MACX MCR-TC-I(-C)

Temperature signal conditioner

Data sheet
108682_en_06

 2024-11-05

1 Description

The programmable temperature signal conditioner is designed for the electrically isolated operation of thermocouple sensors in accordance with
IEC 60584/EN 60584-1
(type A-1, A-2, A-3, B, C, D, E, J, K, L, Lr, M, N, R, S, T, U) and mV sources. The measured values are converted into a linear 0/4 mA ... 20 mA signal to drive a non-intrinsically safe load.

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).

One plug for the cold junction compensation is included with the device (IOA MCR-CJC-PT100, Item No.: 1085776).

You can configure features such as sensor type, connection technology, measuring range, measuring unit, filter, alarm signal, and output range using the clipx ENGINEER or FDT/DTM software.

You can configure and parameterize the device during operation and when the power is disconnected.

Use the IFS-USB-PROG-ADAPTER programming adapter (Item No. 2811271) to connect the device to the PC.

Alternatively, you can use the Bluetooth programming adapter (Item No. 2905872).

Sockets are integrated into the COMBICON connectors for connecting measuring devices.

Installation in zone 2 in accordance with Ex ec type of protection is permitted.

Features

- Input for thermocouples and mV sources
- 4...20 mA or 20...4 mA output signal range
- High level of accuracy over the entire measuring range
- Configuration via software (clipx ENGINEER or DTM)
- Up to SIL 2/SC 2 in accordance with IEC/EN 61508 at output 4 mA ... 20 mA
- Safe electrical isolation between input, output, and supply
- Installation in Ex zone 2 permitted
- High transmission accuracy
- Status and error indicator in accordance with NE 44
- Power supply possible via DIN rail connector
- Housing width of 12.5 mm
- Screw connection available

You can use the Signal Conditioner app to call-up comprehensive module information via the integrated QR code reader.

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

Make sure you always use the latest documentation.
It can be downloaded at: phoenixcontact.com/product/1050228

2 Table of contents

3 Ordering data

Description	Type	Item no.	Pcs./Pkt.
Temperature transducer: converts signals from thermocouples and mV sources into 0/4…20 mA signals. Freely programmable, 3-way electrical isolation, screw connection, SIL.	MACX MCR-TC-I	1050228	1
Temperature transducer: converts signals from thermocouples and mV sources into 0/4…20 mA signals. Order configuration, freely programmable, 3-way electrical isolation, screw connection, SIL.	MACX MCR-TC-I-C	1052459	1

Accessories	Type	Item no.	Pcs./Pkt.
DIN rail connector (TBUS), 5-pos., for bridging the supply voltage, can be snapped onto NS 35/... DIN rail in accordance with EN 60715	ME 6,2 TBUS-2 1,5/5-ST-3,81 GY	2695439	10
Power rail adapter (ME 6,2 TBUS-PR-ADAPTER), 2-pos., enables MINI and MACX Analog modules to be adapted for supply via universal power rail UPR-03 and UPR-05.	ME 6,2 TBUS-PR-ADAPTER	1136500	10
The partition plate is used to maintain Ex i isolating distances when Ex i and non-Ex i devices are mounted side by side on a DIN rail.	MCR-DP	1430594	1
Plug for cold junction compensation for thermocouples, in combination with MACX MCR(-EX)-TC... temperature transducers	IOA MCR-CJC-PT100	1085776	1
Cover for screw shafts of the MSTB connector ranges with a pitch of 5.0 mm and 5.08 mm. These can be aligned and shortened for use with different numbers of positions.	EA-MSTB 2,5/ 5	1831016	50
Universal termination carrier for connecting 16 MACX Analog Ex i signal conditioners to digital or analog I/O cards, via D-SUB connector, 37-pos. (1:1 connection), with HART multiplexer connection	TC-D37SUB-AIO16-EX-PS-UNI	2902932	1
Universal termination carrier for connecting 16 MACX Analog Ex i signal conditioners to digital or analog I/O cards, via D-SUB connector, 37-pos. (1:1 connection)	TC-D37SUB-ADIO16-EX-P-UNI	2924854	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
Bluetooth adapter with micro USB and S-PORT interface for wireless communication with the MINI Analog, MINI Analog Pro, MACX Analog, Interface System Gateways, and PLC logic device series.	IFS-BT-PROG-ADAPTER	2905872	1
Insulating sleeve, color: white	MPS-IH WH	0201663	10
Insulating sleeve, color: red	MPS-IH RD	0201676	10
Insulating sleeve, color: blue	MPS-IH BU	0201689	10

Accessories	Type	Item no.	Pcs./Pkt.
Insulating sleeve, color: yellow	MPS-IH YE	0201692	10
Insulating sleeve, color: green	MPS-IH GN	0201702	10
Insulating sleeve, color: gray	MPS-IH GY	0201728	10
Insulating sleeve, color: black	MPS-IH BK	0201731	10
Test plug, with solder connection up to 1 mm² conductor cross section, number of positions: 1, color: gray	MPS-MT	0201744	10
Plastic label, Sheet, white, unlabeled, can be labeled with: BLUEMARK ID COLOR, BLUEMARK ID, BLUEMARK CLED, PLOTMARK, CMS-P1-PLOTTER, mounting type: adhesive, Number of individual labels: 10, text field height: 9 mm, text field width: 11 mm	UC-EMLP (11X9)	0819291	10
Plastic label, Sheet, yellow, unlabeled, can be labeled with: BLUEMARK ID COLOR, BLUEMARK ID, BLUEMARK CLED, PLOTMARK, CMS-P1-PLOTTER, mounting type: adhesive, Number of individual labels: 10, text field height: 9 mm, text field width: 11 mm	UC-EMLP (11X9) YE	0822602	10
Plastic label, can be ordered: by sheet, white, labeled according to customer specifications, mounting type: adhesive	UC-EMLP (11X9) CUS	0824547	1
Plastic label, can be ordered: by sheet, yellow, labeled according to customer specifications, mounting type: adhesive	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, Number of individual labels: 10, text field height: 9 mm, text field width: 11 mm	UC-EMLP (11X9) SR	0828094	10
Plastic label, can be ordered: by sheet, silver, labeled according to customer specifications, mounting type: adhesive, Number of individual labels: 10	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, Number of individual labels: 135, text field height: 9 mm, text field width: 11 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, Number of individual labels: 135, text field height: 9 mm, text field width: 11 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, Number of individual labels: 135, text field height: 9 mm, text field width: 11 mm	US-EMLP (11X9) SR	0828872	10

Accessories	Type	Item no.	Pcs./Pkt.
Device marker, Sheet, white, unlabeled, can be labeled with: TOPMARK NEO, TOPMARK LASER, mounting type: adhesive, Number of individual labels: 255, text field height: 9 mm, text field width: 11 mm	LS-EMLP (11X9) WH	0831678	10
Device marker, Sheet, silver, unlabeled, can be labeled with: TOPMARK NEO, TOPMARK LASER, mounting type: adhesive, Number of individual labels: 255, text field height: 9 mm, text field width: 11 mm	LS-EMLP (11X9) SR	0831705	10
Device marker, Sheet, yellow, unlabeled, can be labeled with: TOPMARK NEO, TOPMARK LASER, mounting type: adhesive, Number of individual labels: 255, text field height: 9 mm, text field width: 11 mm	LS-EMLP (11X9) YE	0831732	10
Power and fault signaling module with screw connection, including corresponding ME 17,5 TBUS 1,5/ 5-ST-3,81 GY DIN rail connector	MACX MCR-PTB	2865625	1
Power and fault signaling module with Push-in connection, including corresponding ME 17,5 TBUS 1,5/ 5-ST-3,81 GY DIN rail connector	MACX MCR-PTB-SP	2924184	1
Primary-switched power supply, QUINT POWER, screw connection, DIN rail mounting, supply of devices possible via the TBUS DIN rail connector, protective coating, input: single-phase, output: 24 V DC/2.5 A	QUINT4-SYS-PS/1AC/24DC/2.5/SC	2904614	1
Actuation tool, for ST terminal blocks, insulated, also suitable for use as a bladed screwdriver, size: 0.6 x 3.5 x 100 mm, 2-component grip, with non-slip grip	SZS 0,6X3,5	1205053	10

4 Technical data

Hardware/firmware version	
Hardware/firmware version (1050228)	07 / 01
Hardware/firmware version (1052459)	07 / 01

The technical data and safety characteristics are valid as of the specified HW/FW version.

Input data Thermocouples	
Sensor types that can be used (TC)	B, E, J, K, N, R, S, T, L, U, C, D, A-1, A-2, A-3, M, Lr
Temperature measuring range	-250 °C ... 2500 °C (Range depending on the sensor type)
Voltage	-1000 mV ... 1000 mV
Temperature measuring range	Min. 50 K with thermocouple, 10% of the nominal span of the respective range with mV sources

Output data Current output	
Configurable/programmable	Yes
Current output signal	0 mA ... 20 mA 4 mA ... 20 mA (SIL)
Load/output load current output	≤ 600 Ω
Output ripple (current)	< 15 μA_{PP} < 10 μA_{rms}
Behavior in the event of a sensor error	Freely definable

General data	
Nominal supply voltage	24 V DC -20 % ... +25 %
Supply voltage range	19.2 V DC ... 30 V DC
Max. current consumption	< 40 mA (24 V DC)
Power dissipation	≤ 0.76 W
Power consumption	≤ 1 W
Transmission error, typical	0.1 % (For full identification of transmission errors, see the data sheet)
Temperature coefficient, typical	0.01 %/K
Cold point error, max.	± 2 K
Step response (0–99%) with filter factor = 1	1 s ≤ 1.7 s
Degree of protection	IP20
Flammability rating according to UL 94	V0 (Housing)
Status display	Green LED (supply voltage) Red LED, flashing 2.4 Hz (cable error, sensor error on input or output, ERR) Red LED, flashing 1.2 Hz (service operation, ERR) Red LED, permanently on (module error, ERR)

General data	
Dimensions W/H/D	12.5 mm / 112.5 mm / 113.7 mm (MACX MCR-TC-I) 12.5 mm / 112.5 mm / 113.7 mm (MACX MCR-TC-I-C)
Depth (Snapped onto DIN rail NS 35/7,5 in accordance with EN 60715)	114.5 mm
Type of housing	PA 6.6-FR

Ambient conditions	
Ambient temperature (operation)	-40 °C … 70 °C (Any mounting position)
Ambient temperature (storage/transport)	-40 °C … 80 °C
Permissible humidity (operation)	5 % … 95 % (non-condensing)
Altitude Ambient temperature (operation) Rated insulation voltage	≤ 2000 m -40 °C … 70 °C 300 V_{rms}
Height range Ambient temperature (operation) Rated insulation voltage	> 2000 m … 3000 m -40 °C … 60 °C 150 V_{rms}
Height range Ambient temperature (operation) Rated insulation voltage	> 3000 m … 4000 m -40 °C … 55 °C 150 V_{rms}
Height range Ambient temperature (operation) Rated insulation voltage	> 4000 m … 5000 m -40 °C … 49 °C 150 V_{rms}

Electrical isolation (≤ 2000 m above mean sea level)	
Electrical isolation	3-way isolation
Test voltage Overvoltage category Pollution degree	2.5 kV AC (50 Hz, 60 s) II 2
Input/output/power supply Standards/regulations Rated insulation voltage Insulation	 IEC/EN 61010-1 300 V_{rms} Safe isolation
Input/output Standards/regulations Rated insulation voltage	 IEC/EN 60079-11 375 V_{PP}
Input/power supply Standards/regulations Rated insulation voltage	 IEC/EN 60079-11 375 V_{PP}

Connection data	
Connection method	Screw connection
Conductor cross section, rigid	0.2 mm² … 2.5 mm²
Conductor cross section, flexible	0.2 mm² … 2.5 mm²
Conductor cross section AWG	24 … 14
Stripping length	7 mm
Tightening torque	0.5 Nm … 0.6 Nm
Diameter Test socket in the connector	2 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	
CE CE-compliant and EN 61326	
ATEX IBExU19ATEX1006 X	II 3 G Ex ec ic IIC T4 Gc
IECEx IECEx IBE 19.0001 X	Ex ec ic IIC T4 Gc
UL, USA/Canada	UL 61010 Listed Class I, Div. 2, Groups A, B, C, D T4 Class I, Zone 2, Group IIC T4
Shipbuilding approval DNV GL TAA00000AG	
Temperature	B
Humidity	B
Vibration	A
EMC	B
Enclosure	Required protection according to the Rules shall be provided upon installation on board
Safety Integrity Level (SIL, IEC 61508) SEBS-A.150520/17, V2.0	2
Systematic Capability	2
INMETRO DNV 21.0064 X	Ex ec ic IIC T4 Gc
EAC Ex BY/112 02.01 TP012 103.01 00082	2Ex ec ic IIC T4 Gc

5 Safety regulations and installation notes

5.1 Installation notes

- The EPL Gc (ATEX category 3) device is suitable for installation in zone 2 potentially explosive areas. It satisfies the requirements of the following standards:
  IEC/EN 60079-0, IEC/EN 60079-7, IEC/EN 60079-11
  ABNT NBR IEC 60079-0, ABNT NBR IEC 60079-7, ABNT NBR IEC 60079-11
  For detailed information, please refer to the declarations of conformity.
- Installation, operation, and maintenance may only be carried out by qualified electricians. Follow the installation instructions as described.
- When installing and operating the device, observe the applicable regulations and safety directives (including national safety directives), as well as the generally recognized technical regulations.
- Observe the safety information, conditions, and limits of use specified in the product documentation. Comply with them.
- The device must not be opened or modified. Do not repair the device yourself, replace it with an equivalent device. Repairs may only be carried out by the manufacturer. The manufacturer is not liable for damage resulting from violation.
- While the devices are in operation, contact-dangerous voltages may be present on the control elements. For this reason parameterization, conductor connection, and opening of the module lid are allowed only when devices are in a de-energized state unless the connected circuits are exclusively SELV or PELV circuits.
- The IP20 degree of protection (IEC/EN 60529) specifies that the device is intended for use in a clean and dry environment. Do not subject the device to mechanical and/or thermal stress that exceeds the specified limits.
- The device complies with the EMC regulations for industrial areas (EMC class A). When using the device in residential areas, it may cause radio interference.
- Only Phoenix Contact devices may be connected to the programming interface that have been specified for this – see respective data sheet.
- A SELV/PELV power supply unit with a nominal voltage of 24 V DC (max. 30 V DC) is needed for the external power supply of the device.
- Only use copper connecting cables.
- The USB programming adapter may not be connected, disconnected, or used in potentially explosive areas.

5.2 Installation in the Ex area (zone 2)

- Observe the specified conditions for use in potentially explosive areas. For installation, use a suitable approved housing with a minimum degree of protection of IP54 that meets the requirements of IEC/EN 60079-7 or another degree of protection in accordance with ABNT NBR IEC 60079-7, Section 1. 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 the Ex zone.
- In potentially explosive areas, connecting and disconnecting cables and plugs in non-intrinsically safe circuits and the latching of devices onto and unlatching devices from the DIN rail connector is only permitted in a de-energized state or when the atmosphere is not potentially explosive.
- The device must be stopped and immediately removed from the Ex area if it is damaged, was subject to an impermissible load, stored incorrectly or if it malfunctions.

5.3 Potentially dust-explosive areas

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

5.4 Safety-related applications (SIL)

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

5.5 UL notes

PROCESS CONTROL EQUIPMENT FOR HAZARDOUS LOCATIONS

1 WARNING EXPLOSION HAZARD - Do not disconnect equipment unless power has been removed or the area is known to be non-hazardous.

2 WARNING - EXPLOSION HAZARD - Substitution of components may impair suitability for Class I, Zone 2/Division 2.

6 Installation

6.1 Connection notes

WARNING: Electrical danger due to improper installation

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

- Disconnecting devices and branch circuit protection with suitable AC or DC rating shall be provided in the building installation.
- The device is intended for installation in a control cabinet or in a comparable enclosure. The device may only be operated when it has been installed. The control cabinet must meet the requirements of UL/IEC 61010-1 in terms of protection against spread of fire and protection against electric shock or burn.
- Provide for a switch/circuit-breaker in the vicinity of a device that is marked as disconnect device for this device.
- Provide for an overcurrent protection device (I ≤ 16 A) in the installation.
- For UL applications, install a UL-approved (JDYX2) overcurrent protection unit (I ≤ 16 A, U > 30 V DC, usable in DC circuits, slow-blow) in the installation.
- To protect the device against mechanical or electrical damage, install it in suitable housing with an appropriate degree of protection according to IEC/EN 60529.
- During maintenance work, disconnect the device from all effective power sources.
- 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 V_{eff}. 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.

6.2 Electrostatic discharge

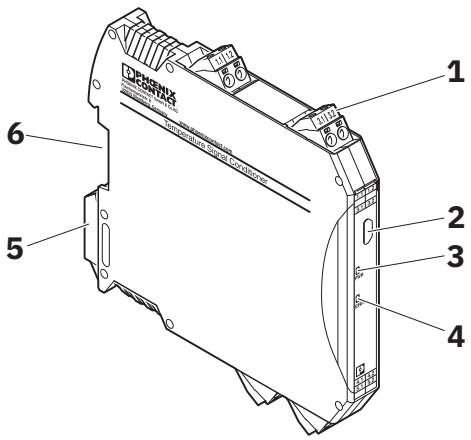
NOTE: Electrostatic discharge

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 EN 61340-5-1 and EN 61340-5-2.

Take protective measures against electrostatic discharge before operating or installing the device.

6.3 Structure

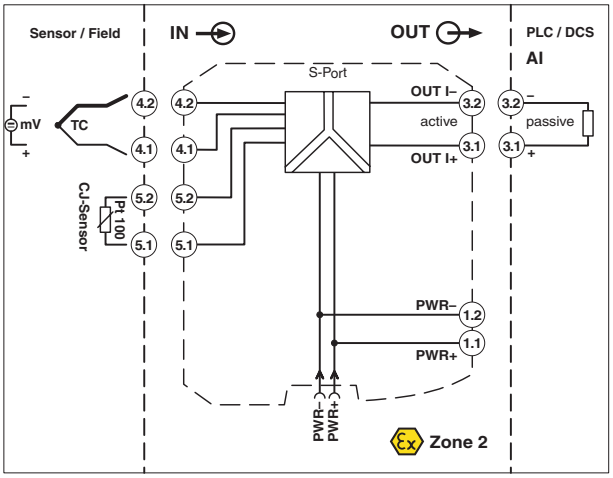
Figure 1 Structure



1 COMBICON plug-in screw terminal block; not pluggable on the Ex i side
2 Programming socket for connection of the programming adapter
3 Green “PWR” LED, power supply
4 Error indicator "ERR" red LED
5 Snap-on foot for DIN rail mounting
6 Connection for DIN rail connector

6.4 Basic circuit diagram with connection terminal blocks

Figure 2 Basic circuit diagram



6.5 Temperature measurement with thermocouple sensors

For temperature measurements with thermocouple sensors, you must connect connection points 4.1 and 4.2, taking the polarity of the sensor into account.

Sensor type			According to	Measuring range	Smallest measuring range span
B	≙	Pt 30 Rh-Pt 6 Rh	IEC/EN 60548	+500 °C ... +1820 °C	50 K
E	≙	NiCr-CuNi	IEC/EN 60548	-230 °C ... +1000 °C	50 K
J	≙	Fe-CuNi	IEC/EN 60548	-210 °C ... +1200 °C	50 K
K	≙	NiCr-Ni	IEC/EN 60548	-250 °C ... +1372 °C	50 K
N	≙	NiCrSi-NiSi	IEC/EN 60548	-250 °C ... +1300 °C	50 K
R	≙	Pt 13 Rh-Pt	IEC/EN 60548	-50 °C ... +1768 °C	50 K
S	≙	Pt 10 Rh-Pt	IEC/EN 60548	-50 °C ... +1768 °C	50 K
T	≙	Cu-CuNi	IEC/EN 60548	-200 °C ... +400 °C	50 K
L	≙	Fe-CuNi	DIN 43760	-200 °C ... +900 °C	50 K
U	≙	Cu-CuNi	DIN 43760	-200 °C ... +600 °C	50 K
CA	≙	C ASTM JE988 (2002)		0 °C... +2315 °C	50 K
DA	≙	D ASTM JE988 (2002)		0 °C... +2315 °C	50 K
A1G	≙	A-1 GOST 8.585-2001		0 °C ... +2500 °C	50 K
A2G	≙	A-2 GOST 8.585-2001		0 °C ... +1800 °C	50 K
A3G	≙	A-3 GOST 8.585-2001		0 °C ... +1800 °C	50 K
MG	≙	M GOST 8.585-2001		-200 °C ... +100 °C	50 K
LG	≙	L GOST 8.585-2001		-200 °C ... +100 °C	50 K

Cold junction compensation

The device has an internal sensor for cold junction compensation.

When measuring mV voltages, cold junction compensation is automatically switched off.

You can set cold junction compensation to a fixed value via software.

6.6 Measuring mV voltages

Terminal points 4.1 (“+” input) and 4.2 (“-” input) can be used for measuring voltages in the range of -1000 mV ... +1000 mV.

6.7 Power supply

You must refer to the “MACX and MINI Analog power manual“ for the design of the power supply; it is available to download at www.phoenixcontact.com/products under the item listing.

NOTE

Never connect the supply voltage directly to the DIN rail connector. It is not permitted to draw power from the DIN rail connector or from individual modules.

The supply voltage can be supplied via connection terminal blocks 1.1 (+) and 1.2 (-) or via the DIN rail connector.

Supply via the MACX Analog module

Where the total current consumption of the aligned modules does not exceed 400 mA, the power can be supplied directly at the connection terminal blocks of the module.

Up to 16 modules can be supplied depending on the current consumption of the modules.

We recommend connecting a 630 mA fuse (normal-blow or slow-blow) upstream.

Supply via power and error message module

The MACX MCR-PTB (Item No. 2865625) or the MACX MCR-PTB-SP (Item No. 2924184) supply and error message module is used to provide the supply voltage to the DIN rail connector.

Simple or redundant diode-decoupled power supply is possible.

Depending on the current consumption of the modules, up to 150 individual modules can be supplied by a supply that is protected by a fuse.

The module has integrated error evaluation. An auxiliary supply failure or fuse fault is indicated at a relay contact and displayed via a flashing LED.

Supply via a system power supply unit

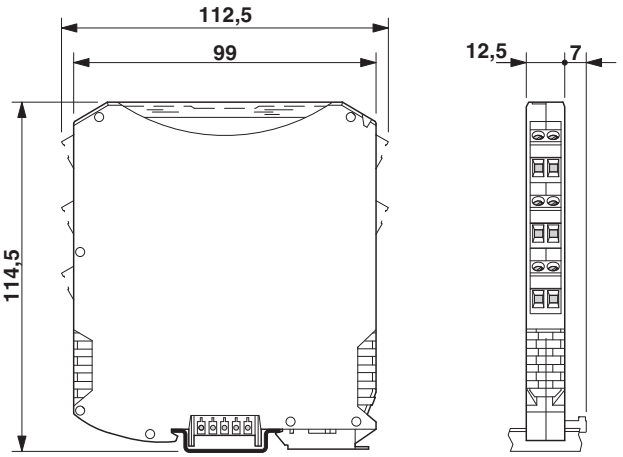
Use the QUINT4-SYS-PS/1AC/24DC/2.5/SC (Item No. 2904614) as the system power supply.

The power supply can be installed on all 35 mm DIN rails in accordance with EN 60715. The normal mounting position is horizontal (input terminals facing down). The minimum clearance to other devices is 30 mm above/below.

If you would like to supply adjacent items using the power supply, use a DIN rail bus distributor. To do so, insert the DIN rail bus adapter ME 22,5 TBUS ADAPTER KMGY (Item No.: 2201756) and the DIN rail connector ME 17,5 TBUS 1,5/ 5-ST-3,81 KMGY (Item No.: 2713645) plugged together in the DIN rail.

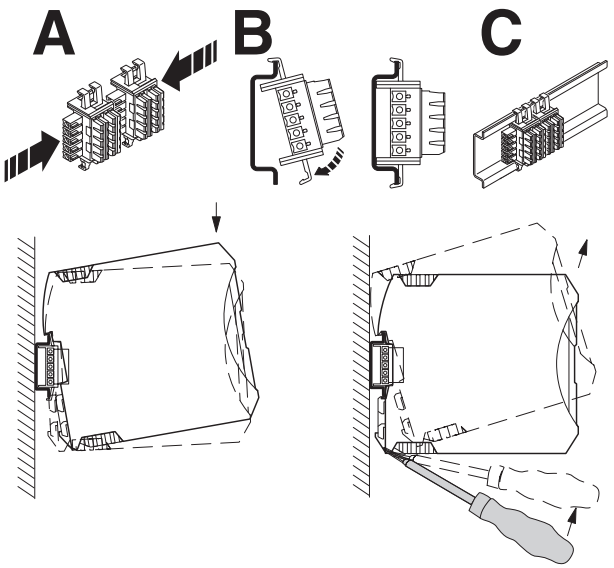
6.8 Dimensions

Figure 3 Dimensions



6.9 Mounting

Figure 4 Mounting and removing



- Mount the device on a 35 mm DIN rail in accordance with EN 60715.
- When using the DIN rail connector, first insert it in the 35 mm DIN rail in accordance with EN 60715 (A – C). DIN rails with a height of 7.5 mm or more can be used. The DIN rail connector is used to bridge the power supply and communication.
- The snap-in direction of device (D) and DIN rail connector (C) must be observed: snap-on foot on the bottom and connector on the left.
- Install the module in a suitable housing to meet the requirements for the protection class.
- Before startup, check that the device is operating and wired correctly, in particular with regard to the wiring and marking of the intrinsically safe circuits.

6.10 Partition plate

If you want to mount Ex i and non-Ex i devices next to each other on a DIN rail, you will require the MCR-DP partition plate (item no. 1430594). The partition plate ensures that Ex i isolating distances are maintained.

The partition plate is tailored to the MINI Analog, MINI Analog Pro, and MACX Analog device series and the QUINT4 system power supply (item no. 2904614).

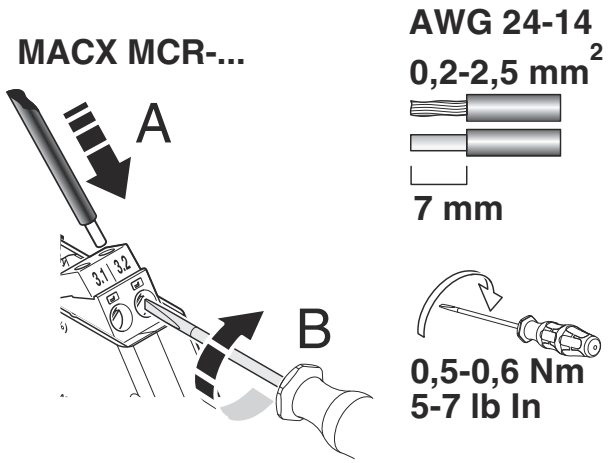
The partition plate is compatible with the ME … TBUS DIN rail connectors (e.g., item no. 1090049, 2695439).

6.11 Connecting the cables

- Screw terminal blocks: fit the litz wires with ferrules, permitted conductor cross section: 0.2 mm² to 2.5 mm²
- Install intrinsically safe and non-intrinsically safe cables separately.

Screw connection

Figure 5 Screw connection



- Strip the wire by approximately 7 mm and crimp the ferrules.
- Insert the wire into the corresponding connection terminal block.
- Use a screwdriver to tighten the screw in the opening above the connection terminal block.
  Tightening torque: 0.6 Nm

6.12 LED status indicators

LED	Color/status	Description
PWR	Green	Supply voltage
	On	Ready to operate
		Configuration without device supply via IFS-USB-PROG-ADAPTER programming adapter
DAT	Green	Currently with no function
ERR	Red	Error
	On	Module error
	Flashing (1.2 Hz)	Service mode
	Flashing (2.4 Hz)	Line error

6.13 Startup

- Before startup, check that the device is operating and wired correctly.

6.14 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.

Short circuits of thermocouples and mV sources cannot be detected because 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.

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 4.1 and 4.2, a 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.

Output monitoring function

The current output can be monitored for line breaks and maximum load. This is activated via the configuration. In safety-relevant applications (SIL = ON), output monitoring is always active.

7 Configuration

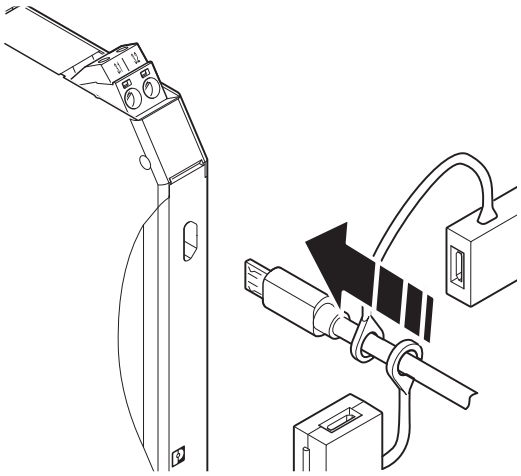
WARNING - Explosion Hazard

If configuring for zone 2, the PC must be approved for use in zone 2!

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.

The configuration software can be downloaded as a DTM and as a standalone clipx ENGINEER version free of charge from: www.phoenixcontact.com/products. The online manual and the online help for the intuitive software explain the configuration, parameterization, and service options (e.g., online monitoring) and their use.

Figure 6 IFS-USB-PROG-ADAPTER



- Connect the device and PC using the IFS-USB-PROG-ADAPTER programming adapter (Item No. 2811271).

Alternatively, you can use the Bluetooth programming adapter (Item No. 2905872).

7.1 System requirements

For a complete list of system requirements, please refer to the clipx ENGINEER website at https://www.phoenixcontact.com/product/1272241.

Use the IFS-USB-PROG-ADAPTER (Item No.: 2811271) for connecting the device to the PC. The drivers for the USB programming adapter are installed automatically.

Alternatively, you can use the Bluetooth programming adapter (Item No. 2905872).

8 Minimum spans and measuring accuracy

8.1 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

8.2 Input for voltage signals

Minimum measuring span: 10% of the nominal span of the relevant range

Measuring accuracy:

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

8.3 Cold junction error

Cold junction error: max. ±2 K after transient period (with internal cold junction compensation).

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

The maximum cold junction transient period after an ambient temperature change >10 K is 10 minutes.

8.4 Output signals

Error analog output

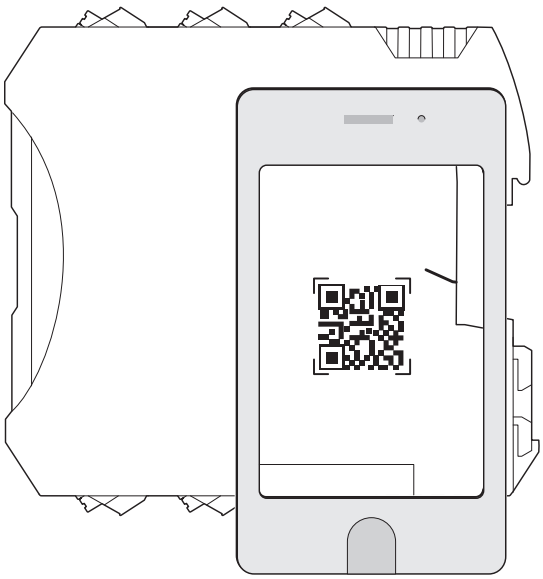
4 µA, 0.02% at 0 mA ... 20 mA

9 Digital nameplate

The digital nameplate provides the option of obtaining product-specific data related to a specific serial number.

If you scan the QR code (digital nameplate) on the device, you can, for example, retrieve documents on the production status as well as clearly identify the hardware and firmware status of the device at hand.

Figure 7 Scan QR code



10 Safety-related applications

The following notes apply for the devices:

Designation	Item No.
Standard configuration	
MACX MCR-TC-I	1050228
Order configuration	
MACX MCR-TC-I-C	1052459

The devices listed above are certified by TÜV Nord.

Certificate number: SEBS-A.150520/17, V 2.0

10.1 Safety function and safety requirements

The safety-relevant devices are used to acquire a sensor signal (thermocouple) or millivolt signal 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 downstream of the device (e.g. safety-relevant PLC) must recognize these states and control the actuator as the final link in the safety chain accordingly.

If an internal fault is detected, the device also switches to the safe state (current output <3.6 mA or >21 mA).

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

The device is released (restarted) by switching off the supply voltage and switching it back on again, by resetting the device 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 the fault is still present, the devices 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 device and to which the device responds by switching to the safe state are safe faults (λs).

Faults where the device 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

Function	Output signal	Safe state	Cause
Safety function	4 mA ... 20 mA	<3.6 mA or >21 mA relay is not actuated	Deviation >5%
Input monitoring	4 mA ... 20 mA	2 mA ... 3,6 mA, >21 mA	Line fault, input
Output monitoring	4 mA ... 20 mA	= 0 mA	Line fault, output

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

Please note that the scope of monitoring functions is limited when using mV sources (see "Function limitations").

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.

10.2 Safety integrity requirements

Due to the multiple connection options, only two configurations, for “thermocouple with external cold junction compensation” and “millivolt signal”, are considered in the following.

These are representative of all configurations at the input terminals and reflect the most conservative case.

FIT (Failure in Time)
1 FIT is 1 failure per 10^9 hours

10.2.1 Error rates

NOTE
The specified safety characteristics only relate to the device and do not include the connected sensors.

Input	Thermocouple with external cold junction compensation
Output	Analog output 4 mA ... 20 mA

- Type B device (in accordance with IEC/EN 61508-2)
- Safety Integrity Level (SIL) 2 / SC 2
- Architecture $1oo1_D$
- HFT 0
- MTTR 24 h
- Ambient temperature 40°C

The failure rates in FIT for the entire device are as follows:

λ_{SU}	λ_{SD}	λ_{DU}	λ_{DD}	SFF	DC_D
240.1	0.8	34.6	403	94.2 %	92.5 %

The total failure rate is 678.5 FIT

The MTBF is 96 years.

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

PFD_{avg} values

T [PROOF]	1 year	2 years	5 years
PFD_{avg}	$1.514 * 10^{-4}$	$3.028 * 10^{-4}$	$7.57 * 10^{-4}$

PFH = $3.46 * 10^{-8}$/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 30 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 safety circuit is assumed to be 10%.

10.2.2 Error rates

Input	Millivolt signal
Output	Analog output 4 mA ... 20 mA

- Type B device (in accordance with IEC/EN 61508-2)
- Safety integrity level (SIL) 2
- Architecture $1oo1_D$
- HFT 0
- MTTR 24 h
- Ambient temperature 40°C

The failure rates in FIT for the entire device are as follows:

λ_{SU}	λ_{SD}	λ_{DU}	λ_{DD}	SFF	DC_D
240.1	0.8	39.8	394.4	93.8 %	93.7 %

The total failure rate is 674.3 FIT.

The MTBF is 96 years.

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

PFD_{avg} values

T [PROOF]	1 year	2 years	5 years
PFD_{avg}	$1.743 * 10^{-4}$	$3.485 * 10^{-4}$	$8.713 * 10^{-3}$

PFH = $3.98 * 10^{-8}$/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 30 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 safety circuit is assumed to be 10%.

10.3 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) should be 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.
– The specified error rates are based on an ambient temperature of +40°C. For an ambient temperature of +60°C, the error rates must be multiplied by factor 2.5. Factor 2.5 is based on guide values.
– The supplying power supply unit must be able to absorb an interruption to the supply voltage of 20 ms.

10.4 Configuring a SIL device

The following configuration options are available:

– The devices are delivered with a standard configuration for safety-relevant applications with a 4 mA ... 20 mA output.
– Customer-specific preconfigured devices (-C) can be delivered for both safety-relevant applications and “normal” applications.
– The devices can also be configured by users for both safety-relevant applications and “normal” applications.

You can read out and change the configuration of all devices at any time.

For safety-relevant applications, you should change the password set in the factory.

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

In this case, please contact Phoenix Contact.

Configuring safety-relevant applications

- Connect the device and PC using the IFS-USB-PROG-ADAPTER programming adapter (Item No. 2811271).
- Alternatively, you can also use the Bluetooth programming adapter (Item No. 2905872).
- Call up the clipx ENGINEER configuration software.
- Read out the current configuration.
- Enter the password in clipx ENGINEER in the “PIN” hardware configuration (set to 1111 in the factory).
- Activate/deactivate SIL.

In “SIL ON”, you can deactivate the “Restart after failsafe” function.

This means that in the event of a fault, the device enters the failsafe state in accordance with the safety functions, but is not restarted.

- Write the changed configuration data to the device.
- 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 professionals.

WARNING

If you activate Functional Safety or make configuration changes with Functional Safety activated, you must observe the rules in the section “Safety-relevant applications, installation and startup”.

WARNING: Limitations for safety-relevant applications

Only 4 mA ... 20 mA, limited programming of output current in the event of line faults ($2\ mA \leq I_{Out} \leq 3.6\ mA$ or $I_{Out} \geq 21\ mA$)

WARNING

Once new configuration data has been written, the device performs a warm start that changes the properties of the device.

Adapt the downstream control device to these modifications.

WARNING

The device must be write-protected to prevent improper use.

To apply write protection, issue a password.

10.5 Installation and startup

NOTE: Installation, operation, and maintenance may only be carried out by professionals.

During installation, observe the instructions in the package slip:

Designation	MNR No.
PACKB.MACX MCR-TC-I(-C)	1077326

The package slip is supplied with the device. It can also be downloaded at: www.phoenixcontact.com/products.

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

- Check that the configuration of the device is correct for the intended application.
- Connect the device according to the installation notes.
- Ensure that the connected sensor corresponds to the intended configuration.
- Check that the device operates correctly with the measuring transducer and sensor connected.
- A calibrated sensor simulator and a calibrated digital multimeter may be required in order to check the device with the measuring transducer connected.
- Start up the safety circuit and check that it operates correctly.

10.6 Notes on operation

In normal operation, only the green LED (PWR) is on.

If a malfunction occurs during operation and the red LED (ERR) flashes, there is a line fault.

The output current of the device is then between 2 mA … 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).

Check all signal lines.

The device will automatically switch back to normal operation once the fault has been eliminated.

If a fault occurs during operation and the red LED (ERR) is permanently lit, 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 via the configuration software (Service > Reset).

The device should then return to normal operation.

If not, you must replace the device.

10.7 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 must be configured as a life zero signal. As a result, a short circuit is detected as underrange.

Underrange therefore is always an error state.

When using the mV input, a resistance (10 kΩ / 0.6 W) must be connected between input terminals 4.1 and 4.2.

As a result, a sensor break is detected as underrange.

Underrange therefore is always an error state.

10.8 Recurring checks

The function of the entire safety loop must be checked regularly according to IEC/EN 61508 and IEC/EN 61511.

The intervals for checking are specified by the intervals of each individual device within the safety loop.

The devices must be checked at least every five years (maximum proof test interval).

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

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 and a calibrated digital multimeter are necessary for checking the devices.

1. Take appropriate steps to prevent incorrect use.
2. Disconnect the safety circuit from further processing.
3. Connect the sensor simulator to the input of the measuring transducer using the intended connection technology.
4. Connect the digital multimeter to the output in current measuring operating mode (20 mA range).
5. Restore the safety circuit to full functionality.
6. Resume normal operation.

10.9 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
Flachsmarktstr. 8
32825 Blomberg
GERMANY

10.10 Standards

The devices are developed and tested according to the following standards:

IEC/EN 61508-1: 2011	Functional Safety of electrical/electronic/programmable electronic safety-related systems - Part 1: General requirements
IEC/EN 61508-2: 2011	Functional Safety of electrical/electronic/programmable electronic safety-related systems - Part 2: Requirements for electrical/electronic/programmable electronic safety-related systems
IEC/EN 61326-1: 2006	Electrical equipment for measurement, control and laboratory use - EMC requirements
IEC/EN 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

10.11 Abbreviations

Abbreviation		Meaning
DC_D	Diagnostic coverage of dangerous failures	Diagnostic coverage of dangerous failures: $DC_D = \lambda_{DD}/(\lambda_{DU} + \lambda_{DD})$
DC_S	Diagnostic coverage of safe failures	Diagnostic coverage of safe failures: $DC_S = \lambda_{SD}/(\lambda_{SU} + \lambda_{SD})$
FIT	Failure in time	1 FIT = 1 failure/10^9 h
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
β	Common cause factor	Proportion of undetected failures as a result of a common cause
β_D	Common cause factor, diagnostic	Proportion of failures as a result of a common cause which are detected by the diagnostic test.
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
λ_{SD}	Rate of safe detectable failures	Proportion of detectable safe failures per hour
λ_{SU}	Rate of safe undetectable failures	Proportion of undetectable 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_D	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.

11 Revision history

Document revision	Hardware revision	Firmware revision	Date	Description
06	07 (1050228)	01 (1050228)	2024-08-12	Block diagram corrected
	07 (1052459)	01 (1052459)		Description of digital nameplate added
				New accessory MCR-DP (item no. 1430594) added
				NEPSI approval removed
				UKCA approval removed
				INMETRO approval added
				Update to SIL certificate (SC 2 added)