MACX MCR-T-UIREL-UP...

Ex n

SIL IEC 61508 PL EN ISO 13849

Temperature transducer with input for temperature sensors, voltage signals, resistance-type sensors, and potentiometers

Data sheet
104603_en_09

1 Description

The configurable and programmable temperature transducer is designed for operating temperature sensors (RTD and thermocouples), voltage signal and resistance-type sensors as well as potentiometers. The measured values are converted into a linear current or voltage signal.

The temperature transducer is either configured with a standard configuration or with an order-specific configuration in accordance with an order key and is delivered calibrated ready for operation (C versions).

In addition to an analog current and voltage output, the temperature transducer also has three switching outputs. If you are using the device in safety-related applications, relays 2 and 3 are grouped to form one safety-related switching output. The power supply has been designed as a wide range power supply.

The devices can be installed in zone 2 according to the “n” type of protection (IEC/EN 60079-15).

Features such as sensor type, connection technology, measuring range, measuring unit, filter, alarm signal and output range can be configured using the ANALOG-CONF software and a device-specific DTM (Device Type Manager).

WARNING: Explosion hazard

The category 3 device is designed for installation in zone 2 potentially explosive areas. It satisfies the requirements of the following standards. Comprehensive details are to be found in the EU Declaration of Conformity which is enclosed and also available on our website in the latest version:

EN/IEC 60079-0, EN/IEC60079-15

When installing and operating the device, the applicable safety directives (including national safety directives), accident prevention regulations, as well as general technical regulations must be observed.

Make sure you always use the latest documentation.

It can be downloaded at phoenixcontact.net/products.

This document is valid for the products listed in the “Ordering data”.

Features

- Temperature sensors (RTDs and thermocouples), resistance-type sensors, and potentiometers can be used in applications up to SIL 2
- Voltage signals can be used with restrictions in applications up to SIL 2
- Current and voltage output
- Switching output (3 PDT relays)
- Configuration via software (FDT/DTM, ANALOG-CONF) or operator interface (IFS-OP-UNIT)
- Up to SIL 2 according to IEC/EN 61508 on output 4 ... 20 mA
- PL d according to EN ISO 13849-1
- 3-way electrical isolation
- Installation in Ex zone 2 permitted
- Wide range power supply 19.2 ... 253 V AC/DC
- With screw or spring-cage connection (Push-in Technology)

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3 Ordering data

Description	Type	Order No.	Pcs./Pkt.
Freely programmable temperature transducer with analog output and 3 limit value relays, standard configuration, resistance thermometer in 2-, 3-, or 4-wire technology, thermocouples, electrical isolation, wide-range power supply, screw connection, SIL, PL.	MACX MCR-T-UIREL-UP	2811378	1
Freely programmable temperature transducer with analog output and 3 limit value relays, standard configuration, resistance thermometer in 2-, 3-, or 4-wire technology, thermocouples, electrical isolation, wide-range power supply, push-in connection, SIL, PL.	MACX MCR-T-UIREL-UP-SP	2811828	1
Freely programmable temperature transducer with analog output and 3 limit value relays, order configuration, resistance thermometer in 2-, 3-, or 4-wire technology, thermocouples, electrical isolation, wide-range power supply, screw connection, SIL, PL.	MACX MCR-T-UIREL-UP-C	2811514	1
Freely programmable temperature transducer with analog output and 3 limit value relays, order configuration, resistance thermometer in 2-, 3-, or 4-wire technology, thermocouples, electrical isolation, wide-range power supply, push-in connection, SIL, PL.	MACX MCR-T-UIREL-UP-SP-C	2811831	1

Accessories	Type	Order No.	Pcs./Pkt.
The control unit facilitates straightforward parameterization and operation of the MACX MCR(-EX)-...-UI(REL)(-UP) on-site, even without software. With the copying function, other modules can be configured quickly and cost-effectively. Can be snapped onto the 35 mm module.	IFS-OP-UNIT	2811899	1
The adapter (IFS-OP-CRADLE) for the operator interface is ideal for use as a remote operator panel and display device for 17.5 mm/35 mm modules. Can be mounted directly on the DIN rail.	IFS-OP-CRADLE	2811886	1
Programming adapter with USB interface, for programming with software. The USB driver is included in the software solutions for the products to be programmed, such as measuring transducers or motor managers.	IFS-USB-PROG-ADAPTER	2811271	1
Connection terminal block for current signals, +20 mA ... -20 mA, for safe switching of limit values, in combination with MACX ...-T-UI... temperature transducers.	MACX MCR-I20	2905680	1
Plug for cold junction compensation for thermocouples, for safe switching of limit values, in combination with MACX ...-T-UI... temperature transducers.	MACX MCR-CJC	2924993	1
Plastic label, Sheet, white, unlabeled, can be labeled with: BLUEMARK ID COLOR, BLUEMARK ID, BLUEMARK CLED, PLOTMARK, CMS-P1-PLOTTER, mounting type: adhesive, lettering field size: 11 x 9 mm	UC-EMLP (11X9)	0819291	10

Accessories	Type	Order No.	Pcs./Pkt.
Plastic label, can be ordered: by sheet, white, labeled according to customer specifications, mounting type: adhesive, lettering field size: 11 x 9 mm	UC-EMLP (11X9) CUS	0824547	1
Plastic label, Sheet, yellow, unlabeled, can be labeled with: BLUEMARK ID COLOR, BLUEMARK ID, BLUEMARK CLED, PLOTMARK, CMS-P1-PLOTTER, mounting type: adhesive, lettering field size: 11 x 9 mm	UC-EMLP (11X9) YE	0822602	10
Plastic label, can be ordered: by sheet, yellow, labeled according to customer specifications, mounting type: adhesive, lettering field size: 11 x 9 mm	UC-EMLP (11X9) YE CUS	0824548	1
Plastic label, Sheet, silver, unlabeled, can be labeled with: BLUEMARK ID COLOR, BLUEMARK ID, BLUEMARK CLED, PLOTMARK, CMS-P1-PLOTTER, mounting type: adhesive, lettering field size: 11 x 9 mm	UC-EMLP (11X9) SR	0828094	10
Plastic label, can be ordered: by sheet, silver, labeled according to customer specifications, mounting type: adhesive, lettering field size: 11 x 9 mm	UC-EMLP (11X9) SR CUS	0828098	1
Plastic label, Card, white, unlabeled, can be labeled with: BLUEMARK ID COLOR, BLUEMARK ID, THERMOMARK PRIME, THERMOMARK CARD 2.0, THERMOMARK CARD, mounting type: adhesive, lettering field size: 11 x 9 mm	US-EMLP (11X9)	0828789	10
Plastic label, Card, yellow, unlabeled, can be labeled with: BLUEMARK ID COLOR, BLUEMARK ID, THERMOMARK PRIME, THERMOMARK CARD 2.0, THERMOMARK CARD, mounting type: adhesive, lettering field size: 11 x 9 mm	US-EMLP (11X9) YE	0828871	10
Plastic label, Card, silver, unlabeled, can be labeled with: BLUEMARK ID COLOR, BLUEMARK ID, THERMOMARK PRIME, THERMOMARK CARD 2.0, THERMOMARK CARD, mounting type: adhesive, lettering field size: 11 x 9 mm	US-EMLP (11X9) SR	0828872	10
Device marker, Sheet, white, unlabeled, can be labeled with: TOPMARK NEO, TOPMARK LASER, mounting type: adhesive, lettering field size: 11 x 9 mm	LS-EMLP (11X9) WH	0831678	10
Device marker, Sheet, yellow, unlabeled, can be labeled with: TOPMARK NEO, TOPMARK LASER, mounting type: adhesive, lettering field size: 11 x 9 mm	LS-EMLP (11X9) YE	0831732	10
Device marker, Sheet, silver, unlabeled, can be labeled with: TOPMARK NEO, TOPMARK LASER, mounting type: adhesive, lettering field size: 11 x 9 mm	LS-EMLP (11X9) SR	0831705	10
Test plugs, with solder connection up to 1 mm^2 conductor cross section, color: gray	MPS-MT	0201744	10
Insulating sleeve, color: black	MPS-IH BK	0201731	10
Insulating sleeve, color: gray	MPS-IH GY	0201728	10
Insulating sleeve, color: green	MPS-IH GN	0201702	10
Insulating sleeve, color: yellow	MPS-IH YE	0201692	10

Accessories	Type	Order No.	Pcs./Pkt.
Insulating sleeve, color: blue	MPS-IH BU	0201689	10
Insulating sleeve, color: red	MPS-IH RD	0201676	10
Insulating sleeve, color: white	MPS-IH WH	0201663	10

4 Technical data

Input data	
Sensor types (RTD) that can be used	Pt, Ni, Cu sensors: 2, 3, 4-wire
Sensor types that can be used (TC)	B, E, J, K, N, R, S, T, L, U, CA, DA, A1G, A2G, A3G, MG, LG
Potentiometer	0 Ω ... 50 kΩ
Voltage	-1000 mV ... 1000 mV

Output	
Switching output	Relay output
Configurable/programmable	Yes
Contact type	3 PDTs
Contact material	$AgSnO_2$, hard gold-plated
Maximum switching voltage	250 V AC (250 V DC)
Maximum inrush current	2 A (250 V AC) 2 A (28 V DC)
Configurable/programmable	Yes
Output signal maximum voltage	± 11 V
Current output signal	4 mA ... 20 mA (in the case of SIL; further free configuration without SIL)
Output signal maximum current	22 mA
Load/output load voltage output	≥ 10 kΩ
Load/output load current output	≤ 600 Ω (at 20 mA)
Behavior in the event of a sensor error	according to NE 43 or freely configurable

General data	
Supply voltage range	24 V ... 230 V AC/DC (-20 %/+10 %, 50/60 Hz)
Power consumption	< 2.4 W
Maximum transmission error	0.1 % (e.g. for Pt 100, 300 K span, 4 ... 20 mA)
Maximum temperature coefficient	0.01 %/K
Electrical isolation	4-way, between input/output/power supply/switching output
Flammability rating according to UL 94	V0
Overvoltage category	II
Degree of pollution	2
Dimensions W/H/D	35 mm / 112,5 mm / 114.5 mm (MACX MCR-T-UIREL-UP) 35 mm / 116 mm / 114.5 mm (MACX MCR-T-UIREL-UP-SP)
Type of housing	PA 6.6-FR grey

Ambient conditions	
Ambient temperature (operation)	-20 °C ... 65 °C
Ambient temperature (storage/transport)	-40 °C ... 85 °C
Permissible humidity (operation)	typ. 5 % ... 95 % (non-condensing)
Maximum altitude for use above sea level	≤ 2000 m

Electrical isolation	
Input/output/power supply Rated insulation voltage (overvoltage category II; degree of pollution 2, safe isolation as per EN 61010-1) 50 Hz, 1 min., test voltage	 300 V_{rms} 2.5 kV
Input/output Peak value in accordance with EN 60079-11	 375 V
Input/power supply Peak value in accordance with EN 60079-11	 375 V
Input/switching output Peak value in accordance with EN 60079-11	 375 V

Connection data	Screw connection	Push-in connection
Conductor cross section, solid	0.2 mm^2 ... 2.5 mm^2	0.2 mm^2 ... 1.5 mm^2
Conductor cross section, flexible	0.2 mm^2 ... 2.5 mm^2	0.2 mm^2 ... 1.5 mm^2
Conductor cross section AWG	24 ... 14	24 ... 16
Stripping length	7 mm	8 mm

Conformance with EMC directive
Noise immunity according to EN 61000-6-2 When being exposed to interference, there may be minimal deviations.
Noise emission according to EN 61000-6-4

Conformance/Approvals	
Conformance	CE-compliant
ATEX (IBExU 10 ATEX B001 X)	Ex II 3 G Ex nA nC ic IIC T4 Gc X
IECEx (IECEx IBE 10.0011 X)	Ex nA nC ic IIC T4 Gc X
UL	UL 508 Listed Class I, Div. 2, Groups A, B, C, D T6 Class I, Zone 2, Group IIC T6
Shipbuilding (DNV GL TAA000020C) Temperature Humidity Vibration EMC Enclosure	 B B A A Required protection according to the Rules shall be provided upon installation on board
Safety Integrity Level (SIL)	to 2
Performance level according to ISO 13849	PLd

5 Safety regulations and installation notes

5.1 Content of the EU Declaration of Conformity

Manufacturer: PHOENIX CONTACT GmbH & Co.KG, Flachsmarktstr.8, 32825 Blomberg, Germany

Product designation:	Order No.:
MACX MCR-T-UIREL-UP	2811378
MACX MCR-T-UIREL-UP-SP	2811828
MACX MCR-T-UIREL-UP-C	2811514
MACX MCR-T-UIREL-UP-SP-C	2811831

The above mentioned product conforms with the most important requirements of the following directive(s) and their modification directives:

2006/42/EC	Machinery Directive
2011/65/EU	RoHS directive
2014/30/EU	Electromagnetic Compatibility Directive (EMC)
2014/34/EU	ATEX Directive

5.2 Safety notes

- Observe the safety regulations of electrical engineering and industrial safety and liability associations.
- Disregarding these safety regulations may result in death, serious personal injury or damage to equipment.
- The device must be operated in a closed control cabinet!
- Before working on the device, disconnect the power.
- During operation, parts of electrical switching devices carry hazardous voltages.
- In the event of an error, replace the device.
- Keep the product documentation in a safe place.

5.3 Installation notes

- The category 3 device is designed for installation in zone 2 potentially explosive areas. It satisfies the requirements of the following standards. Comprehensive details are to be found in the EU Declaration of Conformity which is enclosed and also available on our website in the latest version:
  EN/IEC 60079-0, EN/IEC60079-15
- Installation, operation, and maintenance may only be carried out by qualified electricians. Follow the installation instructions as described. When installing and operating the device, the applicable regulations and safety directives (including national safety directives), as well as the general codes of practice, must be observed. The safety-related data is provided in the packing slip and on the certificates (conformity assessment, additional approvals where applicable).
- Do not open or modify the device. Do not repair the device yourself; replace it with an equivalent device instead. Repairs may only be carried out by the manufacturer. The manufacturer is not liable for damage resulting from noncompliance.
- The IP20 degree of protection (IEC 60529/EN 60529) of the device is intended for use in a clean and dry environment. Do not subject the device to mechanical and/or thermal loads that exceed the specified limits.
- The device is not designed for use in potentially dust-explosive atmospheres. If dust is present, installation must take place in a suitable and approved housing (at least IP54) that meets the requirements of EN 60079-31. The specified surface temperature of the housing must be observed.
- Only specified devices from Phoenix Contact may be connected to the 12-pos. S-PORT interface.
- The device complies with the EMC regulations for industrial areas (EMC class A). When used in residential areas, the device may cause radio interference.
- The device must be stopped if it is damaged, has been subjected to an impermissible load, stored incorrectly, or if it malfunctions.

5.4 Installation in zone 2

- Observe the specified conditions for use in potentially explosive areas! Install the device in a suitable approved housing that meets the requirements of IEC/EN 60079-15 and has IP54 protection at the minimum. Also observe the requirements of IEC/EN 60079-14.
- Only devices which are designed for operation in Ex zone 2 and are suitable for the conditions at the installation location may be connected to the circuits in zone 2.
- In zone 2, non-intrinsically safe cables may only be connected or disconnected when the power is switched off.
- The device has to be stopped and immediately removed from the Ex area if it is damaged, was subjected to an impermissible load, stored incorrectly, or if it malfunctions.
- Temporary malfunctions (transients) must not exceed 497 V (355 V x 1.4).

5.5 Installation in zone 22

- The device is not suitable for installation in zone 22.
- If, however, you wish to use the device in zone 22, it must be installed in a housing that complies with IEC/EN 60079-31. In doing so, observe the maximum surface temperatures. Observe the requirements of IEC/EN 60079-14.

5.6 Use in safety-related applications (SIL, PL)

When using the device in safety-related applications, observe the instructions in the appendix, as the requirements differ for safety-related functions.

Switching output 1 is not intended for safety-related applications.

In safety-related applications (SIL), switching outputs 2 and 3 must be combined according to the requirements of the application (see “Connection examples” on page 31).

The configuration of switching output 2 is also applied to switching output 3.

In SIL ON mode, switching output 3 cannot be configured separately.

Please observe the restrictions in Appendix 1 “Safety-related applications (SIL 2)” Section 1.6 “Functional restrictions” when using the mV input in safety applications up to SIL 2.

WARNING: Danger of death!

It is possible to set SIL ON or SIL OFF in the configuration tools. Applications according to the Machinery directive (EN ISO 13849-1) only permit the SIL ON mode. Another mode means danger of death and is not permitted.

5.7 UL note

The safety specifications, which are based on UL approval, can be found in the “Control Drawing”. The “Control Drawing” is part of the package slip.

6 Sensor types

Description	Sensor type	Measuring range		Measuring unit	Smallest measuring range span
		Start	End		
Resistance temperature detector (RTD) Others can be selected or freely configured in the software.	Pt 100 according to IEC/EN 60751	-200	850	°C	20 K
	Pt 200 according to IEC/EN 60751	-200	850	°C	20 K
	Pt 500 according to IEC/EN 60751	-200	850	°C	20 K
	Pt 1000 according to IEC/EN 60751	-200	850	°C	20 K
	Pt 100 according to Sama RC21-4-1966	-200	850	°C	20 K
	Pt 1000 according to Sama RC21-4-1966	-200	850	°C	20 K
	Pt 100 according to GOST 6651	-200	850	°C	20 K
	Pt 1000 according to GOST 6651	-200	850	°C	20 K
	Pt 100 according to JIS C1604/1997	-200	850	°C	20 K
	Pt 1000 according to JIS C1604/1997	-200	850	°C	20 K
	Ni 100 according to DIN 43760/DIN IEC 60751	-60	250	°C	20 K
	Ni 1000 according to DIN 43760/DIN IEC 60751	-60	250	°C	20 K
	Ni 100 according to Sama RC21-4-1966	-60	180	°C	20 K
	Ni 1000 according to Sama RC21-4-1966	-60	180	°C	20 K
	Ni 1000 (Landis & Gyr)	-50	160	°C	20 K
	Cu 10 according to Sama RC21-4-1966	-70	500	°C	100 K
	Cu 50/Cu 100 according to GOST 6651 (α = 1.428)	-50	200	°C	100 K
	Cu 53 according to GOST 6651 (α = 1.426)	-50	180	°C	100 K
	KTY81-110 (Philips)	-55	150	°C	20 K
	KTY84-130 (Philips)	-40	300	°C	20 K
Thermocouples (TC) Others can be selected in the software.	B according to IEC/EN 60584 (Pt30Rh-Pt6Rh)	500	1820	°C	50 K
	E according to IEC/EN 60584 (NiCr-CuNi)	-230	1000	°C	50 K
	J according to IEC/EN 60584 (Fe-CuNi)	-210	1200	°C	50 K
	K according to IEC/EN 60584 (NiCr-Ni)	-250	1372	°C	50 K
	N according to IEC/EN 60584 (NiCrSi-NiSi)	-250	1300	°C	50 K
	R according to IEC/EN 60584 (Pt13Rh-Pt)	-50	1768	°C	50 K
	S according to IEC/EN 60584 (Pt10Rh-Pt)	-50	1768	°C	50 K
	T according to IEC/EN 60584 (Cu-CuNi)	-200	400	°C	50 K
	L according to DIN 43760 (Fe-CuNi)	-200	900	°C	50 K
	U according to DIN 43760 (Cu-CuNi)	-200	600	°C	50 K
	CA C ASTM JE988 (2002)	0	2315	°C	50 K
	DA D ASTM JE988 (2002)	0	2315	°C	50 K
	A1G A-1 GOST 8.585-2001	0	2500	°C	50 K
	A2G A-2 GOST 8.585-2001	0	1800	°C	50 K
	A3G A-3 GOST 8.585-2001	0	1800	°C	50 K
	MG M GOST 8.585-2001	-200	100	°C	50 K
	LG L GOST 8.585-2001	-200	800	°C	50 K
Resistance-type sensors (R) (2, 3, 4-wire) Other areas can be selected in the software.	Resistance 0 ... 50000 Ω	0	50000	Ω	10% of the selected measuring range
Potentiometers (3-wire) Other areas can be selected in the software.	Potentiometer: 0 … 50000 Ω	0	100	%	10% of the selected measuring range
Voltage signals (mV) Others can be selected in the software.	Voltage (mV)	-1000	+1000	mV	10% of nominal span

Description	Sensor type	Measuring range		Measuring unit	Smallest measuring range span
		Start	End		
	Temperature conversion guide for °C to °F:	$T[°F] = \frac{9}{5} T[°C] + 32$			
Other setting options can be configured using the ANALOG-CONF software, e.g., a freely configurable user characteristic curve with 30 interpolation points.					

Depending on the connection technology, the following terminal points are to be connected for temperature measurement (see Figure 2 on page 18).

6.1 Thermocouple (TC) with internal cold junction compensation

– Thermocouple connection: terminals 4.1 “+”, 4.2 “-”

Use the MACX MCR-CJC cold junction compensation connector provided (Order No. 2924993).

TC + CJ: use the cold junction compensation connector provided at connection terminal blocks 4.1, 4.2, and 4.3.

6.2 Thermocouple (TC) with external or without cold junction compensation

– Thermocouple connection: terminals 5.1 “+”, 5.2 “-”

TC + CJ external: use the external cold junction sensor (e.g., Pt 100) at connection terminal blocks 4.2 and 4.3.

6.3 Voltage input

– Connection for U ≤ ±1000 mV: terminals 5.1 “+“, 5.2 “-“

6.4 Potentiometer

– Connection: terminals 4.1, 4.2, 4.3

6.5 Resistance temperature detector (RTD)

RL ≤ 25 Ω for each lead.

– 2-wire connection technology: terminals 4.2, 4.3
  The cable resistance can be compensated with the help of the ANALOG-CONF PC program, the IFS-OP-UNIT operator interface or in service mode (DIP switch).
– 3-wire connection technology: terminals 4.1, 4.2, 4.3
  In the case of 3-wire connection technology, ensure that all three cables have the same resistance.
– 4-wire connection technology: terminals 4.2, 4.3, 5.1, 5.2
– 2 x 2-wire connection technology
  RTD 1 terminals: 4.2, 4.3
  RTD 2 terminals: 5.1, 5.2

6.6 Resistance measurement

Up to 75 Ω: RL ≤ 2.5 Ω for each lead.
Up to 150 Ω: RL ≤ 5 Ω for each lead.
Up to 300 Ω: RL ≤ 10 Ω for each lead.

Terminal points 4.2 and 4.3 are used for measuring differing resistances.

6.7 Notes on using thermocouples

Thermocouples consist of two conductors connected to each other on one side. The conductors consisting of different metals with different thermoelectric properties are exposed to a temperature gradient and, therefore, will convert heat flow to electrical voltage. Electrical voltage is measured at both thermocouple connections.

6.7.1 Cold junction compensation

In a thermocouple, however, voltage will not only be generated at the contact point of the connected conductors, but also at both connection points of the measuring transducer, as each of these points together with the connected thermocouple cable will form another thermocouple.

In order to be able to calculate the absolute measurement point temperature value from this voltage difference, and thus also the temperature difference, the temperature of the connection points must be the same and known.

For this purpose, the connection points are artificially maintained at a known temperature: for laboratory measurements, for example, at 0°C using ice water, in industrial applications by thermostatically controlled heating and cooling.

When considering the connection point temperature, this is referred to as cold junction compensation.

Cold junction compensation can also be implemented with a separate temperature measurement at the connection points.

Interface modules are available for the connection of thermocouples, in which cold junction compensation is already integrated. Interface modules of this type are also signal transformers with cable connections to the evaluation unit.

Thermocouples are often referred to with the abbreviation TC.

> Thermocouples are suitable for high temperatures or large temperature ranges.
>
> Resistance temperature detectors are more suitable for temperatures up to a maximum of 800°C.

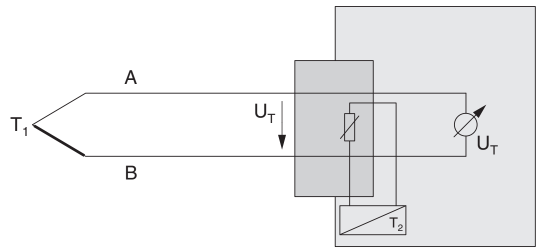


Figure 1 Thermocouple and interface module at the sensor including cold junction compensation

- T_1 Temperature at the measurement point
- T_2 Temperature at the connection point
- U_T Voltage generated between the measurement point and the connection point. Indicates the absolute temperature T_1 at the measurement point by considering the connection point temperature T_2.

6.7.2 Thermocouple types

Type	Standard	Temperature range [°C]	IEC color code
B	IEC 584	+500 ... +1820	Not defined
E	IEC 584	-230 ... +1000	Purple
J	IEC 584	-210 ... +1200	Black
K	IEC 584	-250 ... +1372	Green
N	IEC 584	-200 ... +1300	Pink
R	IEC 584	-50 ... +1768	Orange
S	IEC 584	-50 ... +1768	Not defined
T	IEC 584	-200 ... +400	Brown
L	DIN 43710	-200 ... +900	-
U	DIN 43710	-200 ... +600	-
A-1	GOST 8.585	0 ...+2500	-
A-2	GOST 8.585	0 ...+1800	-
A-3	GOST 8.585	0 ...+1800	-
M	GOST 8.585	-200 ... +100	-
L	GOST 8.585	-200 ... +800	-

7 Minimum spans and measuring accuracy

7.1 Input for Pt RTDs and Ni RTDs

Minimum measuring span:

For 10 Ω ≤ R_0 < 100 Ω: 100 K

For 100 Ω ≤ R_0 ≤ 10 kΩ: 20 K

R_0 is the resistance value of the sensor at 0°C.

Measuring accuracy:

For 10 Ω ≤ R_0 < 100 Ω: **0.2 K x 100 Ω / R_0**

= 0.1% x (100 Ω / R_0) x (200 K / measuring span)

For 100 Ω ≤ R_0 ≤ 1 kΩ: **0.2 K**

= 0.1% x (200 K / measuring span)

For 1 kΩ < R_0 ≤ 10 kΩ: **0.4 K**

= 0.1% x (400 K / measuring span)

7.2 Input for Cu RTDs

Minimum measuring span:

For 10 Ω ≤ R_0 < 100 Ω: 100 K

For 100 Ω ≤ R_0 ≤ 10 kΩ: 20 K

Measuring accuracy:

For 10 Ω ≤ R_0 < 100 Ω: **0.5 K x 100 Ω / R_0**

= 0.1% x (100 Ω / R_0) x (500 K / measuring span)

For 100 Ω ≤ R_0 ≤ 1 kΩ: **0.5 K**

= 0.1% x (500 K / measuring span)

For 1 kΩ < R_0 ≤ 10 kΩ: **1.0 K**

= 0.1% x (1000 K / measuring span)

7.3 Input for Ni 1000 (Landis & Gyr), KTY 81-110, KTY 84-130 (Philips)

Minimum measuring span: 20 K

Measuring accuracy: 0.2 K

7.4 Input for thermocouples

Minimum measuring span with TC: 50 K

Measuring accuracy of the input with TC signals:

TC type E, J, K, N, T, L, U, M, Lr

Without cold junction error: 0.30 K

TC type B, R, S, C, D, A1, A2, A3

Without cold junction error: 0.50 K

7.5 Cold junction error

Cold junction error: ±1 K, maximum

(for internal cold junction compensation)

For external compensation it depends on the quality of the cold junction and the sensor used.

7.6 Input for voltage signals

Minimum measuring span:

10% of the nominal span of the respective range.

Measuring accuracy:

-1000	...	1000 mV	: 0.01%	(of the measuring range)
-500	...	500 mV	: 0.01%	(of the measuring range)
-250	...	250 mV	: 0.01%	(of the measuring range)
-125	...	125 mV	: 0.01%	(of the measuring range)
-60	...	60 mV	: 0.01%	(of the measuring range)
-30	...	30 mV	: 0.01%	(of the measuring range)
-15	...	15 mV	: 0.01%	(of the measuring range)

7.7 Resistance-type sensors and resistors

50% of measuring range ≤ (nominal value of resistance-type sensor + lead resistance) ≤ measuring range

Minimum measuring span: 10% of the selected measuring range

Measuring accuracy:

0	...	75 Ω	: 0.10%	(of the measuring range)
0	...	150 Ω	: 0.05%	(of the measuring range)
0	...	300 Ω	: 0.02%	(of the measuring range)
0	...	600 Ω	: 0.01%	(of the measuring range)
0	...	1200 Ω	: 0.01%	(of the measuring range)
0	...	2400 Ω	: 0.01%	(of the measuring range)
0	...	4800 Ω	: 0.01%	(of the measuring range)
0	...	6250 Ω	: 0.02%	(of the measuring range)
0	...	12500 Ω	: 0.02%	(of the measuring range)
0	...	25000 Ω	: 0.02%	(of the measuring range)
0	...	50000 Ω	: 0.02%	(of the measuring range)

Example:

Resistance-type sensor with nominal value: 1000 Ω

Measuring range to be selected: 0 ... 1200 Ω

Minimum measuring span: 10% of the selected measuring range = 120 Ω

Measuring accuracy: 0.01% of the selected measuring range = 120 mΩ

7.8 Potentiometers

50% of measuring range ≤ (nominal value of potentiometer + lead resistance) ≤ measuring range

Minimum measuring span: 10% of the selected measuring range

Measuring accuracy:

0 ... 75 Ω	: 0.10%	(of the measuring range)
0 ... 150 Ω	: 0.05%	(of the measuring range)
0 ... 300 Ω	: 0.02%	(of the measuring range)
0 ... 600 Ω	: 0.02%	(of the measuring range)
0 ... 1200 Ω	: 0.02%	(of the measuring range)
0 ... 2400 Ω	: 0.02%	(of the measuring range)
0 ... 4800 Ω	: 0.02%	(of the measuring range)
0 ... 6250 Ω	: 0.10%	(of the measuring range)
0 ... 12500 Ω	: 0.10%	(of the measuring range)
0 ... 25000 Ω	: 0.10%	(of the measuring range)
0 ... 50000 Ω	: 0.10%	(of the measuring range)

Example:

Potentiometer with nominal value: 1000 Ω

Measuring range to be selected: 0 ... 1200 Ω

Minimum measuring span: 10% of the selected measuring range = 120 Ω

Measuring accuracy: 0.02% of the selected measuring range = 240 mΩ

7.9 Output signals

Error at analog output:

2 mV	0.01% at -10 ... 10 V
2 mV	0.02% at 0 ... 10 V
4 µA	0.02% at 0 ... 20 mA

8 Installation

8.1 Connection notes

WARNING: Electrical danger due to improper installation

Observe the connection notes for safe installation in accordance with EN/UL 61010-1:

- Provide a switch/circuit breaker close to the device that is labeled as the disconnect device for this device (or the entire control cabinet).
- Provide for a overcurrent protection device (I ≤ 16 A) in the installation.
- To protect the device against mechanical or electrical damage, install it in a suitable housing with appropriate degree of protection as per IEC 60529.
- During installation, servicing, and maintenance work, disconnect the device from all effective power sources, provided you are not dealing with SELV or PELV circuits.
- If the device is not used as described in the documentation, the intended protection can be negatively affected.
- Thanks to its housing, the device has basic insulation to the neighboring devices, for 300 Veff. If several devices are installed next to each other, this has to be taken into account, and additional insulation has to be installed if necessary! If the neighboring device is equipped with basic insulation, no additional insulation is necessary.
- The voltages applied to the input, output, and power supply are extra-low voltages (ELV). Depending on the application, hazardous contact voltage (>30 V AC/ >60 V DC) to ground may occur. Safe electrical isolation from the other connections exists for this case.

8.2 Electrostatic discharge

NOTE: Electrostatic discharge

The device contains components that can be damaged or destroyed by electrostatic discharge. When handling the device, observe the necessary safety precautions against electrostatic discharge (ESD) according to IEC/EN 61340–5–1.

8.3 Basic circuit diagrams

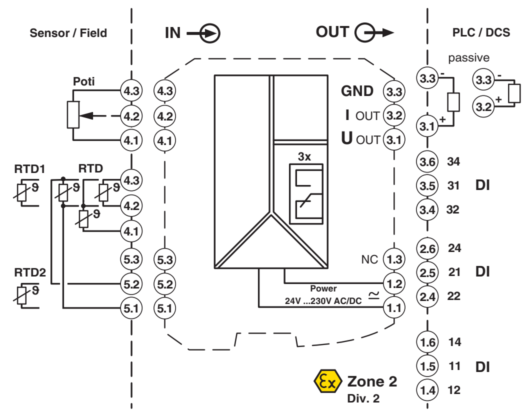


Figure 2 Sensor connection - resistance temperature detectors and potentiometers

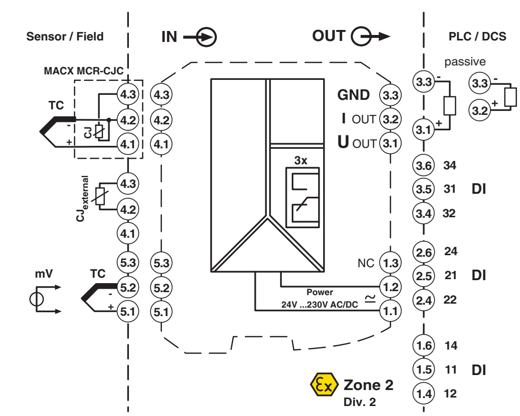


Figure 3 Sensor connection - thermocouples and mV sources

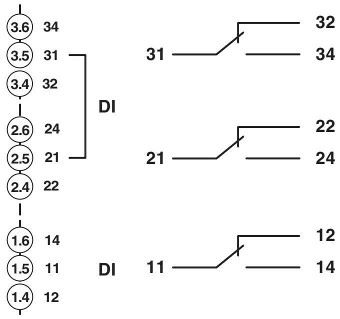


Figure 4 Connection designation for the changeover contacts

> Notes for safety-related applications (SIL/PL):
> The relays must be bridged in parallel to obtain an N/C contact (see "Connection example 2:" on page 31).
> The relays must be bridged in series to obtain an N/O contact (see "Connection example 1:" on page 31 and "Connection example 4:" on page 31).

8.4 Structure

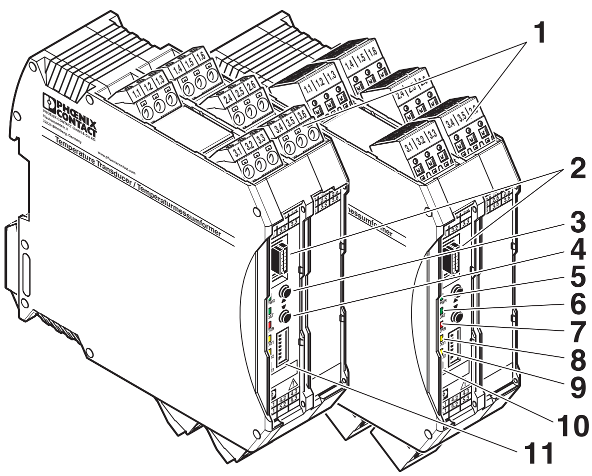


Figure 5 MACX MCR-T-UIREL-UP(-SP)

1. **1** COMBICON plug-in, screw, or push-in spring connection terminal
2. **2** S-PORT (12-pos. programming interface)
3. **3** Button S3 (UP), adjustment and reset functions
4. **4** Button S2 (DOWN), adjustment and reset functions
5. **5** PWR LED, green, power supply
6. **6** DAT LED, green, no function at present
7. **7** ERR LED, red
   on: module error
   1.2 Hz flashing: service mode
   2.4 Hz flashing: line error
8. **8** DO1 LED, yellow, status of switching output 1
9. **9** DO2 LED, yellow, status of switching output 2
10. **10** DO3 LED, yellow, status of switching output 3
11. **11** DIP switch S1 for service mode

8.5 Dimensions

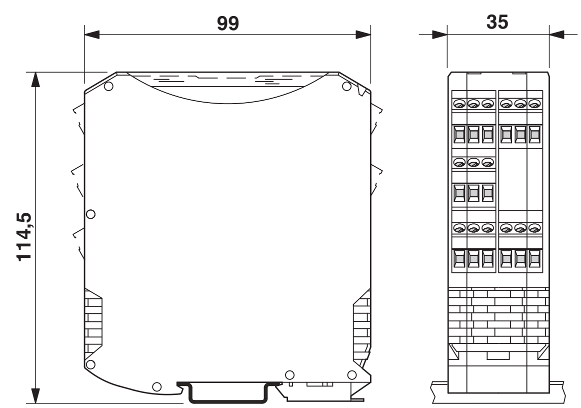


Figure 6 Dimensions (in mm)

8.6 Mounting

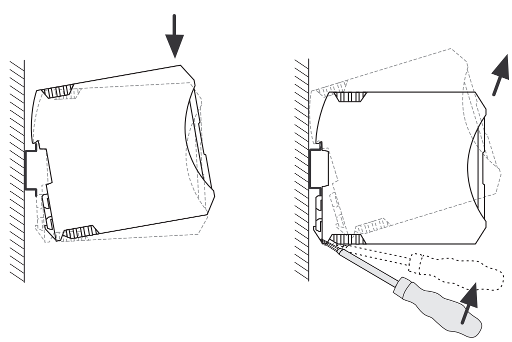


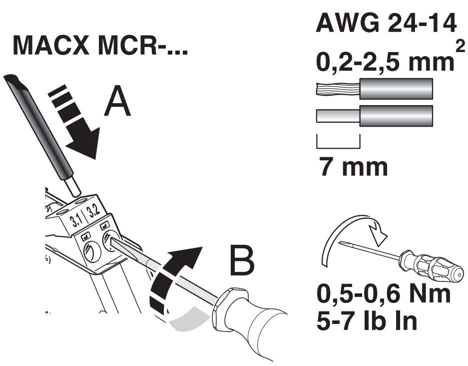
Figure 7 Mounting and removal

- Mount the module on a 35 mm DIN rail according to EN 60715.
- Install the module in suitable housing to meet the requirements for the protection class.
- Before startup, check that the MACX MCR-T-UIREL-UP... is operating and wired correctly.

8.7 Connection of the cables

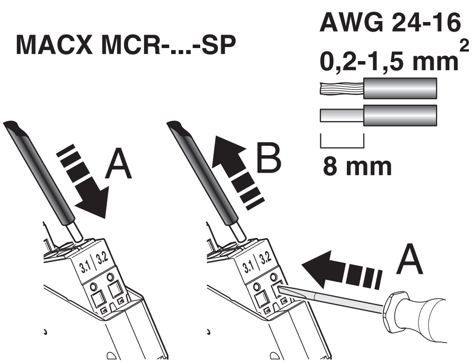
– Screw terminal blocks (for MACX MCR-T-UIREL-UP); fit the litz wires with ferrules.
  Permissible cable cross-section: 0.2 mm^2 ... 2.5 mm^2
– Spring-cage terminal blocks (for MACX MCR-T-UIREL-UP-SP); fit the litz wires with ferrules.
  Permissible cable cross-section: 0.2 mm^2 ... 1.5 mm^2
– Install intrinsically safe and non-intrinsically safe cables separately.

Screw connection:



- Insert the conductor into the corresponding connection terminal block.
- Use a screwdriver to tighten the screw in the opening above the connection terminal block.

Spring-cage connection:



- Insert the conductor into the corresponding connection terminal block.

8.8 Power supply

The power supply has been designed as a wide range power supply (19.2 ... 253 V AC/DC). The module is supplied with voltage via connection terminal blocks 1.1 and 1.2.

8.9 Current output

The current output can be freely configured between 0 ... 20 mA. The minimum span is 4 mA. In safety-related applications (SIL = ON), the output is fixed at 4 ... 20 mA.

– Connection: terminals 3.2 “+”, 3.3 “-”

Insert a wire jumper at the terminals of the current output (terminals 3.2 and 3.3) when not using the current output. Otherwise, the module will detect an open circuit and switch to the safe state (relays drop out).

8.10 Voltage output

The voltage output cannot be used for safety-related applications (SIL = ON).

The voltage output can be freely configured between -10 ... +10 V. The minimum span is 2 V.

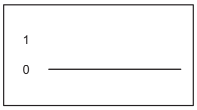
– Connection: terminals 3.2 “+”, 3.3 “-”

8.11 Switching output

The three switching outputs provide a changeover contact each. The switching output behavior can be selected independent of one other. Switching points SPL[1] and SPH[2] can be configured across the entire sensor range:

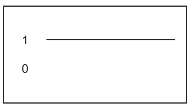
Switching behavior of the switching output

Switching behavior 0



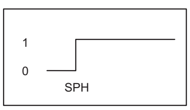
Switching output is permanently dropped.

Switching behavior 1



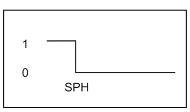
Switching output is permanently picked up.

Switching behavior 2



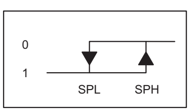
Switching output picks up when SPH[2] is exceeded.

Switching behavior 3



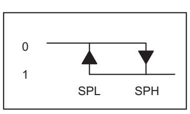
Switching output drops out when SPH[2] is underrange.

Switching behavior 4



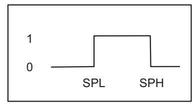
Switching output picks up when SPH[2] is exceeded and drops out when SPL[1] is underrange (hysteresis).

Switching behavior 5



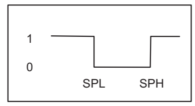
Switching output drops out when SPL[2] is exceeded and picks up when SPH[1] is underrange (hysteresis).

Switching behavior 6



Switching output picks up between SPL[1] and SPH[2].

Switching behavior 7



Switching output drops out between SPL[1] and SPH[2].

[1] SPL = Set Point Low (lower switching point)

[2] SPH = Set Point High (upper switching point)

Switching output 1 is not intended for safety-related applications.

In SIL ON mode, switching output 1 is available as simple signal contact. Switching output 2 in combination with switching output 3 is used for safety-related limit values.

In safety-related applications (SIL), switching outputs 2 and 3 must be combined according to the requirements of the application (see application examples).

The configuration of switching output 2 is also applied to switching output 3.

In SIL ON mode, switching output 3 cannot be configured separately.

If only the switching outputs are to be used, the current output (connection terminals 3.2 and 3.3) must be short circuited or subjected to a load.

Otherwise, the device switches to the safe state if line fault detection is activated.

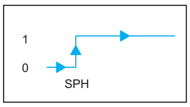
When using the mV input in applications up to SIL 2, only a limited scope of functions is available. Switching behaviors 0, 2, 4, 6 only can be used with restrictions (see Appendix 1 “Safety-related applications (SIL 2)” Section 1.6 “Functional restrictions”).

8.12 Switching output behavior with manual acknowledgement (latching)

Latching: no automatic restart after exceeding the limit value (SPH: Set Point High) or falling below the limit value (SPL: Set Point Low).

Disable the “Restart after fail safe” option in the configuration software.

8.12.1 Switching behavior (2): undertemperature limit (≤SPH)



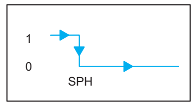
Normal operating state >SPH

Step	Measure	
1	Measured value	>SPH, and module is activated
2	Relay	ON
3	Measured value	≤SPH
4	Relay	OFF
5	Measured value	>SPH
6	Relay	Remains OFF (latches) until delay time has elapsed and is then acknowledged manually
	Acknowledgement is only possible if there is no critical state anymore and the delay time has elapsed.	

Critical operating state ≤SPH

Step	Measure	
1	Measured value	≤SPH, and module is activated
2	Relay	OFF
3	Measured value	>SPH
4	Relay	Remains OFF (latches) until delay time has elapsed and is then acknowledged manually
	Acknowledgement is only possible if there is no critical state anymore and the delay time has elapsed.	

8.12.2 Switching behavior (3): overtemperature limit (≥SPH)



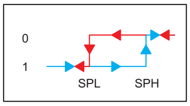
Normal operating state <SPH

Step	Measure	
1	Measured value	<SPH, and module is activated
2	Relay	ON
3	Measured value	≥SPH
4	Relay	OFF
5	Measured value	<SPH
6	Relay	Remains OFF (latches) until delay time has elapsed and is then acknowledged manually
	Acknowledgement is only possible if there is no critical state anymore and the delay time has elapsed.	

Critical operating state ≥SPH

Step	Measure	
1	Measured value	≥SPH, and module is activated
2	Relay	OFF
3	Measured value	<SPH
4	Relay	Remains OFF (latches) until delay time has elapsed and is then acknowledged manually
	Acknowledgement is only possible if there is no critical state anymore and the delay time has elapsed.	

8.12.3 Switching behavior (4): undertemperature limit with hysteresis (≤SPL)



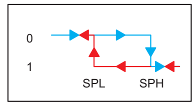
Normal operating state >SPL

Step	Measure	
1	Measured value	>SPL, and module is activated
2	Relay	ON
3	Measured value	≤SPL
4	Relay	OFF
5	Measured value	>SPH
6	Relay	Remains OFF (latches) until delay time has elapsed and is then acknowledged manually Acknowledgement is only possible if there is no critical state anymore and the delay time has elapsed.

Critical operating state ≤SPL

Step	Measure	
1	Measured value	≤SPL, and module is activated
2	Relay	OFF
3	Measured value	>SPH
4	Relay	Remains OFF (latches) until delay time has elapsed and is then acknowledged manually Acknowledgement is only possible if there is no critical state anymore and the delay time has elapsed.

8.12.4 Switching behavior (5): overtemperature limit with hysteresis (≥SPH)



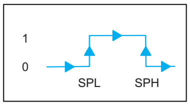
Normal operating state <SPH

Step	Measure	
1	Measured value	<SPH, and module is activated
2	Relay	ON
3	Measured value	≥SPH
4	Relay	OFF
5	Measured value	<SPL
6	Relay	Remains OFF (latches) until delay time has elapsed and is then acknowledged manually Acknowledgement is only possible if there is no critical state anymore and the delay time has elapsed.

Critical operating state ≥SPH

Step	Measure	
1	Measured value	≥SPH, and module is activated
2	Relay	OFF
3	Measured value	<SPL
4	Relay	Remains OFF (latches) until delay time has elapsed and is then acknowledged manually Acknowledgement is only possible if there is no critical state anymore and the delay time has elapsed.

8.12.5 Switching behavior (6): temperature range limit (≤SPL and ≥SPH)



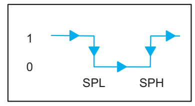
Normal operating state >SPL and <SPH

Step	Measure	
1	Measured value	>SPL and <SPH, module is activated
2	Relay	ON
3	Measured value	≤SPL or ≥SPH
4	Relay	OFF
5	Measured value	>SPL or <SPH
6	Relay	Remains OFF (latches) until delay time has elapsed and is then acknowledged manually
		Acknowledgement is only possible if there is no critical state anymore and the delay time has elapsed.

Critical operating state ≤SPL and ≥SPH

1	Measured value	a) ≤SPL, and module is activated b) ≥SPH, and module is activated
2	Relay	OFF
3	Measured value	a) >SPL and <SPH b) <SPH and >SPL
4	Relay	Remains OFF (latches) until delay time has elapsed and is then acknowledged manually
		Acknowledgement is only possible if there is no critical state anymore and the delay time has elapsed.

8.12.6 Switching behavior (7): temperature range limit (≥SPL and ≤SPH)



Normal operating state <SPL and >SPH

Step	Measure	
1	Measured value	a) <SPL, and module is activated b) >SPH, and module is activated
2	Relay	ON
3	Measured value	a) ≥SPL and ≤SPH b) ≤SPH and ≥SPL
4	Relay	OFF
5	Measured value	<SPL or >SPH
6	Relay	Remains OFF (latches) until delay time has elapsed and is then acknowledged manually
		Acknowledgement is only possible if there is no critical state anymore and the delay time has elapsed.

Critical operating state ≥SPL and ≤SPH

Step	Measure	
1	Measured value	≥SPL and ≤SPH, and module is activated
2	Relay	OFF
3	Measured value	<SPL or >SPH
4	Relay	Remains OFF (latches) until delay time has elapsed and is then acknowledged manually
		Acknowledgement is only possible if there is no critical state anymore and the delay time has elapsed.

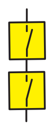
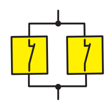
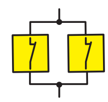
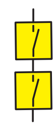
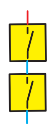
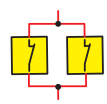
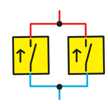
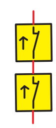
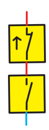
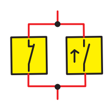
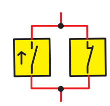
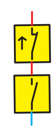
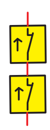
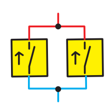
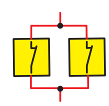
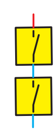
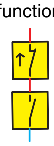
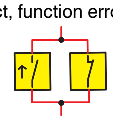
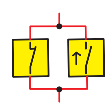
8.13 Connecting relay contacts

You need to define the state that is required in the event of a measuring transducer failure in order to select the appropriate relays to be used.

If an N/C contact is required in the event of a failure, two N/O contacts must be connected in parallel.

If an N/O contact is required in the event of a failure, two N/C contacts must be connected in series.

The behavior of the measuring transducer in normal mode can still be configured, however, the connection used in the event of a measuring transducer failure must also be considered.

Normal function		Closing behavior	Opening behavior	Closing behavior	Opening behavior
Safe state of the switching contacts		Open	Closed	Closed	Open
Connection of the relay contacts					
Switching behavior (SB) set		Normal (SB 0, 2, 4, 6)	Normal (SB 0, 2, 4, 6)	Inverse (SB 1, 3, 5, 7)	Inverse (SB 1, 3, 5, 7)
Relay contacts before reaching the switching threshold	Without error				
	With error	Defect, function OK 	Defect, function OK 	Defect, function error 	Defect, function error 
Relay contacts after reaching the switching threshold	Without error				
	With error	Defect, function error 	Defect, function error 	Defect, function OK 	Defect, function OK 
Blue cable = Non-live					
Red cable = Live					
 If defective	Defective = The contact is incorrectly controlled or it has been mechanically short-circuited				
 If defective	Defective = The contact is incorrectly not controlled or it has been mechanically short-circuited				
 If defective	Defective = The contact is incorrectly controlled or it has been mechanically interrupted				
 If defective	Defective = The contact is incorrectly not controlled or it has been mechanically interrupted				

8.14 Monitoring function

The temperature transducer is equipped with monitoring functions for the input and output range.

Input monitoring function

The input monitoring function for line break and short circuit refers to the sensor connected to the input. When an error is detected, the output signal is set to the configured error value. In the case of RTD sensors and resistance-type sensors, short-circuit failures are detected resistance values <1 Ω.

Short circuits of thermocouples and mV sources cannot be detected, since 0 V can be a valid signal. Short circuits can be detected in the event of underrange, provided that a life-zero signal is configured.

On RTD sensors, resistance-type sensors and potentiometers, a line break is detected when the current flow through the sensor is faulty.

When using the mV input, a line break is not detected. When connecting a resistance (10 kΩ / 0.6 W or similar) between input terminals 5.1 and 5.2, line break can be detected in the event of underrange.

As soon as the fault has been eliminated, the temperature transducer continues to perform its normal functions (see “LED status indicators” on page 29, Line fault).

Output monitoring function

The current output can be monitored for line breaks and maximum load. This is activated via the configuration. In safety-related applications (SIL = ON), output monitoring is always active. The voltage output is not monitored. As soon as the fault has been eliminated, the temperature transducer continues to perform its normal functions. (See “LED status indicators” on page 29, Line fault)

8.15 Operating modes

> If the configuration is modified using the IFS-OP-UNIT operator interface and PC-based software (e.g., ANALOG-CONF) or via the DIP switch, the changes made must always be checked again and released before transfer to the temperature transducer.
>
> After the transfer, the new data in the temperature transducer is applied by means of activation and a warm start.

8.15.1 SIL ON / SIL OFF

The temperature transducer can either be operated in normal SIL ON or SIL OFF mode. The standard configuration is SIL ON with DIP switch S1 set to the OFF position.

8.15.2 Service mode

Service mode can be selected at any time via the IFS-OP-UNIT operator interface and the configuration software, e.g., ANALOG-CONF or via DIP switch S1.

If settings are changed during service mode and service mode is then exited, the temperature transducer performs a warm start in order to apply the newly set values. If no changes are made, the transducer starts up in normal measuring mode without a warm start. The switching output switches according to its configuration.

In service mode, it is also possible to simulate the output signal independently of the input signal (force). In this case, in safety-related applications, the safety function of the device is deactivated and the initial value for the analog output signal is 2 mA, which allows subsequent devices to detect the deviation from normal mode as a result of the measured value being underrange.

During service mode, the switching output is deactivated and remains in its idle position.

9 Configuration

WARNING: Explosion hazard
If configuring for zone 2, the PC must be approved for use in zone 2.

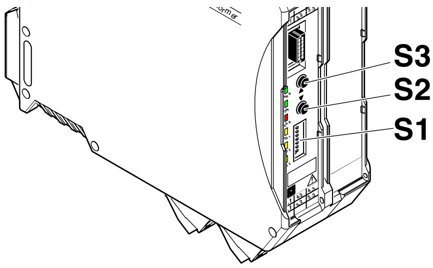


Figure 8 Position of the DIP switch and button

When one of the S1-2 ... S1-8 DIP switches is switched on (ON), the device is switched to service mode. The red ERR LED flashes (1.2 Hz) and a diagnostic peripheral fault is displayed on the start screen.

9.1 Delivery state / standard configuration

Switch position, DIP S1							
1	2	3	4	5	6	7	8
OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF

9.2 Zero adjust, adjustment via DIP switches S2 and S3 (only possible with SIL OFF)

- Set the adjustment by setting DIP switch S1-2 to ON.
- Observe the analog output and set with the S2 (descending value) or S3 (ascending value) button.
  Or
  Pressing buttons S2 and S3 simultaneously for >3 seconds resets the cable compensation.
- Save the set value by setting DIP switch S1-2 back to OFF.

Switch position, DIP S1							
1	2	3	4	5	6	7	8
OFF	**ON**	OFF	OFF	OFF	OFF	OFF	OFF

9.3 Span adjust, adjustment via DIP switches 2 and 3 (only possible with SIL OFF)

- Set the adjustment by setting DIP switch S1-3 to ON.
- Observe the analog output and set with the S2 (descending value) or S3 (ascending value) button.
  Or
  Pressing buttons S2 and S3 simultaneously for >3 seconds resets the cable compensation.
- Save the set value by setting DIP switch S1-3 back to OFF.
- Pressing buttons S2 and S3 simultaneously for >3 seconds resets the adjustment.

Switch position, DIP S1							
1	2	3	4	5	6	7	8
OFF	OFF	**ON**	OFF	OFF	OFF	OFF	OFF

9.4 Force output

When SIL is activated, the analog output starts at 2 mA and the switching output is deactivated.

- Set the adjustment by setting DIP switch S1-4 to ON.
- Observe the analog output and set with the S2 (descending value) or S3 (ascending value) button.
- The specification/simulation is reset and ended by setting DIP switch S1-4 back to OFF.

Switch position, DIP S1							
1	2	3	4	5	6	7	8
OFF	OFF	OFF	**ON**	OFF	OFF	OFF	OFF

9.5 Cable compensation, 2-wire RTD or RTD 1 with 2 x RTD

- Set the RTD 1 cable compensation via DIP switches S1-1 to OFF and S1-5 to ON.
- Short circuit the sensor.
- Apply the current measured value as the cable resistance by pressing the S2 button.
- Save the set value by setting DIP switch S1-5 back to OFF.

Pressing buttons S2 and S3 simultaneously for >3 seconds resets the cable compensation.

Switch position, DIP S1							
1	2	3	4	5	6	7	8
OFF	OFF	OFF	OFF	**ON**	OFF	OFF	OFF

9.6 Cable compensation RTD 2 with 2 x RTD or TC with external cold junction compensation (TC + CJ external)

- Set the RTD 2 cable compensation via DIP switches S1-1 to ON and S1-5 to ON.
- Short circuit the sensor.
- Apply the current measured value as the cable resistance by pressing the S2 button.
- Save the set value by setting DIP switches S1-1 and S1-5 back to OFF.

Pressing buttons S2 and S3 simultaneously for >3 seconds resets the cable compensation.

Switch position, DIP S1							
1	2	3	4	5	6	7	8
ON	OFF	OFF	OFF	**ON**	OFF	OFF	OFF

9.7 Automatic potentiometer adjustment (teach-in)

- Set the teach-in function by setting DIP switch S1-6 to ON.
- Set the potentiometer to the start of range.
- Press the S2 button.
- Set the potentiometer to the end of range.
- Press the S3 button.
- Save the new measuring range by setting DIP switch S1-6 back to OFF.

Pressing buttons S2 and S3 simultaneously for >3 seconds resets both values.

Switch position, DIP S1							
1	2	3	4	5	6	7	8
OFF	OFF	OFF	OFF	OFF	**ON**	OFF	OFF

9.8 Manual acknowledgement of switching outputs (latch function)

Switching output 1

- Set manual acknowledgment of switching input 1 by setting DIP switch S1-7 to ON.
- Press buttons S2 and S3 simultaneously for >3 seconds.

Reset DIP switch S1-7 to OFF.

Switch position, DIP S1							
1	2	3	4	5	6	7	8
OFF	OFF	OFF	OFF	OFF	OFF	**ON**	OFF

Switching output 2

- Set manual acknowledgment of switching input 2 by setting DIP switch S1-8 to ON.
- Press buttons S2 and S3 simultaneously for >3 seconds.

Reset DIP switch S1-8 to OFF.

Switch position, DIP S1							
1	2	3	4	5	6	7	8
OFF	OFF	OFF	OFF	OFF	OFF	OFF	**ON**

Switching output 3

- Set manual acknowledgment of switching input 3 by setting DIP switches S1-7 and S1-8 to ON.
- Press buttons S2 and S3 simultaneously for >3 seconds.

Reset DIP switches S1-7 and S1-8 to OFF.

Switch position, DIP S1							
1	2	3	4	5	6	7	8
OFF	OFF	OFF	OFF	OFF	OFF	**ON**	**ON**

9.9 LED status indicators

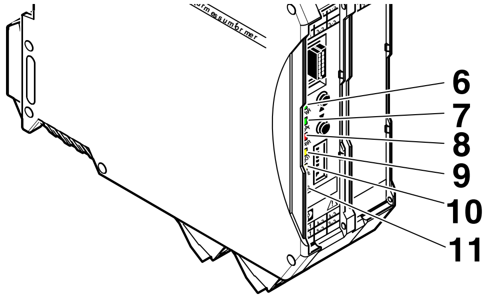


Figure 9 LED status indicators

No.	LED	Color	Description
6	PWR	Green	Supply voltage
		On	Indicates ready-to-operate state of the temperature transducer if supply voltage is available.
			The temperature transducer is configured without device supply via the IFS-USB-PROG-ADAPTER programming adapter.
7	DAT	Green	No function at present
8	ERR	Red	Error
		On	Module error
		Flashing (1.2 Hz)	Service mode active
		Flashing (2.4 Hz)	Line fault
9	DO1	Yellow	Switching output 1
		On	Switching output active
10	DO2	Yellow	Switching output 2
		On	Switching output active
11	DO3	Yellow	Switching output 3
		On	Switching output active

10 Password

The device is protected by means of a four-digit password set in the factory in order to prevent impermissible changes to the configuration.

Default setting: 1111

For safety-related applications, the password set in the factory must always be changed.

If the password is lost, a reset is not possible.

In this case, please contact Phoenix Contact.

If, however, only data from the device is to be displayed or the device is to be used in non-safety-related applications, the password can be deactivated.

Setting: 0000

The device can be accessed either via the IFS-OP-UNIT (Order No. 2811899) or via a service PC with connected IFS-USB-PROG-ADAPTER programming adapter (Order No. 2811271) and the ANALOG-CONF configuration software.

Further information on configuration with the IFS-OP-UNIT or the ANALOG-CONF configuration software can be found in the relevant user manual.

WARNING: If *Functional Safety* is activated by a reconfiguration or changes are made to the active *Functional Safety* configuration, the rules in the appendix under “Installation and startup” must be observed.

WARNING: Limitations for safety-related applications

4 ... 20 mA only, limited programming of output current in the event of line faults (2 mA ≤ I_{Out} ≤ 3.6 mA or I_{Out} ≥ 21 mA)

WARNING: Once new configuration data has been written, the device performs a warm start that changes the properties of the device. The following control device must be adapted to these modifications.

NOTE: To save the password, write the changed password to the temperature transducer.

11 Configuration with the service PC

When making changes to the configuration data, use the ANALOG-CONF software (free download: phoenixcontact.net/products).

> Information on configuration, parameterization, and service options (e.g., online monitoring) and their execution can be found in the online help of the software and in the associated user manuals of the DTMs (Device Type Manager).

- Connect the device and PC with the help of the IFS-USB-PROG-ADAPTER programming adapter (Order No. 2811271).

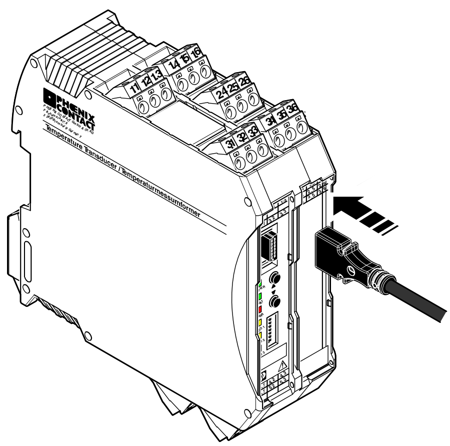


Figure 10 IFS-USB-PROG-ADAPTER

Changes to the configuration and parameterization data can be made during operation with a connected Ex measuring circuit as well as in a disconnected state.

11.1 System requirements

– PC or compatible computer with 400 MHz or higher with at least 256 Mbyte RAM
– At least 15 Mbyte available hard disk space
– Free USB interface, at least USB 1.1
– Screen resolution of 1024 x 768 pixels
– Windows 2000 SP4, Windows XP SP2, Windows 7, Windows 8, Win 10

> The drivers for the IFS-USB-PROG-ADAPTER USB programming adapter are installed automatically.

11.2 Configuring the user characteristic curve

> Freely configurable user characteristic curve for individual adaptation of resistance temperature detectors (RTD) and thermocouples (TC).

The user characteristic curve is created with the PC-based ANALOG-CONF software and stored in the temperature transducer.

> The user characteristic curve is either selected with the ANALOG-CONF or with the IFS-OP-UNIT software.

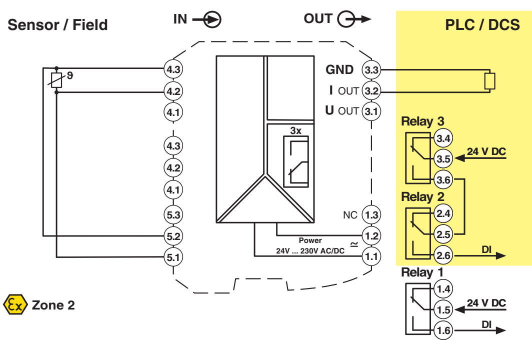
12 Connection examples

12.1 Current output

Connection example 1:

Input: 4-wire RTD

Output: Current output (4 ... 20 mA) with simple signal contact (switching output 1) and safe limit value (combination of switching outputs 2 and 3, N/O contact connected in series)

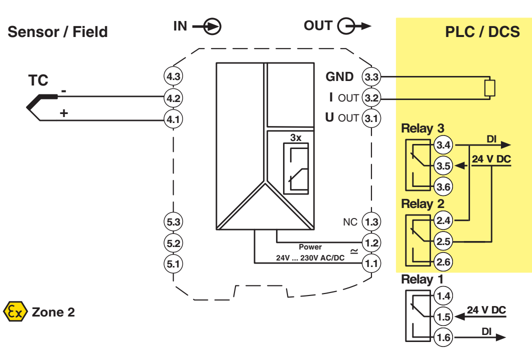


Connection example 2:

Input: Thermocouple with internal cold junction compensation

Use the MACX MCR-CJC cold junction compensation plug provided (Order No. 2924993).

Output: Current output (4 ... 20 mA) with simple signal contact (switching output 1, N/O contact) and safe limit value (combination of switching outputs 2 and 3, N/C contact connected in parallel)

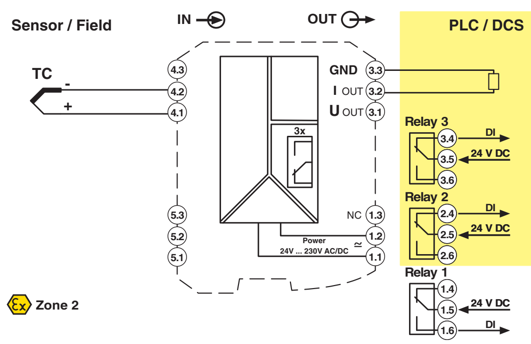


Connection example 3:

Input: Thermocouple with internal cold junction compensation

Use the MACX MCR-CJC cold junction compensation plug provided (Order No. 2924993).

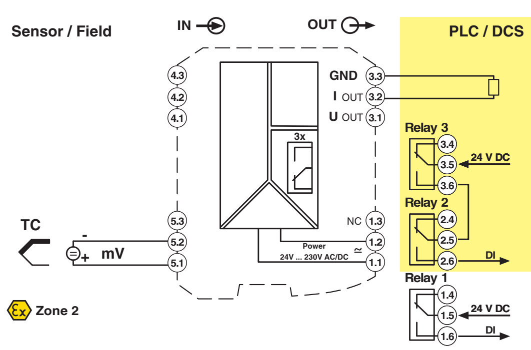
Output: Current output (4 ... 20 mA) with simple signal contact (switching output 1, N/O contact) and safe limit value (combination of switching outputs 2 and 3, N/C contact connected in parallel) connected to safe controller with plausibility comparison



Connection example 4:

Input: Thermocouple with external or without cold junction compensation or voltage input

Output: Current output (4 ... 20 mA) with simple signal contact (switching output 1, N/O contact) and safe limit value (combination of switching outputs 2 and 3, N/O contact connected in series)

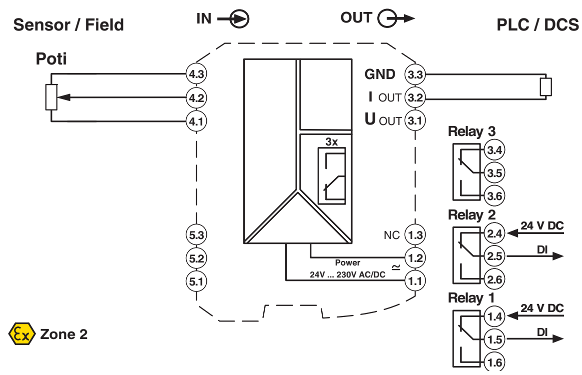


.

When using the mV input in applications up to SIL 2, only a limited scope of functions is available (see Appendix 1 "Safety-related applications (SIL 2)" , Section 1.6 "Functional restrictions").

Connection example 5:

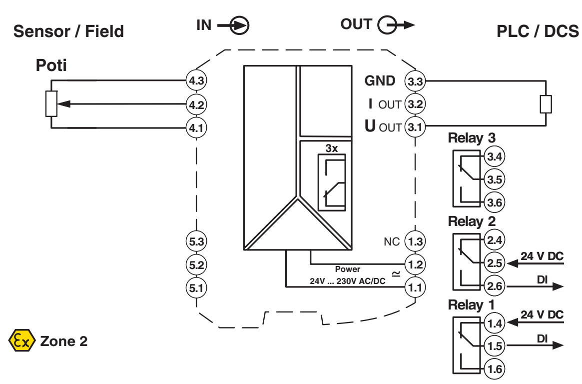
Input:	Potentiometer
Output:	Current output (0 ... 20 mA) and signal contact (switching outputs 1 and 2) can be configured independent of one another.



12.2 Voltage output

Connection example:

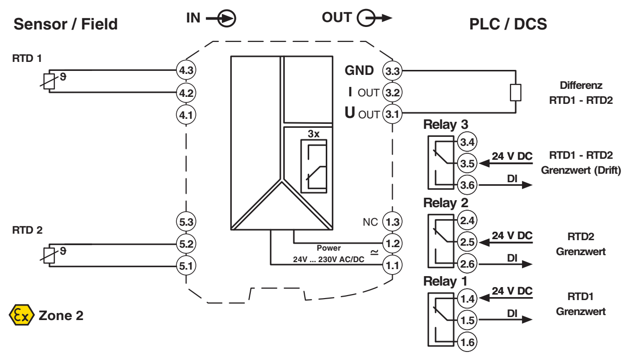
Input:	Potentiometer
Output:	Voltage output (-10 ... 10 V) connected to passive controller with signal contacts (switching outputs 1 and 2) can be configured independent of one another.



12.3 Switching output

Connection example:

Input:	2 x 2-wire RTD
Output:	Voltage output (-10 ... 10 V), difference of RTD1 - RTD2
Switching output:	Switching outputs 1, 2 and 3 configured independent of one another



13 Flow chart, operator interface

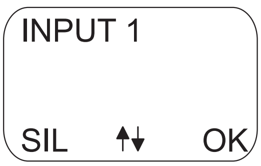
Configuration with the IFS-OP-UNIT

If you wish to use the MACX MCR-T-UIREL-UP in combination with the IFS-OP-UNIT and with the IFS-OP-CRADLE, the various operating functions that can be selected are shown on the display.

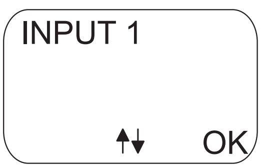
The IFS-OP-UNIT operator interface can either be snapped directly onto compatible 35 mm modules or can be used as a remote display together with the IFS-OP-CRADLE cradle unit.

i	When active, the SIL functionality is displayed on the start screen.

Example: display view for SIL ON



Example: display view for SIL OFF

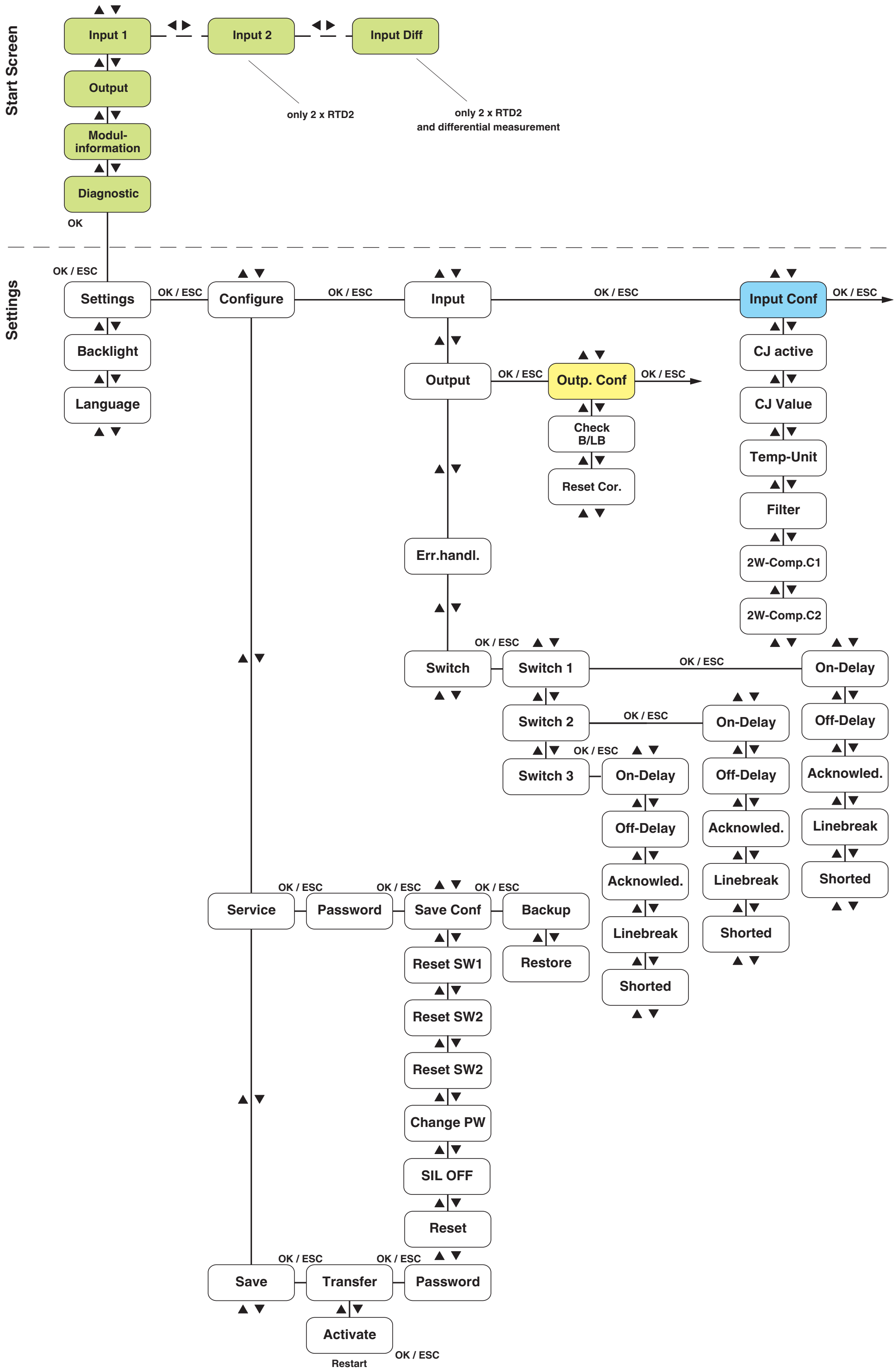


i	For safety reasons, the SIL ON function cannot be switched on again via the IFS-OP-UNIT operator interface.

i	SIL can be switched off/deactivated via the SIL OFF menu item. To reactivate/switch on the SIL function, PC-based configuration software, e.g., ANALOG-CONF, is required.

i	If no input is entered for five minutes during configuration, the configuration is ended and any unsaved data will be lost.

13.1 Menu structure



13.2 Key for start screen

Display of input and output signals, module and diagnostic information

Input 1	Display of the actual value of input 1
Input 2	Display of the actual value of input 2, only if a second RTD is configured in 2-wire connection technology
Input Diff	Display of the actual value of the differential measurement with 2 x RTD in 2-wire connection technology
Output	Display of the actual value for the analog output
Modul-information	Display of module information (order designation, hardware/firmware version)
Diagnostic	Module diagnostics (simulation, module error, peripheral fault)

13.3 Key for MENU:

Settings	The active configuration is read out from the module
Backlight	Setting for the background illumination (**on**, off, autodim)
Language	Setting for the menu language (**English**, German)

13.4 Key for SETTINGS - Configure

Configure	Configuration of input, output, error handling, and switching outputs

13.5 Key for SETTINGS - Service

Service	Access to the menu items of the service area
Password	Input of a 4-digit numeric password in order to open the service area. (If the password is 0000, the password prompt is switched off).
Save Conf	Access to the menu items for the backup and restore functions of the module configuration
Reset SW1	Resets switching output 1 when it is latched
Reset SW2	Resets switching output 2 when it is latched
Reset SW3	Resets switching output 3 when it is latched Can only be configured with SIL OFF
Change PW	Changes the password set (Change only becomes effective when the configuration has been transmitted to the module and activated)

SIL OFF Changes the setting from SIL ON to SIL OFF

> **NOTE:** It is only possible to switch on the SIL function via PC-based configuration software, e.g., ANALOG-CONF.

Reset Resets the IFS-OP-UNIT and the connected module

Backup Saves the active configuration of the connected, compatible module in the IFS-OP-UNIT operator interface (copy function)

Restore Transmits the saved module configuration from the internal memory of the IFS-OP-UNIT operator interface to the connected module (copy function)

> Then activate the configuration by selecting Yes in the Activate menu item.

13.6 Key for SETTINGS - Save

Save Access to the menu items for the transmission and activation of the module configuration

Transfer Transmits the configuration from the IFS-OP-UNIT operator interface to the connected module

Password Input of a 4-digit numeric password in order to transmit the configuration.

(If the password is 0000, the password prompt is switched off).

Activate Activation of the module configuration (Yes/No)

> Following activation, the module performs a warm start.

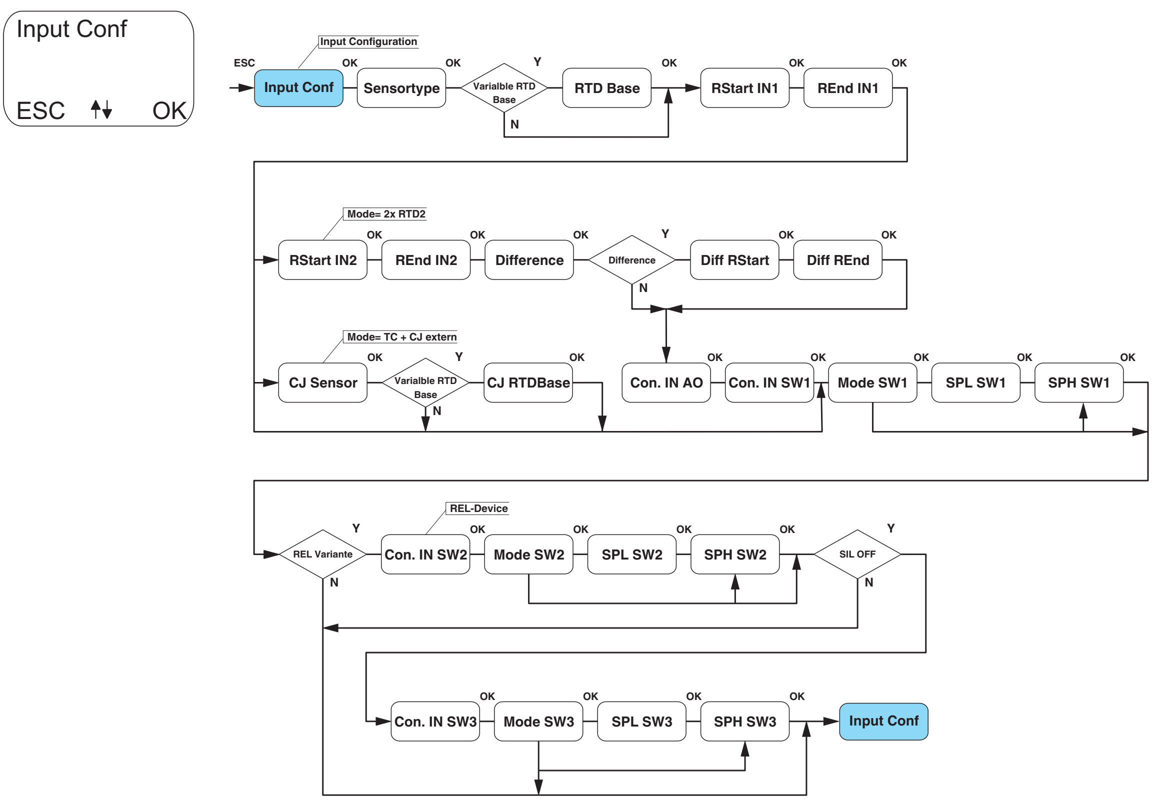
13.7 Key for input

Input	Access to the menu items for the configuration of the input (See “Key for input configuration (analog input)” on page 37)

13.7.1 Key for input configuration (analog input)

Input Conf	Setting for the dependent parameters of the input mode, sensor type, start and end of range, associated inputs, switching behavior, switching points
KS an/aus	Cold junction compensation for TC + CJ and TC + CJ ext. (on, off)
CJ Value	Correction of the cold junction value for CJ = on Presetting of the cold junction value for CJ = off (-20 ... 65 K)
Temp-Unit	Setting for the temperature unit (°C, °F)
Filter	Setting for the filter factor (1 ... 10)
2W-Comp.C1	Setting for the cable resistance for RTD 2-wire connection technology, channel 1 (0 ... 50 Ω)
2W-Comp.C2	Setting for the cable resistance for RTD 2-wire connection technology, channel 2 (0 ... 50 Ω)

Configuration selection: input configuration



Input Conf	Setting for the sensor mode (RTD4, RTD3, RTD2, 2xRTD2, TC + CJ, TC + CJ ext., potentiometer, mV)
Sensortype	Setting for the sensor type depending on the sensor mode (Pt, Ni, CU, KTY..., USER, for more see “Sensor types” on page 13)
RTD Base	RTD basic resistance for sensor types with a variable basic resistance (e.g., when 100 is selected, the basic resistance is 100 Ω)
RStart IN1	Start of range for input 1 depending on the sensor type, e.g., **-50°C** (°C, °F, Ω, %, mV).
REnd IN1	End of range for input 1 depending on the sensor type, e.g., **150°C** (°C, °F, Ω, %, mV)
RStart IN2	Start of range for input 2 depending on the sensor type and only for 2 x RTD in 2-wire connection technology, e.g., **-50°C** (°C, °F, Ω).
REnd IN2	End of range for input 2 depending on the sensor type and only for 2 x RTD in 2-wire connection technology, e.g., **150°C** (°C, °F, Ω)
Difference	Setting for the differential measurement only for 2 x RTD in 2-wire connection technology and not resistance (off, differential, absolute value differential)
Diff RStart	Start of range for differential, only with differential and absolute value differential (°C, °F)
Diff REnd	End of range for differential, only with differential and absolute value differential (°C, °F)
CJ Sensor	Sensor type of the cold junction, only with TC + CJ ext.
CJ RTDBase	RTD basic resistance of the cold junction, only with TC + CJ ext.
Con. IN AO	Associated input of the analog output (input 1, input 2, differential), appears only in sensor mode 2 x RTD2 (2 x RTD 2-wire connection technology)
Con. IN SW1	Associated input of switching output 1 (input 1, input 2, differential), appears only in sensor mode 2 x RTD2 (2 x RTD 2-wire connection technology)
Mode SW1	Mode of switching input 1 (0 ... 7), see “Switching output” on page 21
SPL SW1	Setpoint low of switching input 1 (only if mode >3), see “Switching output” on page 21
SPH SW1	Setpoint high of switching input 1 (only if mode >1), see “Switching output” on page 21
Con. IN SW2	Associated input of switching output 2 (input 1, input 2, differential)
Mode SW2	Mode of switching input 2 (0 ... 7), see “Switching output” on page 21
SPL SW2	Setpoint low of switching input 2 (only if mode >3), see “Switching output” on page 21
SPH SW2	Setpoint high of switching input 2 (only if mode >1), see “Switching output” on page 21

Con. IN SW3	Associated input of switching output 3 (input 1, input 2, differential) Can only be configured with SIL OFF
Mode SW3	Mode of switching input 3 (0 ... 7), see “Switching output” on page 21 Can only be configured with SIL OFF
SPL SW3	Setpoint low of switching input 3 (only if mode >3), see “Switching output” on page 21 Can only be configured with SIL OFF
SPH SW3	Setpoint high of switching input 3 (only if mode >1), see “Switching output” on page 21 Can only be configured with SIL OFF

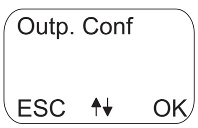
13.8 Key for output

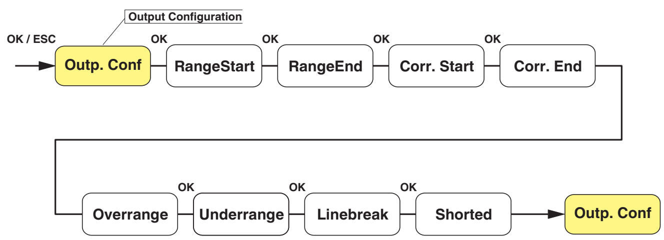
Output	Access to the menu items for the configuration of the output (See “Key for output configuration (analog output)” on page 40)

13.8.1 Key for output configuration (analog output)

Outp. Conf	Setting for the dependent parameters of the analog output – mode, start and end of range, display of correction values, error behavior (OR, UR, LB, SC), **current**/voltage Voltage can only be configured with SIL OFF
Check B/LB	Monitoring of output load/short circuit (**Yes**/No), only configurable with SIL = OFF
Reset Cor.	Resets the correction values of the output

Configuration selection: output configuration





RangeStart	Start of range for the output – setting only possible with SIL = OFF, **4 mA** (0 ... 20 mA, -10 ... 10 V)
RangeEnd	End of range for the output – setting only possible with SIL = OFF **20 mA** (0 ... 20 mA, -10 ... 10 V)
Corr.Start	Display of the start correction value for the analog output (mA, V)
Corr.End	Display of the end correction value for the analog output (mA, V)
Overrange	Analog output value in the event of overrange **NE43 Upsc.** / NE43 Downsc. (Configurable for error behavior = freely definable)
Underrange	Analog output value in the event of underrange **NE43 Upsc.** / NE43 Downsc. (Configurable for error behavior = freely definable)
Linebreak	Analog output value in the event of line break **NE43 Upsc.** / NE43 Downsc. (Configurable for error behavior = freely definable)
Shorted	Analog output value in the event of a short circuit on the line **NE43 Upsc.** / NE43 Downsc. (Configurable for error behavior = freely definable)

13.9 Key for error behavior

Err.handl.	Setting for the error behavior (NE43 increasing, NE43 decreasing, freely definable)

13.10 Key for switching output

Switch	Access to the menu items for setting the switching output

13.10.1 Key for switching output 1

Switch 1	Access to the menu items for setting the switching output 1
On-Delay	Setting for the switch-on delay of switching output 1 (0 ... 10 s)
Off-Delay	Setting for the switch-off delay of switching output 1 (0 ... 10 s)
Acknowled.	Manually acknowledge switching output 1 (latching) (Yes/**No**)
Linebreak	Behavior of switching output 1 in the event of an error - line break (on, **off**, no response)
Shorted	Behavior of switching output 1 in the event of an error - short circuit (on, **off**, no response).

13.10.2 Key for switching output 2

Switch 2	Access to the menu items for setting the switching output 2
On-Delay	Setting for the switch-on delay of switching output 2 (0 ... 10 s)
Off-Delay	Setting for the switch-off delay of switching output 2 (0 ... 10 s)
Acknowled.	Manually acknowledge switching output 2 (latching) (Yes/**No**)
Linebreak	Behavior of switching output 2 in the event of an error - line break (on, **off**, no response)
Shorted	Behavior of switching output 2 in the event of an error - short circuit (on, **off**, no response)

13.10.3Key for switching output 3 (can only be configured with SIL OFF)

Switch 3	Access to the menu items for setting the switching output 3
On-Delay	Setting for the switch-on delay of switching output 3 (0 ... 10 s)
Off-Delay	Setting for the switch-off delay of switching output 3 (0 ... 10 s)
Acknowled.	Manually acknowledge switching output 3 (latching) (Yes/**No**)
Linebreak	Behavior of switching output 3 in the event of an error - line break (on, **off**, no response)
Shorted	Behavior of switching output 3 in the event of an error - short circuit (on, **off**, no response)

14 Error codes of the IFS-OP-UNIT operator interface

The following error codes are shown directly on the display of the IFS-OP-UNIT operator interface when they occur.

Error code	Description
Error 0	Copy error Module type in the IFS-OP-UNIT is different from the connected module.
Error 1, 2, 3	Checksum error Please contact Phoenix Contact.

Appendix

A1 Safety-related applications (SIL 2)

Valid hardware and firmware versions

NOTE: Only those devices with SIL designation and module firmware with revision 0.92 or higher are certified for SIL 2.

SIL regulations apply to the following modules:

Designation	Order No.
Standard configuration	
MACX MCR-T-UI-UP	2811394
MACX MCR-T-UI-UP-SP	2811860
MACX MCR-T-UIREL-UP	2811378
MACX MCR-T-UIREL-UP-SP	2811828
MACX MCR-EX-T-UI-UP	2865654
MACX MCR-EX-T-UI-UP-SP	2924689
MACX MCR-EX-T-UI-UP	2865751
MACX MCR-EX-T-UIREL-UP-SP	2924799
Order configuration	
MACX MCR-T-UI-UP-C	2811873
MACX MCR-T-UI-UP-SP-C	2811970
MACX MCR-T-UIREL-UP-C	2811514
MACX MCR-T-UIREL-UP-SP-C	2811831
MACX MCR-EX-T-UI-UP-C	2811763
MACX MCR-EX-T-UI-UP-SP-C	2924692
MACX MCR-EX-T-UIREL-UP-C	2865722
MACX MCR-EX-T-UIREL-UP-SP-C	2924809

The safety-related temperature transducers listed above from the MACX MCR-(EX)-T-... series have been certified by TÜV Nord.

Certificate no.: SEBS-A.150520/17TB

A1.1 Safety function and safety requirements

The safety-related measuring transducers are used for the acquisition of a sensor signal (RTD, TC sensors, resistance-type sensors, mV sources [can be used with restrictions in SIL applications, see 1.6 “Functional restrictions”]), that is converted into a scaled signal and from which a standardized “live zero” current signal is generated. The entire conversion is continuously monitored to a maximum transmission error of 5%. In the event of greater deviations, the device switches to the safe state. The safe state is an output signal of either <3.6 mA or >21 mA.

NOTE: The evaluation unit following the measuring transducer (e.g., safety-related PLC) must recognize these states and correspondingly control the actuator as the final link in the safety chain.

With the REL versions, an additional signal is generated, which is compared with up to two specified switching thresholds. When the first threshold is reached, the safety relay is switched on without checkback contact and when the second threshold is reached, it is switched off. Depending on the application, the safety for the switching output is implemented by either the series or parallel connection of relays 2 and 3 and a fuse connected in series, and by monitoring the calculated switching value.

If an N/O contact is required, the N/O contacts of relay 2 and relay 3 must be connected in series. In this way, the safe state (relay coil without power and N/O contact open) is also achieved in the event of a faulty contact (permanently closed) (see connection example 1).

If an N/C contact is required, the N/C contacts of relay 2 and relay 3 must be connected in parallel. In this way, the safe state (relay coil without power and N/C contact closed) is also achieved in the event of a faulty contact (permanently open) (see connection example 2).

In the event of deviations of more than 5%, the device switches to the safe state. The safe state in this case is a non-actuated relay.

The hardware is also continuously monitored. If an internal failure is detected, the measuring transducer also switches to the safe state (current output <3.6 mA or >21 mA or non-actuated relay).

The transition to the safe state always takes place within the internal fault detection time of 50 s.

The measuring transducer is released (restarted) by switching off the supply voltage and switching it back on again, by resetting the transducer via the serial interface, or by activating the “Restart” option during configuration. The integrated startup tests are then performed. If the fault is still present, it will be detected during these tests. If it is still present, the measuring transducer switches back to the safe state.

In addition to the safety functions, there are also monitoring functions for the input and the current output.

Evaluation

Faults which are detected in the measuring transducer and to which the transducer responds by switching to the safe state are safe faults (λs).

Faults where the measuring transducer does not follow a change of input signal or generates an output signal that deviates from the intended value by more than ±5%, are evaluated as dangerous faults (λd).

Both safe (λs) and dangerous (λd) faults can be detected by diagnostic measures. Detected dangerous faults (λdd) are handled in the same way as safe faults.

The **monitoring functions** refer to events whose cause is detected and reported outside of the device.

Summary:

Safety/monitoring function	Output signal range	Safe state	Reason
Safety function	4 ... 20 mA	<3.6 mA or >21 mA relay is not actuated	Deviation >5%
Input monitoring	4 ... 20 mA	2 ... 3.6 mA, >21 mA	Line fault, input
Output monitoring	4 ... 20 mA	= 0 mA	Line fault, output

Together with the actual signal transmission, continuous checks and diagnostic functions are performed in the measuring transducers in order to detect faulty behavior.

Please note that the scope of monitoring functions is limited when using mV sources (see 1.6 “Functional restrictions”).

The **internal fault monitoring time** (diagnostics test interval) is the time taken to carry out and repeat these tests in full. Random hardware faults are detected during this time.

The **internal fault monitoring time** is 50 seconds.

A1.2 Requirements on safety integrity

As a result of the multiple connection options, only two device types are considered in the following configurations for “RTD 3-wire” or “mV”. They represent all configurations with a variable resistance at the input terminals or voltage or thermocouple inputs and always indicate the most conservative case. The two device types are:

1. MACX MCR(-EX)-T-UI-UP(-SP)(-C)
2. MACX MCR(-EX)-T-UIREL-UP(-SP)(-C)

FIT (failure in time)

1 FIT is one failure per 10^9 hours

A1.2.1 Failure rates, MACX MCR(-EX)-T-UIREL-UP (-SP)(-C)

Input:	RTD 3-wire connection technology
Output:	Switching outputs 2 and 3 (redundant)

– PL d
– Type B device (according to EN 61508-2)
– Safety integrity level (SIL) 2
– HFT = 0
– 1oo1d architecture

λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	SFF	DC_D
0	$2.34 * 10^{-7}$	$5.43 * 10^{-7}$	$0.43 * 10^{-7}$	94%	92%
0 FIT	234 FIT	543 FIT	43 FIT		

The total failure rate is: $1.34 * 10^{-6}$

The MTBF (mean time between failures) is therefore 85 years.

The probability of a dangerous failure per hour for “continuous demand” mode and the average probability of failure of the specified function for “low demand” mode are determined based on the error rates:

PFD_{avg} values

T[PROOF] =	1 year	2 years	5 years
PFD_{avg} =	$2.88 * 10^{-4}$	$4.67 * 10^{-4}$	$1.01 * 10^{-3}$

PFH* = $4.3 * 10^{-8}$/h

The calculation is performed assuming a checking interval (T_{PROOF}) of one year and a repair time (MTTR) of 24 hours, a test coverage (CPT) of 95%, and a lifetime (LT) of ten years.

On the basis of the value determined for the average probability of failure **PFD_{avg}**, the checking interval can be increased to up to five years.

The values are valid under the following conditions:

– The failure rates of the components used remain constant throughout the period of use.
– The propagation of errors by the device in the system is not taken into consideration.
– The repair time (= replacement) is 24 hours.
– The failure rates of the external power supply are not taken into consideration.
– The average temperature at which the device is to be used is +40°C. In this case, normal industrial conditions are assumed.
– The specified failure rates are based on an average ambient temperature of +40°C. For an average ambient temperature of +60°C, the failure rates must be multiplied by factor 2.5. Factor 2.5 is based on guide values.

1.2.2 Failure rates, MACX MCR(-EX)-T-UIREL-UP (-SP)(-C)

Please note that the scope of monitoring functions is limited when using mV sources (see 1.6 “Functional restrictions”).

Input:	Voltage input mV
Output:	Switching outputs 2 and 3 (redundant)

– PL d
– Type B device (according to EN 61508-2)
– Safety integrity level (SIL) 2
– HFT = 0
– 1oo1d architecture

λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	SFF	DC_D
0	$2.38 * 10^{-7}$	$5.22 * 10^{-7}$	$0.56 * 10^{-7}$	93%	90%
0 FIT	238 FIT	522 FIT	56 FIT		

The total failure rate is: $1.34 * 10^{-6}$

The MTBF (mean time between failures) is therefore 85 years.

The probability of a dangerous failure per hour for “continuous demand” mode and the average probability of failure of the specified function for “low demand” mode are determined based on the error rates:

PFD_{avg} values

T[PROOF] =	1 year	2 years	5 years
PFD_{avg} =	$3.67 * 10^{-4}$	$5.99 * 10^{-4}$	$1.30 * 10^{-3}$

PFH* = $5.6 * 10^{-8}$/h

The calculation is performed assuming a checking interval (T_{PROOF}) of one year and a repair time (MTTR) of 24 hours, a test coverage (CPT) of 95%, and a lifetime (LT) of ten years.

On the basis of the value determined for the average probability of failure **PFD_{avg}**, the checking interval can be increased to five years if the percentage of the device for the entire loop is assumed to be 10%.

The values are valid under the following conditions:

- The failure rates of the components used remain constant throughout the period of use.
- The propagation of errors by the device in the system is not taken into consideration.
- The repair time (= replacement) is eight hours.
- The failure rates of the external power supply are not taken into consideration.
- The average temperature at which the device is to be used is +40°C. In this case, normal industrial conditions are assumed.
- The specified failure rates are based on an average ambient temperature of +40°C. For an average ambient temperature of +60°C, the failure rates must be multiplied by factor 2.5. Factor 2.5 is based on guide values.

1.2.3 Failure rates, MACX MCR(-EX)-T-UI-UP(-SP)(-C)

Input:	RTD 3-wire connection technology
Output:	4 ... 20 mA (current output)

- Type B device (according to EN 61508-2)
- Safety integrity level (SIL) 2
- HFT = 0
- 1oo1d architecture

λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	SFF	DC_D
0	0	$8.05 * 10^{-7}$	$0.43 * 10^{-7}$	94%	94%
0 FIT	0 FIT	805 FIT	43 FIT		

The total failure rate is: $1.18 * 10^{-6}$

The MTBF (mean time between failures) is therefore 97 years.

The probability of a dangerous failure per hour for “continuous demand” mode and the average probability of failure of the specified function for “low demand” mode are determined based on the error rates:

PFD_{avg} values

T[PROOF] =	1 year	2 years	5 years
PFD_{avg} =	$2.95 * 10^{-4}$	$4.76 * 10^{-4}$	$1.02 * 10^{-3}$

PFH* = $4.3 * 10^{-8}$/h

The calculation is performed assuming a checking interval (T_{PROOF}) of one year and a repair time (MTTR) of 24 hours, a test coverage (CPT) of 95%, and a lifetime (LT) of ten years.

On the basis of the value determined for the average probability of failure **PFD_{avg}**, the checking interval can be increased to up to five years.

The values are valid under the following conditions:

- The failure rates of the components used remain constant throughout the period of use.
- The propagation of errors by the device in the system is not taken into consideration.
- The repair time (= replacement) is eight hours.
- The failure rates of the external power supply are not taken into consideration.
- The average temperature at which the device is to be used is +40°C. In this case, normal industrial conditions are assumed.
- The specified failure rates are based on an average ambient temperature of +40°C. For an average ambient temperature of +60°C, the failure rates must be multiplied by factor 2.5. Factor 2.5 is based on guide values.

1.2.4 Failure rates, MACX MCR(-EX)-T-UI-UP(-SP)(-C)

Please note that the scope of monitoring functions is limited when using mV sources (see 1.6 “Functional restrictions”).

Input:	Voltage input mV
Output:	4 ... 20 mA (current output)

- Type B device (according to EN 61508-2)
- Safety integrity level (SIL) 2
- HFT = 0
- 1oo1d architecture

λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	SFF	DC_D
0	0	$7.89 * 10^{-7}$	$0.56 * 10^{-7}$	93%	93%
0 FIT	0 FIT	789 FIT	56 FIT		

The total failure rate is: $1.19 * 10^{-6}$

The MTBF (mean time between failures) is therefore 96 years.

The probability of a dangerous failure per hour for “continuous demand” mode and the average probability of failure of the specified function for “low demand” mode are determined based on the error rates:

PFD_{avg} values

T[PROOF] =	1 year	2 years	5 years
PFD_{avg} =	$3.75 * 10^{-4}$	$6.08 * 10^{-4}$	$1.31 * 10^{-3}$

PFH* = $5.6 * 10^{-8}$/h

The calculation is performed assuming a checking interval (T_{PROOF}) of one year and a repair time (MTTR) of 24 hours, a test coverage (CPT) of 95%, and a lifetime (LT) of ten years.

On the basis of the value determined for the average probability of failure **PFD_{avg}**, the checking interval can be increased to up to five years.

The values are valid under the following conditions:

- The failure rates of the components used remain constant throughout the period of use.
- The propagation of errors by the device in the system is not taken into consideration.
- The repair time (= replacement) is eight hours.
- The failure rates of the external power supply are not taken into consideration.
- The average temperature at which the device is to be used is +40°C. In this case, normal industrial conditions are assumed.
- The specified failure rates are based on an average ambient temperature of +40°C. For an average ambient temperature of +60°C, the failure rates must be multiplied by factor 2.5. Factor 2.5 is based on guide values.

A1.3 Configuring an SIL device

The measuring transducer can be ordered with a standard configuration (see 1.) or with a configuration for safety-related applications (see 2.), or can be configured for safety-related applications by the user themselves (see 3.).

1. The measuring transducers are delivered with a standard configuration for safety-related applications with a 4 ... 20 mA output (see order key).
2. Customer-specific pre-configured devices (-C) can be delivered for both safety-related applications and "normal" usage. Configuration data is shown on a label.
3. The measuring transducers can also be configured by users for both safety-related applications and "normal" usage.

The configuration can be read out and changed at any time for all devices.

For safety-related applications, the password set in the factory must always be changed.

If the password is lost, it is not possible to change the configuration.

In this case, please contact Phoenix Contact.

Configuring safety-related applications

- Connect the device and PC with the help of the IFS-USB-PROG-ADAPTER programming adapter (Order No. 2811271).
- Access the ANALOG-CONF configuration software (free download: phoenixcontact.net/products).

  For additional information on the FDT frame application (ANALOG-CONF) and the device drivers (DTM), please refer to the ANALOG-CONF user manual.
- Read out the active configuration.
- Enter the password in the ANALOG-CONF in the "PIN" hardware configuration (set to 1111 in the factory).
- Activate/deactivate SIL.

In the case of "*SIL ON*", it is possible to deactivate the **"***Restart after failsafe***"** item here.

This means that in the event of a failure, the measuring transducer enters the failsafe state according to the safety functions, but is not restarted.

- Write the modified configuration data to the measuring transducer.
- Check that the new configuration data in the control window is correct and confirm with "*OK*" or "*Cancel*" if not correct.

NOTE: Installation, operation, and maintenance may only be carried out by qualified specialist personnel.

WARNING: If *Functional Safety* is activated by a reconfiguration or changes are made to the active *Functional Safety* configuration, the rules in Section "Installation and startup" must be observed.

WARNING: Limitations for safety-related applications

4 ... 20 mA only, limited programming of output current in the event of line faults (2 mA ≤ I_{Out} ≤ 3.6 mA or I_{Out} ≥ 21 mA)

WARNING: Once new configuration data has been written, the device performs a warm start that changes the properties of the device. The following control device must be adapted to these modifications.

WARNING: The device must be write-protected to prevent improper use. Write protection is created by assigning a password.

A1.4 Installation and startup

During installation, always observe the packing slips

Designation	Order No.
PACKB.MACX MCR-T-UI-UP...	9055145
PACKB.MACX MCR-EX-T-UI-UP...	9055147
PACKB.MACX MCR-T-UIREL-UP...	9055146
PACKB.MACX MCR-EX-T-UIREL-UP...	9055148

The packing slip is provided with the device. It can also be downloaded at: phoenixcontact.net/products.

Lockable housing with IP54 protection is recommended for the installation of the measuring transducer.

- Check that the configuration of the measuring transducer is correct for the intended application.
- Connect the measuring transducer according to the installation notes.
- Make sure that the connected sensor corresponds to the configuration.
- Check the functionality of the measuring transducer with connected sensor for correct function.

  A calibrated sensor simulator (RTD/TC) and a calibrated digital multimeter are necessary for checking the measuring transducer.
- Start up the loop and check that it operates correctly.

A1.5 Notes on operation

Only the green LED (PWR) is on during normal operation.

If a malfunction occurs during operation and the red LED (ERR) flashes, there is a line fault. The output current of the measuring transducer is between 2 … 3.6 mA or is higher than 21.0 mA (in the case of faults in the sensor circuit) or is 0 mA (in the case of a line break in the output circuit).

The response of the relays depends on the connected sensor and on the error diagnostic options.

Check all signal lines. The device will automatically switch back to normal operation after the fault has been eliminated.

If a fault occurs during operation and the red LED (ERR) is permanently on, the device has switched to the "safe state" (output current is less than 2 mA).

Restart the device in order to set it to normal operation again.

- If no PC/laptop has been connected, you can also interrupt the power supply.
- Or you can carry out a warm start using the configuration software (*Service* > *Reset*).

The measuring transducer should then return to normal operation. If it does not, the measuring transducer must be replaced.

A1.6 Functional restrictions

Thermocouples

When connecting a thermocouple to the input, you can configure the input signals as a life zero signal. In this way, short circuit is detected as underrange.

mV input

When using the mV input, the input signal musty be configured as a life zero signal. In this way, short circuit is detected as underrange.

Underrange therefore always is an error state.

When using the mV input, a resistance (10 kΩ / 0.6 W) must be connected between input terminals 5.1 and 5.2.

In this way, a sensor break is detected as underrange.

Underrange therefore always is an error state.

When using the mV input, only use switching behavior (SB) that is identical with the failsafe state (de-energized) in the event of a measured value of 0 mV (switching behavior 0, 2, 4, 6).

Other functional restrictions

Safe state = relay de-energized

Switching behavior 2 and 4:

- SPH (SB 2) or SPL (SB 4), minimum, 0 V +5% measuring span (e.g., 50 mV for -500 mV ... +500 mV span)
- Failsafe high not permitted on transducer
- Response to overrange at input is not possible

Switching behavior 6:

- SPL, minimum, 0 V +5% measuring span, SPH, maximum, maximum measuring span value

A1.7 Recurring checks (SIL 2)

The function of the entire safety loop must be checked regularly according to EN 61508 and EN 61511. The intervals for checking are specified by the intervals of each individual device within the safety loop.

It is the operator's responsibility to select the type of checks and the checking intervals in the specified time period.

The measuring transducers must be checked at least every seven years (maximum proof test interval).

Checking must be carried out in such a way that the correct function of the safety equipment in conjunction with all components can be verified.

Possible procedure for recurring checks for discovering dangerous and undetected device failures.

A calibrated sensor simulator (RTD/TC) and a calibrated digital multimeter are necessary for checking the measuring transducer.

- Connect the sensor simulator to the input of the measuring transducer using the appropriate connection technology.
- Connect the digital multimeter to the output in current measuring mode (20 mA range).

The measuring range limits and intermediate values are specified using the sensor simulator.

The corresponding output values of the measuring transducer must be checked on the digital multimeter.

Line faults (break and short circuit) are to be simulated on the input terminals; the configured residual currents are to be determined on the output.

If the function test result is negative, the measuring transducer must be taken out of operation and the process put into a safe state by other measures.

A1.8 Repair

The devices have a long service life, are protected against malfunctions, and are maintenance-free. However, if a device should fail, send it back to Phoenix Contact immediately. The type of malfunction and possible cause must also be stated.

Please use the original packaging or other suitable safe packaging when sending devices back for repairs or recalibration.

Phoenix Contact GmbH & Co. KG

Abteilung Service und Reparatur

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A1.9 Standards (SIL 2)

The measuring transducers are developed and tested according to the following standards:

EN 61508:2001	Functional safety of electrical/electronic/ programmable electronic safety-related systems
EN 61326-1:2006	Electrical equipment for measurement, control and laboratory use - EMC requirements
IEC 61326-3-2:2006	Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 3-2: Immunity requirements for safety-related systems and for equipment intended to perform safety-related functions (functional safety) – Industrial applications with specified electromagnetic environment

A1.10 Abbreviations

Abbreviation		Meaning
DC_D	Diagnostic coverage of dangerous failures	Diagnostic coverage: $DC_D = \lambda_{DD} / (\lambda_{DU} + \lambda_{DD})$
HFT	Hardware fault tolerance	Hardware fault tolerance: ability of a function unit to continue with the execution of a demanded function despite existing faults or deviations
λ_D	Rate of dangerous failures	Proportion of dangerous failures per hour
λ_{DD}	Rate of dangerous detected failures	Proportion of detected dangerous failures per hour
λ_{DU}	Rate of dangerous undetected failures	Proportion of undetected dangerous failures per hour
λ_S	Rate of safe failures	Proportion of safe failures per hour
MTBF	Mean time between failures	Mean time between consecutive failures
PFD_{avg}	Average probability of failure on demand	Average probability of dangerous failure on demand of a safety function
PFH	Probability of a dangerous failure per hour	Probability of failure per hour for the safety function
SFF	Safe failure fraction	Proportion of safe failures: proportion of failures without the potential to set the safety-related system to a dangerous or impermissible function state
SIL	Safety integrity level	International standard IEC 61508 defines four discrete safety integrity levels (SIL 1 to 4). Each level corresponds to a probability range for the failure of a safety function. The higher the safety integrity level of safety-related systems, the lower the probability that the demanded safety functions will not be performed.