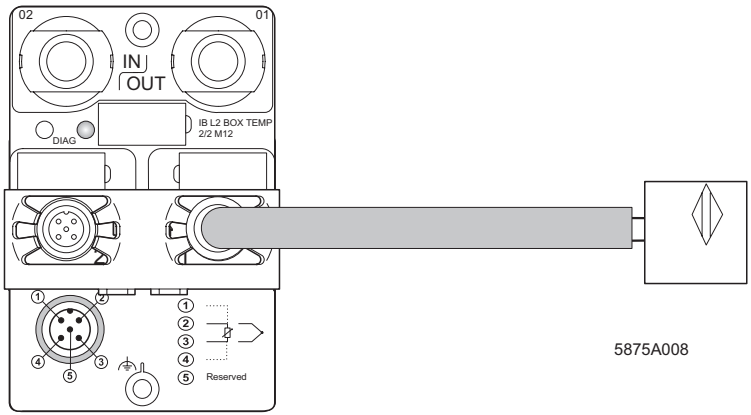

Figure 8 Grounding signal cables using a shield plate

Alternative Shielding of Signal Cables With a Shield Clamp

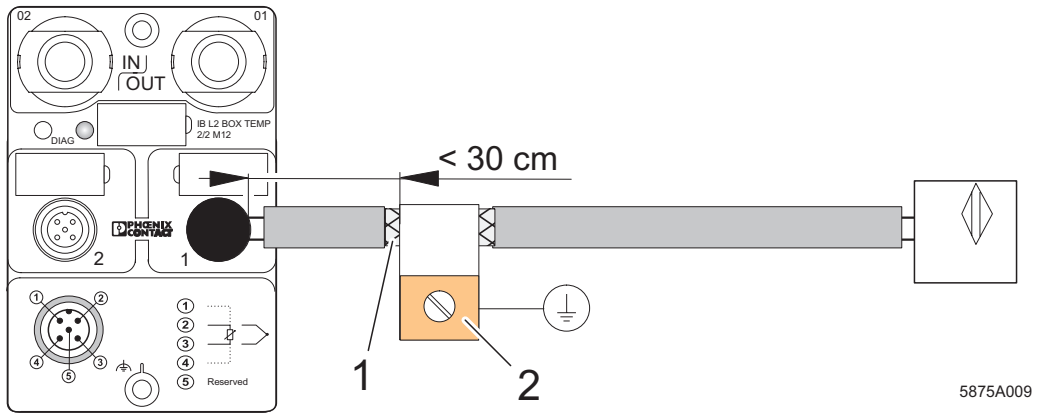

Figure 9 Grounding signal cables using a shield clamp

- Strip a portion of the insulation off the sensor cable within 30 cm (11.811 in.) of the sensor input at the module (1).
- Use a screw to connect the shield clamp (2) to PE (protective earth ground) potential.

Example Extension of the Equalizing Conductor With Thermal Element Terminal Blocks

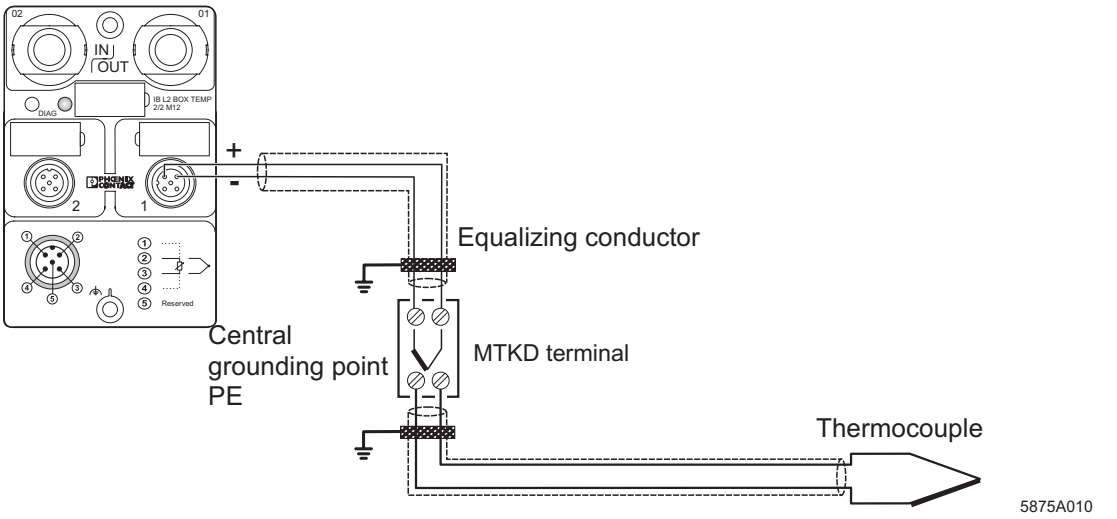

Figure 10 Extension of the equalizing conductor using thermal element terminal blocks

Thermal element terminal blocks (MTKD... type from Phoenix Contact) are available for the extension of thermocouple extension wires.

If you are using an MTKD terminal, the cable is grounded on a central grounding point. In this case, do not install the shield on the module.

To avoid reduced functionality due to EMI, the cable between the MTKD terminal and the module must not be longer than 1 m (3.3 ft.).

Connection Examples

The grounding of the shielded cable is shown schematically in Figure 11 and Figure 12. Connect the shield according to the grounding options given on page 8.

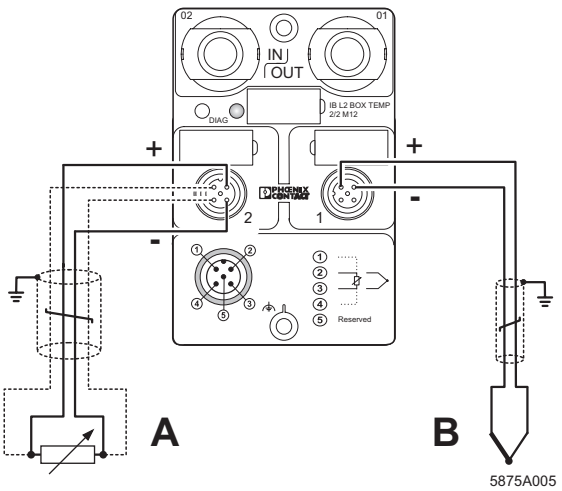

Figure 11 Absolute temperature detection with cold junction compensation

A Measuring point; e.g., 700°C (1292°F) (measurement across resistor)

B Measuring point; e.g., 700°C (1292°F) (measurement across thermocouple with module internal cold junction compensation)

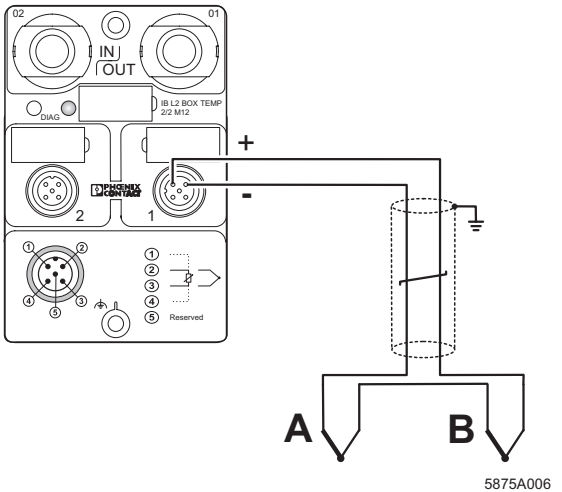

Figure 12 Differential temperature detection with external cold junction

A Measuring point; e.g., 700°C (1292°F)

B External cold junction; e.g., 0°C (32°F) (e.g., ice water)

The internal cold junction compensation can be switched off for differential temperature measurement.

Programming Data

ID code	73_{hex} (115_{dec})
Length code	02_{hex}
Input address area	4 bytes
Output address area	4 bytes
Parameter channel (PCP)	0 bytes
Register length	4 bytes

INTERBUS Process Data Words

INTERBUS Output Data Words for the Configuration of the Module (see page 14)

INTERBUS reference	Word	Word x															
	Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
(Byte/bit) view	Byte	Byte 0								Byte 1							
	Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Socket 2	Assignment	RTD-R_0 code								Reso-lution		V	Sensor type				
Socket 1	Assignment	RTD-R_0 code								Reso-lution		V	Sensor type				

Key:

V Cold junction compensation

Assignment of the Sensor Sockets to the INTERBUS Input Data Word (see page 18)

INTERBUS reference	Word	Word x															
	Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
(Byte/bit) view	Byte	Byte 0								Byte 1							
	Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Socket 2	Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Socket 1	Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

The module operates in process data mode with two words.

INTERBUS OUT Process Data Output Words

You can configure the module with the process data output words. This configuration is valid for both channels.

Even though the configuration is valid for both channels, you can operate different sensors on channel 1 and channel 2. For this, you must configure the module prior to the measurement, so that the requirements for the corresponding channel are met. Then the values of the other channel are invalid.

With process data word 1, you can set the following parameters:

– Sensor type
– Sensor resistance
– Resolution/temperature unit
– Cold junction compensation

With process data word 2, you can set the following parameters:

– Operating mode
  (Normal mode or cyclical calibration mode)

In industrial environments cyclical calibration mode must be activated.

The configuration is saved in a volatile memory (RAM). After the configuration is transmitted, the analog part is re-initialized.

A process data word not equal to 0000_{hex} is considered to be the configuration.

As soon as the voltage is applied to the module (power up), the error message “Measured value invalid” (error code $E010_{hex}$) is displayed in the process data input words. After 1.8 s (maximum) the preset configuration is accepted and the first measured value is available. If you change the configuration, the module is re-initialized. The message “Measured value invalid” (error code $E010_{hex}$) appears in the process data output words for 250 ms (maximum).

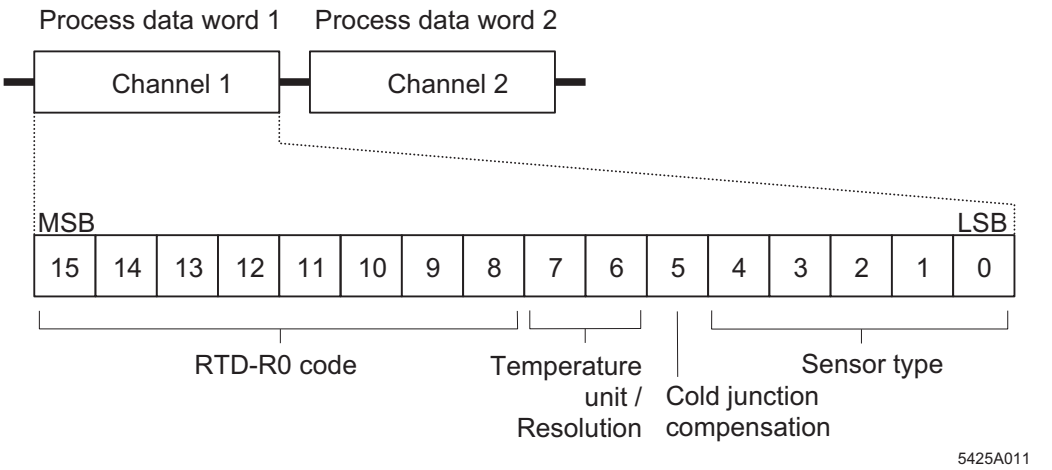

Figure 13 Sequence of the process data output words in the INTERBUS ring and representation of the bits of the first process data word

Cyclical Calibration Mode (Process Data Word 2 = 8301_{hex})

This operating mode is used for very harsh ambient conditions (climate, EMI) to achieve the best results. In this operating mode a self-calibration is performed prior to each measurement.

Set the second process data output word to **8301_{hex}** to activate the cyclical calibration.

When cyclical calibration mode is activated, the process data update time is increased by 1.3 s.

Normal Mode (Process Data Word 2 = 0000_{hex})

If cyclical calibration mode is not required, normal mode is used.

Set the second process data output word to **0000_{hex}**.

RTD-R_0 (Bit 15 to Bit 8)

Code		RTD-R_0
Dec.	Hex.	
0	*00*	*Not permissible*
1	01	10 Ω
2 to 200	02 to C8	20 Ω to 2000 Ω
201 to 255	*C9 to FF*	*Not permissible*

RTD-R_0 is the sensor resistance at 0°C (32°F).

This value is 100 Ω for Pt 100.

RTD-R_0 can be selected from 10 Ω to 2000 Ω in steps of 10 Ω. The permissible RTD-R_0 code is between 1 and 200_{dec}.

Any platinum or nickel sensors can be used. It is possible to use two or more Pt 100 sensors connected in series.

The RTD code of the sensor is calculated according to the formula:

RTD-R_0 code = RTD-R_0 / 10.

The sensor resistance is calculated according to the formula:

RTD-R_0 code = RTD-R_0 code x 10.

The resistance is necessary for four sensor types only: Pt and Ni according to DIN and SAMA. For all other sensors, the value is either fixed or is not important. This is the reason why the resistance is checked only for these sensor types.

Examples for the RTD-R_0 Code

Sensor Type	RTD-R_0 Code (Hex.)
Pt 100, Ni 100	0A
Pt 120, Ni 120	0C
Pt 300, Ni 300	1E
Pt 500, Ni 500	32
Pt 1000, Ni 1000	64
Pt 2000, Ni 2000	C8

Resolution/Temperature Unit (Bit 7 and Bit 6)

Code		Resolution/Temperature Unit
Dec.	Bin.	
0	00	0.1°C (0.1 mV; 0.1 Ω)
1	01	0.01°C (0.01 mV; 0.01 Ω)
2	10	1°C (1 mV; 1 Ω)
3	11	0.1°F

With bits 7 and 6 you can select unit and resolution with which the measured results are output. The temperature unit of the displayed options is only valid for temperature sensors. For the sensors U1 and U2 the unit is mV; for R 0 Ω to R 8000 Ω (linear) it is Ω.

The conversion into Fahrenheit is independent of the sensor; this means that the conversion (linear) is possible even for R 0 Ω to R 8000 Ω. In this case, the process data input value is invalid.

Cold Junction Compensation (Bit 5)

Code		Cold Junction Compensation (With Thermocouple Operation)
Dec.	Bin.	
0	0	With compensation (for absolute temperature measurement)
1	1	Without compensation (for differential temperature measurement)

The internal cold junction temperature can be read with the set sensor type “cold junction sensor” (15_{hex}).

Sensor Type (Bit 4 to Bit 0)

hex	Sensor Type
0	RTD Pt DIN
1	RTD Pt SAMA
2	RTD Ni DIN
3	RTD Ni SAMA
4	RTD Ni L&G
5	RTD Cu 10 SAMA
6	RTD KTY 81-110
7	RTD Cu 50

hex	Sensor Type
8	RTD Cu 53
9	R 0 Ω to R 8000 Ω (linear)
A	TC type J
B	TC type K
C	TC type E
D	TC type R
E	TC type S
F	TC type T

hex	Sensor Type
10	TC type N
11	TC type U
12	TC type L
13	U1: -20 mV to 150 mV
14	U2: -20 mV to 2400 mV
15	Cold junction sensor
16 to 1F	Reserved

Examples for the Configuration With Normal Mode (INTERBUS OUT 2 = 0000_{hex})

Desired Operating Mode	Encoding of the Word INTERBUS OUT 1
Pt 100 DIN sensor and 0.1°C / LSB	$0A00_{hex}$
Pt 100 SAMA sensor and 0.1°C / LSB	$0A01_{hex}$
Pt 1000 SAMA sensor and 0.1°C / LSB	6401_{hex}
Pt 1000 SAMA sensor and 0.01°C / LSB	6441_{hex}
TC type J with cold junction compensation and 0.1°C / LSB	$000A_{hex}$
TC type J with cold junction compensation and 1.0°C / LSB	$008A_{hex}$
TC type K with cold junction compensation and 0.1°C / LSB	$000B_{hex}$
TC type K with cold junction compensation and 1.0°C / LSB	$008B_{hex}$
R 0 Ω to R 8000 Ω (linear) and 1 Ω / LSB	0089_{hex}
U: - 20 mV to +150 mV and 0.01 mV / LSB	0053_{hex}

INTERBUS IN Process Data Input Words

The measured values are transmitted, per channel, through the INTERBUS IN process data input words to the controller board or the computer.

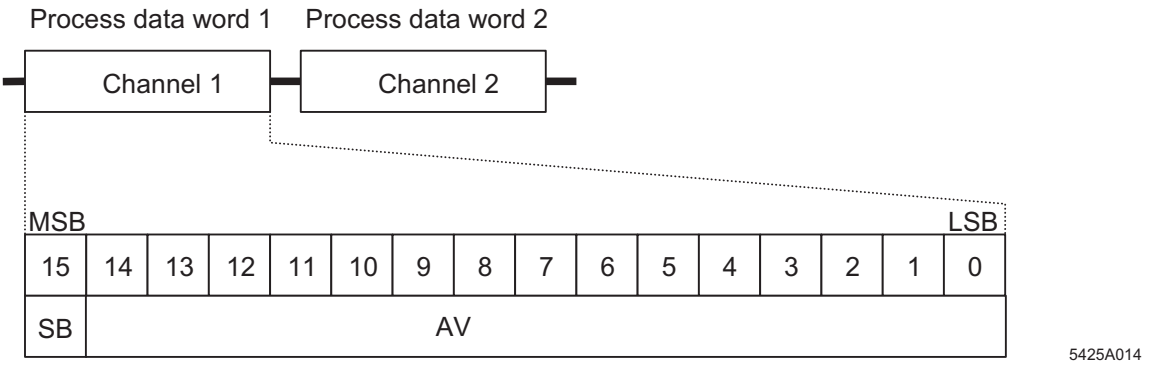

Figure 14 Sequence of the process data input words in the INTERBUS ring and representation of the bits of the first process data word

Key:

SB	Sign bit
AV	Analog value (measured value)

The measured value is displayed as a 16 bit value in the two's complement of the process data. With 0.01 K resolution, the temperature range to be mapped in the process data is limited. If a value is out of this range, the error message **"Out of temperature range"** is generated for the channel.

Temperature Values at Set Resolutions

Process Data Item (hex.)	°C (1 K)	°C (0.1 K)	°C (0.01 K)	°F (0.1 F)
7FFF (maximum)	32767°C	3276.7°C	327.67°C	3276.7°F (= 1802°C)
03E8	1000°C	100.0°C	10.00°C	100.0°F
000A	10°C	1.0°C	0.1°C	1.0°F
0001	1°C	0.1°C	0.01°C	0.1°F
FFFF	-1°C	-0.1°C	-0.01°C	-0.1°F
FC18	–	-100.0°C	-10.0°C	-100.0°F
F555	–	-273.1°C	-27.31°C	-273.1°F
EE0C	–	–	-45.96°C	-459.6°F
E100 (minimum)	–	–	-79.36°C	–
E0xx	–	–	–	Error messages
A000 - DFFF	–	–	–	Reserved
8000 - 9FFF	–	–	–	Codes for configuration

Error Messages

In normal mode, every process data input word is assigned to the temperature value of the corresponding channel. If the channel receives invalid temperature values, an error code is written to the corresponding process data input word. This error code specifies the state of the channel.

The error message **“Internal I/O supply voltage error”** is global and does not refer to one channel. The error message is therefore output to both process data input words. A module error is also indicated and no ADC values are processed.

The error message **“Open circuit”** is not valid for linear voltages (sensor types U1 and U2 (see “Sensor Type (Bit 4 to Bit 0)” on page 17).

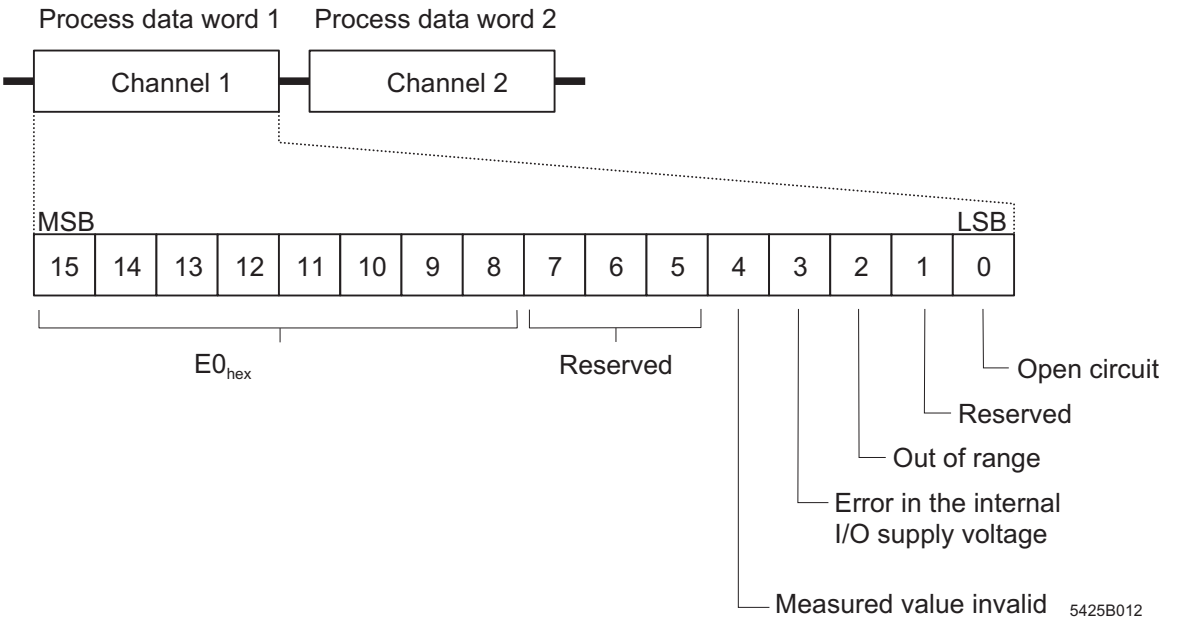

Figure 15 Assignment of the process data input words when an error occurs

Power Up
No configuration is preset upon the connection of the module. The module writes the error message “Measured value invalid” to both process data input words. The first measured value appears within 1.8 seconds (maximum) after a valid configuration has been written.

Limit Values

The limits of the overload capability for Pt and Ni sensors according to DIN and SAMA are effective for R_0 = 100 Ω. For other R_0, the values converted proportional to R_0 = 100 Ω are effective.

The error message **"Out of temperature range"** is generated when the value is out of the overload capability.

Sensor Type	Nominal Range		Range of Overload Capability	
	Lower Limit	Upper Limit	Minimum	Maximum
Pt 100 DIN	-200°C	850°C	14.0 Ω	400.0 Ω
Pt 100 SAMA	-200°C	850°C	14.0 Ω	400.0 Ω
Ni 100 DIN	-60°C	180°C	65.0 Ω	240.0 Ω
Ni 100 SAMA	-60°C	180°C	65.0 Ω	240.0 Ω
Ni L&G	-50°C	160°C	750.0 Ω	2000.0 Ω
Cu 10 SAMA	-70°C	500°C	5.1 Ω	29.0 Ω
KTY 81-110	-55°C	150°C	465 Ω	2255 Ω
Cu 50	-50°C	200°C	37.72 Ω	94.29 Ω
Cu 53	-50°C	180°C	40.35 Ω	95.0 Ω
R 0 Ω to R 8000 Ω (linear)	0 Ω	8000 Ω	0 Ω	9500 Ω
TC type J	-210°C	1200°C	-8300 µV	70676 µV
TC type K	-200°C	1370°C	-6158 µV	55595 µV
TC type E	-226°C	100°C	-9604 µV	77858 µV
TC type R	-50°C	1768°C	-250 µV	21368 µV
TC type S	-50°C	1768°C	-250 µV	18918 µV
TC type T	-200°C	400°C	-6310 µV	22109 µV
TC type N	-200°C	1300°C	-4162 µV	48222 µV
TC type U	-200°C	600°C	-6080 µV	35730 µV
TC type L	-200°C	900°C	-8450 µV	54560 µV
U1: -20 mV to 150 mV	-20 mV	150 mV	-24.25 mV	154.25 mV
U2: -20 mV to 2400 mV	-20 mV	2400 mV	-80.5 mV	2480.5 mV
Cold junction sensor	-25°C	70°C	-50°C	115°C

Tolerances

Tolerances of the RTD and R Inputs at an Ambient Temperature of T_U = +25°C

Sensor Type	Measuring Range for the Tolerances	Typical Total Error		Maximum Total Error	
		Relative	Absolute	Relative	Absolute
Pt 100 DIN	-200°C to +850°C -328°F to 1562°F	±0.053%	±0.45 K	±0.224%	±1.91 K
Pt 100 SAMA	-200°C to +850°C -328°F to 1562°F	±0.053%	±0.45 K	±0.224%	±1.91 K
Pt 1000 DIN	-200°C to +850°C -328°F to 1562°F	±0.046%	±0.39 K	±0.321%	±2.73 K
Ni 100 DIN	-60°C to +180°C -76°F to +356°F	±0.127%	±0.23 K	±0.538%	±0.97 K
Ni 100 SAMA	-60°C to +180°C -76°F to +356°F	±0.127%	±0.23 K	±0.538%	±0.97 K
Ni L&G	-50°C to +160°C -58°F to +320°F	±0.118%	±0.19 K	±0.825%	±1.32 K
Cu 10 SAMA	-70°C to +500°C -94°F to +932°F	±0.779%	±3.90 K	±1.949%	±9.74 K
KTY 81	-55°C to +150°C -67°F to +302°F	±0.078%	±0.12 K	±0.550%	±0.83 K
Cu 50	-50°C to +200°C -58°F to +392°F	±0.245%	±0.49 K	±1.058%	±2.12 K
Cu 53	-50°C to +180°C -58°F to +356°F	±0.266%	±0.48 K	±1.154%	±2.08 K
R 0 Ω to R 8000 Ω (linear) (1/2 measuring range)	0 Ω to 4000 Ω	±0.019%	±1.52 Ω	±0.133%	±10.64 Ω
R 0 Ω to R 8000 Ω (linear)	0 Ω to 8000 Ω	±0.064%	±5.10 Ω	±0.447%	±35.72 Ω

The data listed on the previous page contains offset, gain, and linearity error. Errors caused by EMI are not included.

All percentage data refers to the corresponding positive final value of the measuring range.

The maximum tolerance indications contain the maximum tolerances that are theoretically possible at the lowest sensitivity in the corresponding measuring ranges. The maximum tolerances that are theoretically possible for the calibration and test equipment are taken into account.

The maximum tolerance indications of the platinum, nickel, and KTY 81 resistance sensors include a resistance for the incoming cable of 200 mΩ (this corresponds to a copper line of approximately 1.5 m x 0.25 mm^2 [24 AWG]).

Tolerances of the RTD and R Inputs at an Ambient Temperature of T_U = -25°C to +60°C

Sensor Type	Measuring Range for the Tolerances	Typical Total Error		Maximum Total Error	
		Relative	Absolute	Relative	Absolute
Pt 100 DIN	-200°C to +850°C -328°F to 1562°F	±0.112%	±0.95 K	±0.349%	±2.96 K
Pt 100 SAMA	-200°C to +850°C -328°F to 1562°F	±0.112%	±0.95 K	±0.349%	±2.96 K
Pt 1000 DIN	-200°C to +850°C -328°F to 1562°F	±0.181%	±1.54 K	±0.506%	±4.30 K
Ni 100 DIN	-60°C to +180°C -76°F to +356°F	±0.267%	±0.49 K	±0.833%	±1.50 K
Ni 100 SAMA	-60°C to +180°C -76°F to +356°F	±0.267%	±0.49 K	±0.833%	±1.50 K
Ni L&G	-50°C to +160°C -58°F to +320°F	±0.500%	±0.80 K	±1.219%	±1.95 K
Cu 10 SAMA	-70°C to +500°C -94°F to +932°F	±0.980%	±4.90 K	±2.468%	±12.34 K
KTY 81	-55°C to +150°C -67°F to +302°F	±0.333%	±0.50 K	±0.810%	±1.22 K
Cu 50	-50°C to +200°C -58°F to +392°F	±0.245%	±0.49 K	±1.964%	±3.93 K
Cu 53	-50°C to +180°C -58°F to +356°F	±0.266%	±0.48 K	±2.094%	±3.77 K
R 0 Ω to R 8000 Ω (linear) (1/2 measuring range)	0 Ω to 4000 Ω	±0.075%	±6.00 Ω	±0.209%	±16.68 Ω
R 0 Ω to R 8000 Ω (linear)	0 Ω to 8000 Ω	±0.089%	±7.00 Ω	±0.604%	±48.32 Ω

The data listed on the previous page contains offset, gain, and linearity error. Errors caused by EMI are not included.

All percentage data refers to the corresponding positive final value of the measuring range.

The maximum tolerance values contain the maximum tolerances that are theoretically possible at unfavorable ambient temperature (-25°C or +60°C [-13°F or +140°F]) and the lowest sensitivity in the corresponding measuring ranges. The maximum tolerances that are theoretically possible for the calibration and test equipment are taken into account.

The maximum tolerance indications of the platinum, nickel, and KTY 81 resistance sensors include a resistance of the incoming cable of 200 mΩ (this corresponds to a copper line of approximately 1.5 m x 0.25 mm^2 [24 AWG]).

Tolerances of the TC Sensors at an Ambient Temperature of T_U = +25°C

Input	Sensor Type	Measuring Range for the Tolerances	Relative Error, Typical	Absolute Error, Typical	Relative Error, Maximum	Absolute Error, Maximum
Thermo-couples	J	-210°C to +1200°C -346°F to +2192°F	±0.015%	±0.19 K	±0.093%	±1.11 K
	K	-200°C to +1372°C -328°F to +2501°F	±0.017%	±0.24 K	±0.104%	±1.43 K
	E	-226°C to +1000°C* -374.8°F to +1832°F	±0.015%	±0.15 K	±0.108%	±1.08 K
	R	-300°C to +1768°C* -58°F to +3214°F	±0.057%	±1.00 K	±0.339%	±6.00 K
	S	-300°C to +1768°C* -58°F to +3214°F	±0.057%	±1.00 K	±0.339%	±6.00 K
	T	-270°C to +400°C -454°F to +752°F	±0.063%	±0.25 K	±0.375%	±1.50 K
	N	-200°C to +1300°C* -328°F to +2372°F	±0.028%	±0.37 K	±0.171%	±2.22 K
	L	-200°C to +900°C -328°F to +1652°F	±0.021%	±0.19 K	±0.123%	±1.11 K
	U	-200°C to +600°C -328°F to +1112°F	±0.042%	±0.25 K	±0.25%	±1.50 K
Internal cold junction	Semi-conduc-tor	-25°C to +85°C Software supported: -50°C to +115°C	–	±0.90 K	–	±4.15 K
Voltage input	Linear signals	-20 mV to +150 mV -20 mV to +2400 mV	±0.007% ±0.005%	±10 µV ±125 µV	±0.100% ±0.025%	±125 µV ±625 µV

* Below the indicated range, more errors are expected because of the low sensitivity of the sensor elements.
In this range, “double” tolerances can occur for the sensor types S and R.

The tolerance values of the TC sensors refer to a differential temperature measurement without cold junction compensation. The tolerances of the sensor elements must also be taken into account.

When measuring absolute temperatures (with cold junction compensation, default), the tolerance of the cold junction must be added to the above mentioned tolerance (see Table “Tolerances of Cold Junctions in Operation at an Ambient Temperature of T_U = -25°C to +60°C” on page 30).

All percentage data refers to the corresponding positive final value of the measuring range.

The maximum tolerance indications contain the maximum tolerances that are theoretically possible at the lowest sensitivity in the corresponding measuring ranges. The maximum tolerances that are theoretically possible for the calibration and test equipment are taken into account.

Tolerances of the TC Sensors at an Ambient Temperature of T_U = -25°C to +60°C

Input	Sensor Type	Measuring Range for the Tolerances	Relative Error, Typical	Absolute Error, Typical	Relative Error, Maximum	Absolute Error, Maximum
Thermo-couples	J	-210°C to +1200°C -346°F to +2192°F	±0.063%	±0.75 K	±0.262%	±3.14 K
	K	-200°C to +1372°C -328°F to +2501°F	±0.060%	±0.83 K	±0.254%	±3.49 K
	E	-226°C to +1000°C* -374.8°F to +1832°F	±0.690%	±0.69 K	±0.293%	±2.93 K
	R	-300°C to +1768°C* -58°F to +3214°F	±0.120%	±2.13 K	±0.530%	±9.37 K
	S	-300°C to +1768°C* -58°F to +3214°F	±0.120%	±2.12 K	±0.530%	±9.37 K
	T	-270°C to +400°C -454°F to +752°F	±0.131%	±0.52 K	±0.580%	±2.32 K
	N	-200°C to +1300°C* -328°F to +2372°F	±0.099%	±1.29 K	±0.384%	±4.99 K
	L	-200°C to +900°C -328°F to +1652°F	±0.089%	±0.81 K	±0.296%	±2.67 K
	U	-200°C to +600°C -328°F to +1112°F	±0.117%	±0.70 K	±0.475%	±2.85 K
Internal cold junction	Semi-conduc-tor	-25°C to +85°C Software supported: -50°C to +115°C	–	±1.35 K	–	±5.25 K
Voltage input	Linear signals	-20 mV to +150 mV -20 mV to +2400 mV	±0.020% ±0.050%	±30 µV ±1205 µV	±0.240% ±0.180%	±360 µV ±4405 µV

* Below the indicated range, more errors are expected because of the low sensitivity of the sensor elements.
In this range, “double” tolerances can occur for the sensor types S and R.

The tolerance values of the TC sensors refer to a differential temperature measurement without cold junction compensation. The tolerances of the sensor elements must also be taken into account (see Table “Tolerances of Cold Junctions in Operation at an Ambient Temperature of T_U = -25°C to +60°C” on page 30).

When measuring absolute temperatures (with cold junction compensation, default), the tolerance of the cold junction must be added to the above mentioned tolerance.

All percentage data refers to the corresponding positive final value of the measuring range. Note the information on the following page.

The maximum tolerance values contain the maximum tolerances that are theoretically possible at an unfavorable ambient temperature (-25°C or +60°C [-13°F or +140°F]) and the lowest sensitivity in the corresponding measuring ranges. The maximum tolerances that are theoretically possible for the calibration and test equipment are taken into account.

In practice, the total error, resulting from the addition of the typical cold junction tolerances and the typical thermocouple tolerances, is most important for absolute temperature measurement (see following tables).

Typical Total Error with Internal Cold Junction Compensation at an Ambient Temperature of T_U = +25°C

Input	Sensor Type	Measuring Range for the Tolerances*	Relative Error	Absolute Error
Thermo-couples	J	-210°C to +1200°C -346°F to +2192°F	±0.091%	±1.09 K
	K	-200°C to +1372°C* -328°F to +2501°F	±0.083%	±1.14 K

Typical Total Error with Internal Cold Junction Compensation at an Ambient Temperature of T_U = -25°C to +60°C

Input	Sensor Type	Measuring Range for the Tolerances*	Relative Error	Absolute Error
Thermo-couples	J	-210°C to +1200°C -346°F to +2192°F	±0.175%	±2.10 K
	K	-200°C to +1372°C* -328°F to +2501°F	±0.159%	±2.18 K

* The tolerances of the sensor elements and, if necessary, the tolerances caused by EMI must also be taken into account.

Tolerances of Cold Junctions in Operation at an Ambient Temperature of T_U = -25°C to +60°C

Error Type	Typical	Maximum
Tolerance (T_U = +25°C)	±0.50°C	±2.50°C
Temperature distribution tolerance of channel 1	-0.40 K	-1.40 K
Temperature distribution tolerance of channel 2	+0.40 K	+1.40°C
Cold junction temperature drift	±0.01°C/K	±0.01°C/K
Linearity	±0.10°C	±0.25°C
Total tolerance of the cold junction at T_U = +25°C	**±0.90°C**	**±4.15°C**
Total tolerance of the cold junction at T_U = -25°C to +60°C	**±1.35°C**	**±5.25°C**

These indications are valid after a warm-up phase of 30 minutes.

Tolerances of the Cold Junction Through Warm-Up Phase

Warm-Up Phase	Additional Tolerance (Typical)	
	Channel 1	Channel 2
1.0 min.	-3.7 K	-3.3 K
5.0 min.	-2.0 K	-1.5 K
10.0 min.	+0.2 K	-0.2 K
>30.0 min.	+0.1 K	-0.1 K

After you apply the supply voltage, you must consider a warm-up phase of 30 minutes. After switching on the module, the tolerances of the cold junction can directly be increased (see table on the left).

Additional Tolerances Influenced by EMI (Electromagnetic Interference)

Type of Electromagnetic Interference	Criterion	Sensor Type	Typical, Relative Deviation of the Final Value of the Measuring Range
Electrostatic discharge (ESD) EN 61000-4-2/IEC 61000-4-2	Criterion B 6 kV contact discharge 8 kV air discharge	All	–
Electromagnetic fields EN 61000-4-3/IEC 61000-4-3	Criterion A Field strength: 10 V/m	TC type K with cold junction compensation	-1.5% to +1.0%
Fast transients (burst) EN 61000-4-4/IEC 61000-4-4	Criterion B 2 kV on Loop; Criterion A 2 kV on shielded sensor cable	All	–
Surge voltage EN 61000-4-5/IEC 61000-4-5	Criterion B	All	–
Conducted interference EN 61000-4-6/IEC 61000-4-6	Criterion B	All	–

With EMI the functions may be affected (criterion B, self-restoring).

Technical Data

General	
Housing dimensions (width x height x depth)	62 mm x 60 mm x 95 mm (2.441 in. x 2.362 in. x 3.740 in.)
Weight	125 g
Operating mode	Process data operation with 2 INTERBUS IN words and 2 INTERBUS OUT words
Connection type of the sensors	2-, 3-, or 4-wire technology
Total power consumption	1.2 W, typical; 1.8 W, maximum
Indications regarding ambient temperature, humidity, air pressure, and degree of protection are different to the indications in the manual.	
Permissible operating temperature	From -25°C to +60 °C (-13°F to +140°F)
Permissible storage temperature	From -25°C to +70°C (-13°F to +158°F)
Air pressure (operation)	From 80 kPa to 106 kPa, 2000 m (6562 ft.) above sea level
Air pressure (storage)	From 70 kPa to 106 kPa, 3000 m (9843 ft.) above sea level
Humidity (operation)	100% condensation permissible
Humidity (storage/transport with **unused** interfaces [standard packaging])	75%, permanent (Transport climate category according to EN 60721-3-2 Class 2K2)
For a short period, slight condensation may appear on the outside of the housing if, for example, the module is taken from a vehicle into a closed room.	
Humidity (storage/transport with **used** interfaces (filler plugs on all unused connections)	100%, condensation permissible (Transport climate category according to EN 60721-3-2 Class 2K3)
The requirements of EN 50178 regarding storage and transport are met.	
Degree of protection	IP 65, IP 67 DIN 40050; IEC 60529
Class of protection	Class 3 according to VDE 0106, IEC 60536
Electrical isolation	Test voltage
Bus/FE	500 V AC, 1 min., 50 Hz
FE/inputs	500 V AC, 1 min., 50 Hz

General (continued)	
Processor monitoring	Watchdog circuit
Preferred installation position	Panel mounting
Functional earth ground connection	Via grounded mounting plate

Interface	
INTERBUS interface	INTERBUS Loop cable

Power Consumption	
Supply voltage U_{SL}	24 V DC
Current consumption of U_{SL}	50 mA, typical; 75 mA, maximum
Total power consumption	1.2 W, typical; 1.8 W, maximum

Supply of the Electronics Module and I/Os Through the BK Module	
Connection method	INTERBUS Loop
Current consumption from INTERBUS Loop	50 mA, typical; 75 mA, maximum

Analog Inputs for Resistance Temperature Detectors (RTD) and Thermocouples (TC)	
Number	2
Connecting the RTD sensors	2-, 3-, and 4-wire termination in 2-wire technology
Connecting the TC sensors	2-wire, shielded equalizing conductor for TC with encapsulated sensors
Sensor types that can be used (RTD)	Pt 100, Pt 1000, Ni..., Cu..., KTY, R 8000
Sensor types that can be used (TC)	E, J, K, L, N, R, S, T, U
Standards of characteristic curves for TC sensors	DIN IEC 60584-1: 1984 (E, J, K, N, R, S, T) DIN 43710 (U, L)
Voltage input ranges	-20 mV to +2400 mV and -20 mV to +150 mV
Temperature measuring unit	°C, °F, mV, Ω can be selected
Temperature measuring range (value range)	See table on page 21
Resolution of the measured values	See table on page 16
Measuring principle	Sigma-delta method
Representation of output value	16-bit two's complement, left-justified

Analog Inputs for Resistance Temperature Detectors (RTD) and Thermocouples (TC)	
Process data update of 2 channels (incl. detection and transmission to the process data registers)	
RTD / R 0 Ω to R 8000 Ω (linear)	Normal operation: 100 ms, maximum Cyclical calibration operation: 1.40 s, maximum
TC without cold junction compensation	Normal operation: 200 ms, maximum Cyclical calibration operation: 1.50 s, maximum
TC with cold junction compensation	Normal operation: 250 ms, maximum Cyclical calibration operation: 1.55 s, maximum
Input filter	Digital filter
Limit frequency of the digital filter	22.6 Hz

Error Messages to the Control System	
Failure of the internal I/O supply voltage (+5 V DC)	Yes
Hardware failure	Yes

Additional Diagnostic Messages in the Process Data Words	
Failure of the internal I/O supply voltage (+5 V DC)	Yes
Open circuit per channel	For resistance temperature detectors (RTD) and thermocouples (TC)
Short circuit	For resistance temperature detectors (RTD)

Ordering Data

Description	Order Designation	Order No.
INTERBUS Loop 2 module with two analog temperature input channels on female M12 sensor connectors	IB L2 BOX TEMP 2/2 M12	27 31 92 4
BK module with INTERBUS Loop 2 branch; IP 65 protection	IBS L2 IP 24 BK-T	27 23 47 9
Protective caps (package unit: 5 pcs.) for unused M12 sockets	IBS IP PROT IO	27 59 91 9
M12 connectors for IB L2 ... modules		
Straight version, with PG7/M12	SACC-M12MS-5CON-PG7	16 62 25 6
Angled version, with PG7/M12	SACC-M12MR-5CON-PG7	16 62 26 9
Metal sensor connector, straight version	SACC-M12MS-5CON-PG7-SH	16 93 41 6
Metal sensor connector, angled version	SACC-M12MR-5CON-PG7-SH	16 93 42 9
INTERBUS Loop cable 2 x 1.5 mm^2 (green) with meters marked on the cable	IBSL SLC Cu2/1,5-Meter	27 21 62 0
INTERBUS Loop set consisting of: 50 zack markers SSZB WH and 15 protective caps for M12 sensor sockets	IBSL ZB-SET	27 21 98 9
INTERBUS Loop set consisting of: 10 PG13,5 grommet, compression ring, splice ring, and black cap nut 10 PG11 grommet, compression ring, splice ring, and green cap nut 5 Filler plugs for the actuator supply of DO and DIO modules	IBSL PG-SET	27 21 99 2
For further accessories for the connection to M12 sockets please refer to the Phoenix Contact Catalog Part 2 “PLUSCON”.		
Shield plate (replacement)	IB L2 SHIELD	27 32 41 5
INTERBUS Loop 2 System Manual	IB L2 SYS PRO UM E	27 43 49 1

Description	Order Designation	Order No.
Thermocouple terminals (pair) for the extension of equalizing conductors		
Thermocouple terminals (pair) for CU/CUNI44 Copper/constantan	MTKD-CU/CUNI	31 00 05 9
Thermocouple terminals (pair) for FE/CUNI44 Iron/constantan	MTKD-FE/CUNI	31 00 04 6
Thermocouple terminals (pair) for NICR/CUNI44 Nickelous chrome/constantan	MTKD-NICR/CUNI	31 00 07 5
Thermocouple terminals (pair) for NICR/NI Nickelous chrome/nickel	MTKD-NICR/NI	31 00 06 2
Thermocouple terminals (pair) for E-CU/A-CU Copper/copper nickel	MTKD-E-CU/A-CU	31 00 09 1
Thermocouple terminals (pair) for S-CU/E-CU Copper/constantan	MTKD-S-CU/E-CU	31 00 10 1
SK shield connection terminals for the shielding of the thermocouple extension wire		
SK 8 shield connection terminal block	SK 8	30 25 16 3
SK 14 shield connection terminal block	SK 14	30 25 17 6
SK 20 shield connection terminal block	SK 20	30 25 18 9
Assembled sensor/actuator cable, M12, 4-pos., free cable end on straight connector		
Cable length 1.5 m	SAC-4P-M12MS/1,5-PUR SH	16 82 71 5
Cable length 3.0 m	SAC-4P-M12MS/3,0-PUR SH	16 82 61 8
Cable length 5.0 m	SAC-4P-M12MS/5,0-PUR SH	16 82 64 7
Assembled sensor/actuator cable, M12, 4-pos., free cable end on angled connector		
Cable length 1.5 m	SAC-4P-M12MR/1,5-PUR SH	16 82 87 0
Cable length 3.0 m	SAC-4P-M12MR/3,0-PUR SH	16 82 88 3
Cable length 5.0 m	SAC-4P-M12MR/5,0-PUR SH	16 82 89 6
For further ordering data refer to the IBS SYS PRO UM E Manual (Order No. 27 51 00 1).		