INSPIRING INNOVATIONS

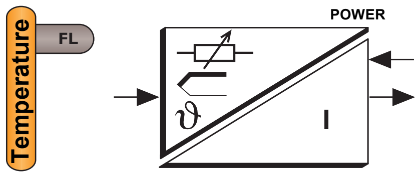
MCR-FL-HT-TS-I-EX

Programmable Intrinsically Safe Loop-Powered Temperature Measuring Transducer for Connection Head With HART® Protocol

INTERFACE

Data Sheet

1 Description



Universal PC programmable temperature measuring transducers convert temperature signals from resistance thermometers and thermocouples as well as sensors with linear mV characteristic curves to analog 4 ... 20 mA signals.

On the output side the temperature measuring transducer is operated in a 4 ... 20 mA current loop, which simultaneously provides the devices with the required power for signal conversion.

The configuration data can be set via the HART® protocol. A programming adapter can be used for this in conjunction with the MCR-PI-CONF-WIN configuration software (Order No. 2814799) or a hand-held operator panel (e.g., DXR 275 from Emerson).

Customer-specific measuring range settings, linearization, and characteristic curve adjustments can also be implemented in this way. With a 2-wire circuit, the cable resistance can be compensated.

Failure information in the event of sensor break or sensor short-circuit can be set according to NE 43. This measuring transducer maintains a high level of accuracy throughout the entire ambient temperature range.

The devices are supplied with the following default configuration: Pt 100 sensor, measuring range 0°C ... +100°C, 3-wire connection.

Features

– For resistance thermometers, thermocouples, resistance-type and voltage sensors
– For installation in connection head, form B
– Application in potentially explosive areas
– Application for safety-related functions

Observe the safety instructions on page 5.

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

A conversion table is available on the Internet at www.download.phoenixcontact.com/general/7000_en_00.pdf.

PHOENIX CONTACT GmbH & Co. KG • 32823 Blomberg • Germany
Phone: +49 - 52 35 - 30 0 • Fax: +49 - 52 35 - 34 12 00 • www.phoenixcontact.com
www.phoenixcontact.com/salesnetwork

Input Signals

	Designation	Measuring Range Limits	Minimum Measurement Range
Resistance Thermometer (RTD)	Pt 100	-200°C ... +850°C	10 K
	Pt 500	-200°C ... +250°C	10 K
	Pt 1000	-200°C ... +250°C	10 K
	According to IEC 60751		
	Ni 100	-60°C ... +250°C	10 K
	Ni 500	-60°C ... +150°C	10 K
	Ni 1000	-60°C ... +150°C	10 K
	According to DIN 43760		
	– Connection method: 2, 3 or 4-wire termination – With 2-wire termination, the cable resistance can be compensated using software (0 Ω ... 30 Ω) – With 3 and 4-wire termination, sensor cable resistance up to a maximum of 11 Ω per cable – Sensor current ≤ 0.2 mA		
Resistance-Type Sensor	Resistance (Ω)	10 Ω ... 400 Ω	10 Ω
		10Ω ... 2000 Ω	100 Ω
Thermocouple (TC)	**Designation**	**Measuring Range Limits**	**Minimum Measurement Range**
	B (PtRh30-PtRh6)	0°C ... +1820°C	500 K
	C (W5Re-W26Re)[1]	0°C ... +2320°C	500 K
	D (W3Re-W25Re)[1]	0°C ... +2495°C	500 K
	E (NiCr-CuNi)	-270°C ... +1000°C	50 K
	J (Fe-CuNi)	-210°C ... +1200°C	50 K
	K (NiCr-Ni)	-270°C ... +1372°C	50 K
	L (Fe-CuNi)[2]	-200°C ... +900°C	50 K
	N (NiCrSi-NiSi)	-270°C ... +1300°C	50 K
	R (PtRh13-Pt)	-50°C ... +1768°C	500 K
	S (PtRh10-Pt)	-50°C ... +1768°C	500 K
	T (Cu-CuNi)	-270°C ... +400°C	50 K
	U (Cu-CuNi)[2]	-200°C ... +600°C	50 K
	According to IEC 60584-1		
	– Reference junction: Internal (Pt 100) – Reference junction accuracy: ±1 K		
Voltage Sensor (mV)	Millivolt sensor (mV)	-10 mV ... 75 mV	5 mV

[1] According to ASTM E988

[2] According to DIN 43710

2 Ordering Data

Temperature Measuring Transducer for Connection Head

Description	Type	Order No.	Pcs./Pck.
MCR temperature measuring transducer for connection head, for resistance thermometers, thermocouples, resistance-type sensors and voltage sensors	MCR-FL-HT-TS-I-EX	2864545	1

Software

Description	Type	Order No.	Pcs./Pck.
Configuration software	MCR-PI-CONF-WIN	2814799	1

3 Technical Data

Input	
Resistance thermometers	Pt 100, Pt 500, Pt 1000 and Ni 100, Ni 500, Ni 1000 in 2, 3 or 4-wire technology; minimum measurement range 10 K
Thermocouple sensors	B, C, D, E, J, K, L, N, R, S, T, U; minimum measurement range 50 K/500 K
Linear mV signals	-10 mV ... +75 mV; minimum measurement range 5 mV
Resistance-type sensors	10 Ω ... 2000 Ω and 10 Ω ... 400 Ω; minimum measurement range 10 Ω/100 Ω

Output	
Output signal	4 mA ... 20 mA/20 mA ... 4 mA
Maximum output signal	≤ 23 mA
Maximum load	(V_{supply} - 10 V)/0.023 A
Output signal in the event of open circuit/short circuit (not for thermocouples)	≤ 3.6 mA/≥ 21.0 mA (configurable)
Measuring range overrange/underrange	≤ 20.5 mA/≥ 3.8 mA (linear increase/decrease)

General Data	
Supply voltage	12 V DC ... 30 V DC
Permissible residual ripple	$U_{PP} \leq 3$ V at $U_b \geq 13$ V and f_{max} = 1 kHz
Maximum current consumption	< 3.5 mA
Transmission error[1]	
Resistance Thermometer (RTD)	0.2 K or 0.08% (Pt 100, Ni 100), 0.5 K or 0.20% (Pt 500, Ni 500), 0.3 K or 0.12% (Pt 1000, Ni 1000)
Thermocouple (TC)	0.5 K or 0.08% (K, J, T, E, L, U), typical, 1.0 K or 0.08% (N, C, D), typical, 2.0 K or 0.08% (S, B, R), typical
Resistance-type sensor (Ω)	±0.1Ω or 0.08% (10 Ω ... 400 Ω), ±1.5 Ω or 0.12% (10 Ω ... 2000 Ω)
Voltage sensor (mV)	±20 µV or 0.08% (-10 mV ... 75 mV)
Influence of the ambient temperature (temperature drift)	
Resistance thermometer (RTD)	Td = ±(15 ppm/K x maximum measuring range + 50 ppm/K x set measuring range) x $\Delta\vartheta$)[2]
Resistance thermometer (Pt100)	Td = ±(15 ppm/K x (measuring range final value + 200) + 50 ppm/K x set measuring range) x $\Delta\vartheta$)[2]
Thermocouple (TC)	Td = ±(50 ppm/K x maximum measuring range + 50 ppm/K x set measuring range) x $\Delta\vartheta$)[2]
Influence of the load[3]	≤ ±0.02%/100 Ω
Response time	< 2 s
Switch-on delay	6 s
Test voltage (input/output)	2 kV AC, 50 Hz, 1 minute
Ambient temperature range	
Operation	See "Safety Data" on page 4
Storage	-40°C ... +100°C
Climatic class	Class C according to EN 60654-1

General Data (Continued)

Condensation	Permitted
Degree of protection	IP00, IP66 (installed in connection head)
Mounting position	Any
Installation position	Connection head according to DIN 43729 form B
Resistance to shock and vibration	4g/2 Hz ... 150 Hz according to IEC 60068-2-6
Configuration	Via HART® protocol
Housing material	Polycarbonate (PC), sealing material (PUR)
Dimensions (diameter x height)	44 mm x 21 mm
Weight	40 g, approximately
Connection data	
Solid	0.2 mm^2 ... 1.75 mm^2
Stranded	0.2 mm^2 ... 1.75 mm^2

[1] Percentage values refer to the set measurement range.

[2] $\Delta\vartheta$ = Difference between the ambient temperature and the reference condition.

[3] All data refers to the measuring range final value.

Conformance With EMC Directive 89/336/EEC

Noise emission	EN 61326 and NAMUR NE 21
Immunity to interference	EN 61326 and NAMUR NE 21

Safety Data

Maximum input voltage U_i	30 V	
Maximum input current I_i	100 mA	
Maximum input power P_i	750 mW	
Maximum output voltage U_o	5 V DC	
Maximum output current I_o	5.4 mA	
Maximum output power P_o	6.6 mW	
Maximum ambient temperature range		
Category 1	T6 = -20°C ... +40°C, T5 = -20°C ... +50°C, T4 = -20°C ... +60°C	
Category 2	T6 = -40°C ... +55°C, T5 = -40°C ... +70°C, T4 = -40°C ... +85°C	
Gas group without existing concentrated external inductance and capacitance		
Maximum external inductance L_o	1000 mH	
Maximum external capacitance C_o	10 µF	
Gas group with existing concentrated external inductance and capacitance	II A/II B	II C
Maximum external inductance L_o	100 mH	100 mH
Maximum external capacitance C_o	9.9 µF	2 µF

Approvals

CE	CE
ATEX	Ex II 1 G and II 2 G EEx ia IIC T6/T5/T4 PTB 02 ATEX 2028
UL	c UL us

LISTED

Cl. I Zn. 0, Ex ia IIC T4/T5/T6

Cl. I Div. 2, Groups A, B, C and D

C.D. No. 83035297

A) This equipment is suitable for use in Class I, Division 2, Groups A, B, C and D or non-hazardous locations only.

B) Warning - explosion hazard - substitution of components may impair suitability for Class 1, Division 2.

C) Warning - explosion hazard - do not disconnect equipment unless power has been switched off or the area is known to be non-hazardous.

4 Safety Instructions

4.1 Explosion Protection

- **Install the device according to the manufacturer's instructions and the relevant standards and regulations.**
- **Parameterization in the Ex area is also permitted with an approved hand-held operator panel. Observe the relevant regulations for connecting intrinsically safe circuits together.**

Safety Instructions for Zones 1 and 2

This item of equipment can be used in zone 1 (II 2G) or zone 2 (II 3G). The sensor circuit should be inserted in zone 0 (II 1G).

Safety Instructions for Zone 0

This information must only be observed if the device is installed directly in zone 0.

- **Explosive vapor/air mixtures must only occur under atmospheric conditions: -20°C $\leq T_a \leq$ +60°C and 0.8 bar $\leq p \leq$ 1.1 bar.**
- **If there are no explosive mixtures present or additional measures have been met according to EN 61127-1, the devices may also be operated outside the atmospheric conditions according to the manufacturer's specifications.**
- **The supply circuit must meet protection type EEx ia IIC (EN 60079-14 12.3).**
- **The devices must only be used in measurement media, to which the materials used in the process are sufficiently resistant.**
- **When operating the entire device in zone 0, the compatibility of the device materials with the measurement media must be ensured (polycarbonate (PC) housing, polyurethane (PUR) sealant).**
- **The temperature measuring transducer must be installed in such a way that there is no risk of electrostatic discharge, e.g., by installing it in a grounded metal head or in grounded housing.**

For use in the USA, Control Drawing No. 83035297 must be taken into account due to UL approval (see page 14).

4.2 Use in Safety-Related Protective Functions (SIL)

The device is used for temperature measurements, which must meet the special requirements of safety technology according to IEC 61508/IEC 61511-1.
This is the case when used in safety-related protective functions to prevent overtemperature and undertemperature.

5 Structure

5.1 Block Diagram

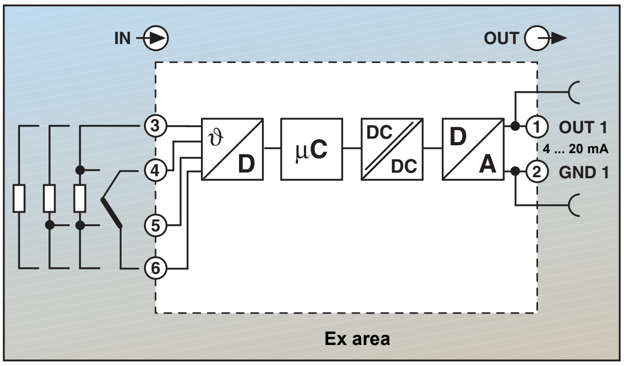


Figure 1 Block diagram

5.2 Dimensions

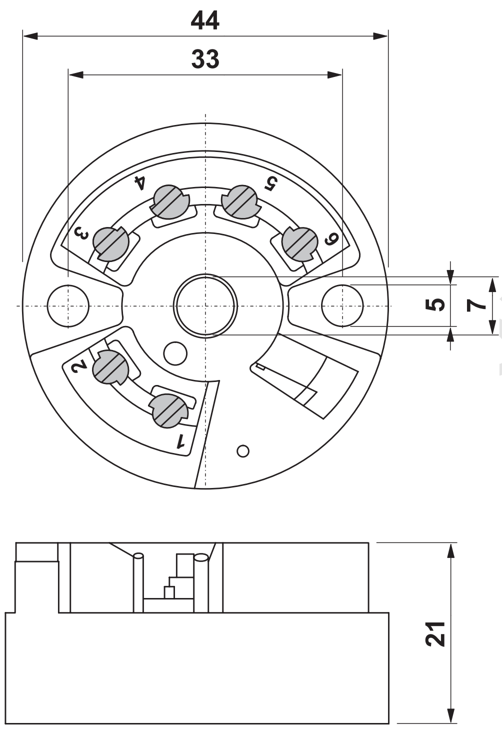


Figure 2 Dimensions (in mm)

6 Use in Safety-Related Protective Functions

The temperature measuring transducer for connection head is suitable for use in a safety-related protective function according to IEC 61511-1 if the corresponding safety information is observed.

FMEDA gives the following parameters:

SIL	2		
Test interval	1 year		
Device type	B		
HFT[1]	0 (single-channel application)		
SFF	> 73%		
PFD_{AVG}[2]	4.69×10^{-4}		
MTBF[3]	263 years		
Safety function[4] monitoring	Minimum	Maximum	Range
λ_{sd}	26 FIT	101 FIT	117 FIT
λ_{su}	165 FIT	165 FIT	165 FIT
λ_{dd}	108 FIT	33 FIT	17 FIT
λ_{du}	107 FIT	107 FIT	107 FIT

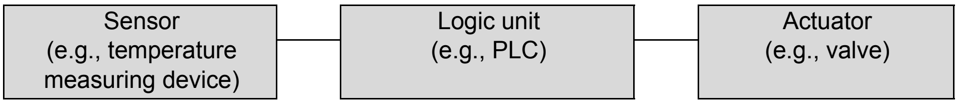
[1] According to Section 11.4.4 of IEC 61511-1

[2] The value is within the range defined for SIL 2 according to ISA S84.01 and IEC 61511-1

[3] According to Siemens SN29500

[4] Assuming that the setting is 4 mA ... 20 mA

The device has been assessed including any modifications as part of operational testing certification.



PFD_{AVG}: ≤ 35% ≤ 15% ≤ 50%

Figure 3 Typical distribution of the "average probability of failure on demand for a safety function" (PFD_{AVG}) over subsystems

In this documentation the MCR-FL-HT-TS-I-EX is part of a safety function.

6.1 Safety Integrity Level MCR-FL-HT-TS-I-EX (Type B) (Device Version V1.02.08 or Later)

The following table shows the achievable Safety Integrity Level (SIL) of the overall safety-related system for type B systems depending on the safe failure fraction (SFF) and the hardware fault tolerance (HFT). Type B systems include, e.g., sensors with complex components such as ASICs (see also IEC 61508-2).

Safe Failure Fraction (SFF)	**Hardware Fault Tolerance (HFT)**		
	0	**1 (0)[1]**	**2 (1)[1]**
< 60%	Not permitted	SIL 1	SIL 2
60% ... < 90%	SIL 1	**SIL 2**	SIL 3
90% ... < 99%	SIL 2	SIL 3	–
≥ 99%	SIL 3	–	–

[1] According to IEC 61511-1, Section 11.4.3, the hardware fault tolerance (HFT) for sensors and actuators with complex components can be decreased by one (value in brackets), if the following requirements are met:

– The device has been operationally tested.

– The user can only configure process-related parameters, e.g., measuring range, signal direction in the event of an error, etc.

– The device configuration level is protected, e.g., via a jumper or password (here: numerical code).

– The function has a required safety integrity level (SIL) of less than 4.

The MCR-FL-HT-TS-I-EX meets all requirements.

7 Safety Function With MCR-FL-HT-TS-I-EX

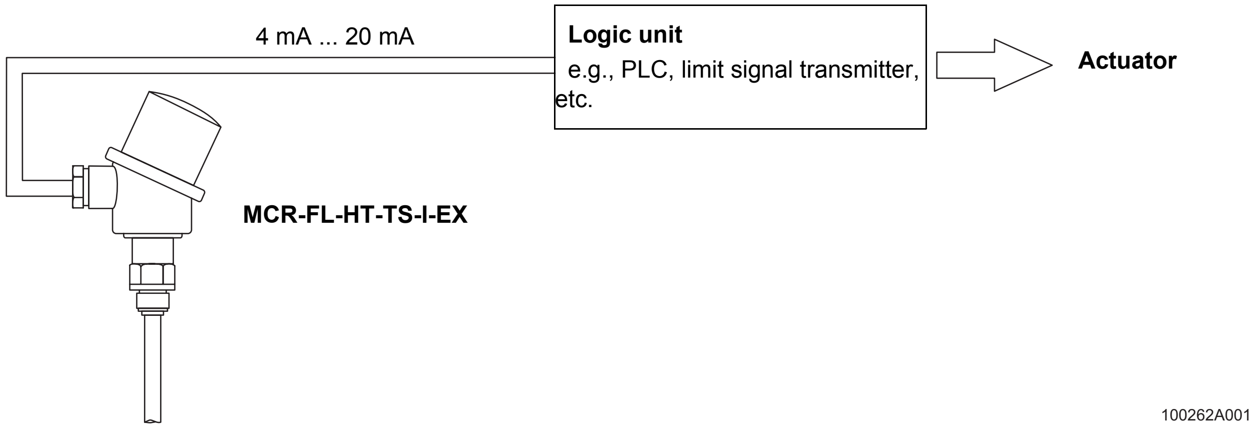


Figure 4 Safety function (e.g., for temperature limit monitoring) with the MCR-FL-HT-TS-I-EX as a subsystem

The MCR-FL-HT-TS-I-EX temperature measuring transducer for connection head generates an analog signal (4 mA ... 20 mA) proportional to the temperature. The analog signal is supplied to a subsequent logic unit, e.g., a PLC or a limit signal transmitter, and is monitored there for exceeding a maximum value.

The logic unit must be able to recognize HI alarms $\geq$ 21.6 mA and LO alarms $\leq$ 3.6 mA to enable malfunction detection.

Specifications for the Safety Function

- See "Safety Parameters" on page 10.
- A replacement time (MTTR) of 8 hours is specified.
- Safety-related systems without auto-locking function must be set to a monitored or otherwise safe state within the replacement time after execution of the safety function.
- SIL applies to device version V1.02.08 or later.

8 Startup and Periodic Checks

8.1 Using the Device for Continuous Measurements

The operation of the safety equipment must be checked at appropriate intervals. It is the operators' responsibility to select the type of checks and the checking intervals in the specified time period. The checks must be performed so that error-free operation of the safety equipment with the interaction of all components is proven.

8.2 Suggested Procedure for Periodic Checks

Tools required for periodic checks:

– Amp meter
– Wire jumper (only for RTD)

Test Steps

1. Set two points within the set measuring range, either with resistance decade or a connected sensor with sufficiently accurate reference conditions.
   Measure output currents.
2. Disconnect sensor from input, the input is open.
   Measure output current.
3. Only if using RTD: Short circuit input with wire jumper.
   Measure output current.

Error Classification

The following table is used to assess the test results for test steps 1 to 3. As soon as one of the test steps returns the result "dangerous", the device has failed dangerously and the remaining test steps can be ignored.

Test Step	Test Result Output Current	Classification
1	Leakage current (see page 8)	Safe
1	Output current corresponds to the created values (within the limits of the specification, see "Output" on page 3).	Normal operation
1	Output current does not correspond to the created values	Dangerous
2	Leakage current	Safe
2	Not leakage current	Dangerous
3 (only RTD)	Leakage current	Safe
3 (only RTD)	Not leakage current	Dangerous

Assessment

If one of the test steps results in a dangerous failure, a dangerous fault is present on the device.

> In the event of this, please inform Phoenix Contact that a device has failed in a protective function with a dangerous fault.

8.3 Settings

For the MCR-FL-HT-TS-I-EX, the MCR-PI-CONF-WIN configuration software can be used to make various software settings.

9 Safety Parameters

TI (test interval, complete function test): Yearly

PFD_{AVG} Depending on the Selected Maintenance Interval

The following diagram illustrates the dependency of PFD_{AVG} on the maintenance interval. PFD_{AVG} increases as the maintenance interval increases.

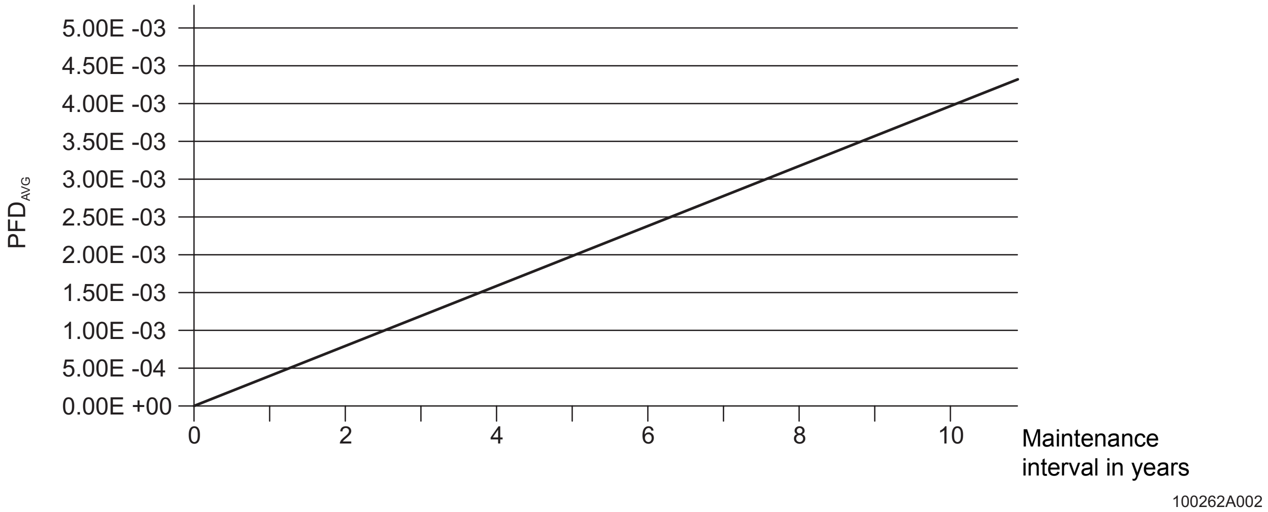


Figure 5 "Average probability of failure on demand for the safety-related system" (PFD_{AVG}) depending on the selected maintenance interval

10 Connections

10.1 2-Wire Connection Method

For short distances.

> The cable resistances directly affect the measured result and falsify it, provided that they are not compensated by the software.

10.2 3-Wire Connection Method

For long distances between the resistance thermometer and the MCR-FL-HT-TS-I-EX and equal cable resistances ($R_{L1} = R_{L2} = R_{L3}$).

> The cable resistance per wire must not exceed 11 Ω.

10.3 4-Wire Connection Method

For long distances between the resistance thermometer and the MCR-FL-HT-TS-I-EX and differing cable resistances ($R_{L1} \neq R_{L2} \neq R_{L3} \neq R_{L4}$).

> The cable resistance per wire must not exceed 11 Ω.

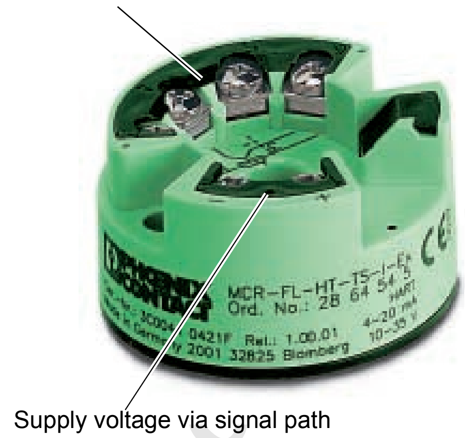


Figure 6 Connections

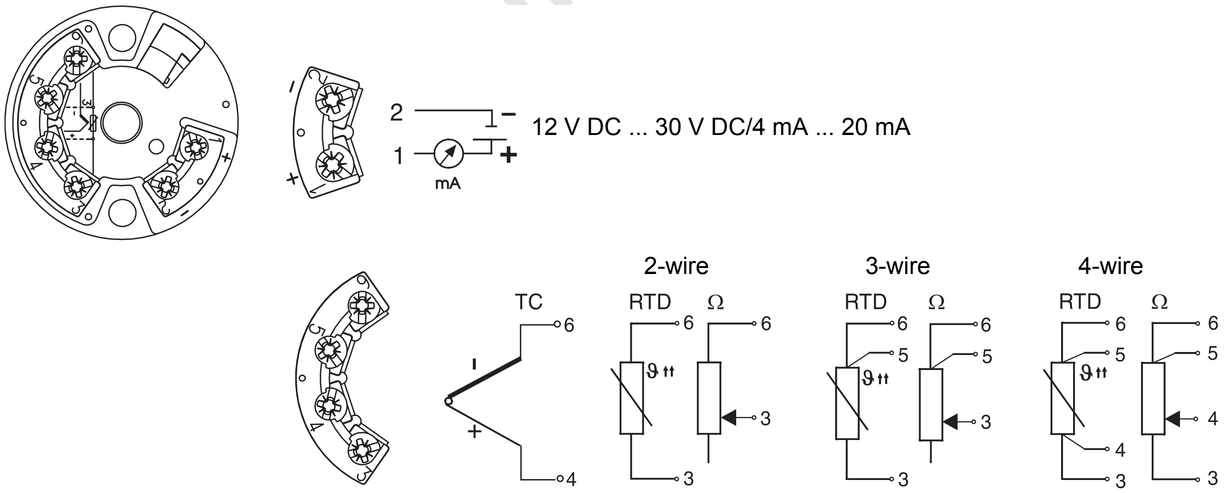


Figure 7 Connection methods

11 Installation in the Sensor Connection Head According to DIN 43729 Form B

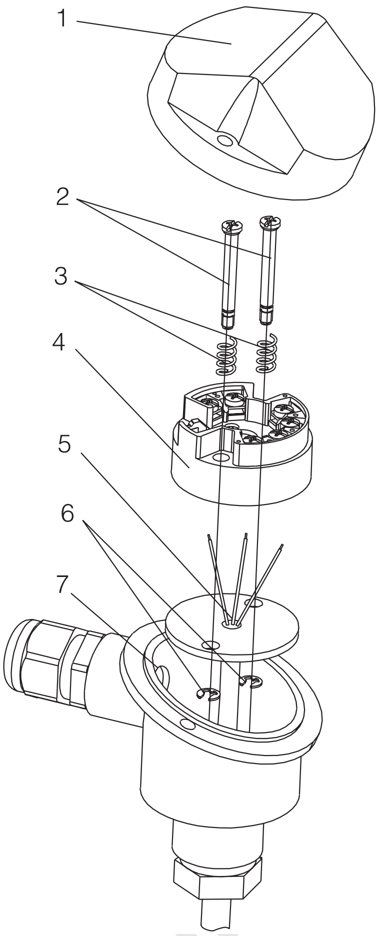


Figure 8 Installation in the sensor connection head

1 Cover
2 Mounting screws
3 Mounting springs
4 Temperature measuring transducer for connection head
5 Sensor insert with connection wires
6 Circlips
7 Cable feed-through

- Insert the connection wires of the sensor insert (5) in the central drill hole on the head measuring transducer.
- Place the mounting springs (3) on the mounting screws (2).
- Pass the mounting screws (2) through the drill holes in the head measuring transducer and the drill holes in the sensor insert (5). Secure both mounting screws with the circlips (6).
- Position the head measuring transducer in the connection head so that the connection terminal blocks for the current output (terminal blocks ① and ②) point towards the cable feed-through (7).
- Then secure the head measuring transducer to the sensor insert in the connection head.

12 Configuration

The devices are supplied with the following default configuration: Pt 100 sensor, measuring range 0°C ... +100°C, 3-wire connection.

The configuration data can be set via the HART® protocol. A programming adapter can be used for this in conjunction with the MCR-PI-CONF-WIN configuration software (Order No. 2814799) or a hand-held operator panel (e.g., DXR 275 from Emerson).

Customer-specific measuring range settings, linearization, and characteristic curve adjustments can also be implemented in this way. In addition, the online help explains the configuration options and their implementation.

Configurable Parameters:

– Sensor type and connection method
– Unit of measurement (°C/°F)
– Measuring ranges
– Internal/external reference junction
– Compensation of the cable resistance for 2-wire connection
– Faults
– Output signal (4 mA ... 20 mA/20 mA ... 4 mA)
– Attenuation
– Offset
– Measuring point designation + descriptor (8 + 16 characters)
– Output simulation
– Customer-specific linearization
– Detection of minimum/maximum process value

13 Application Examples

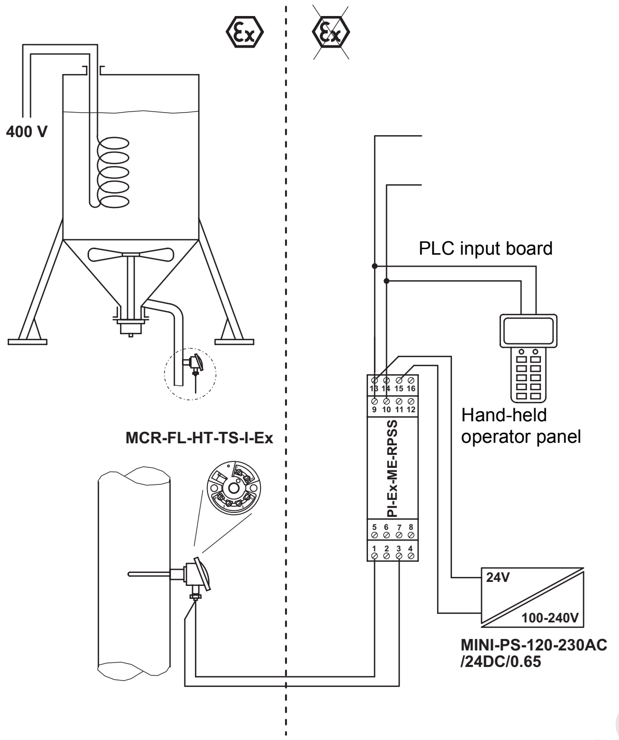


Figure 9 Temperature measurement in pipes

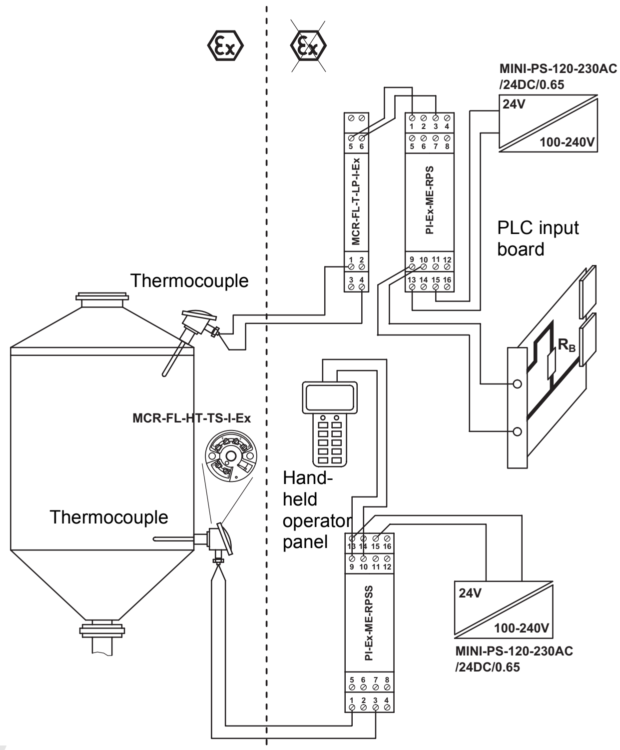


Figure 11 Temperature monitoring in a tank

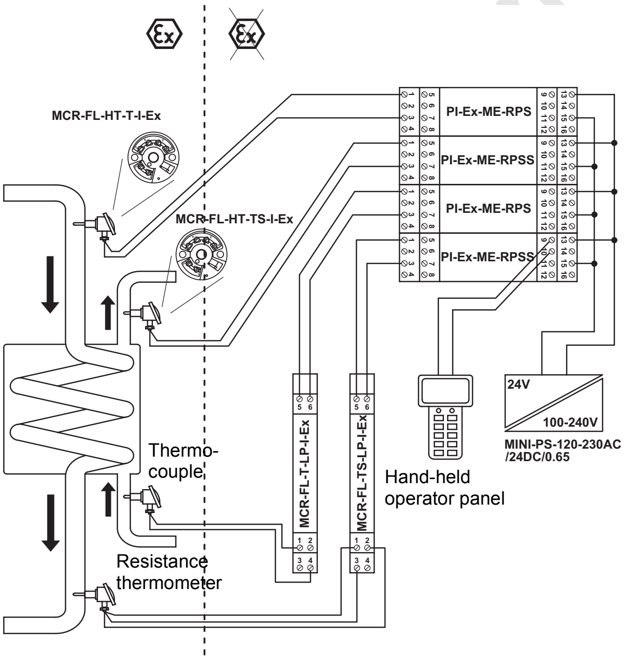
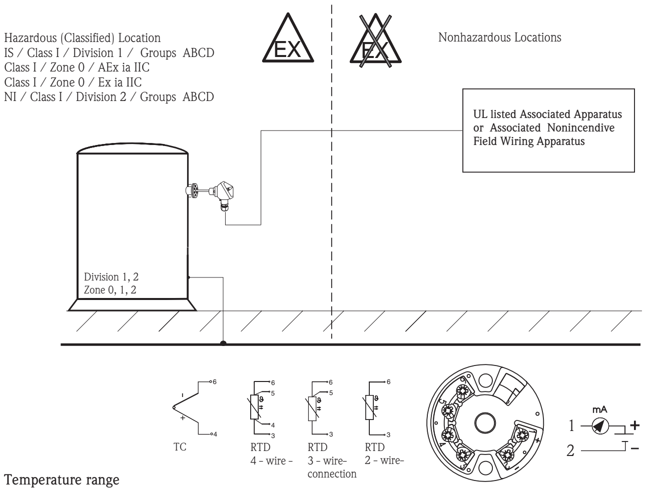


Figure 10 Temperature monitoring in a heat exchanger

14 Appendix



Temperature range

T4	-40°C ... +85°C
T5	-40°C ... +70°C
T6	-40°C ... +55°C

INTRINSICALLY SAFE **IS / Class I / Division 1 / Groups ABCD**
Class I / Zone 0 / AEx ia IIC
Class I / Zone 0 / Ex ia IIC

NONINCENDIVE, FIELD WIRING NI Class I / Div. 2 / Groups ABCD

Sensor circuits (Terminals 1…4)

Uo or Voc or Vt ≤ 5.0 V	Io or Isc ≤ 5.4 mA	Po ≤ 6.6 mW
Group A, B resp. IIC	Co or Ca = 100 µF	Lo or La = 100 mH
Group C, D resp. IIB, IIA	Co or Ca = 1000 µF	Lo or La = 100 mH

Installation Notes MCR-FL-HT-TS-I-Ex

- The head transmitter must be installed in accordance with this control drawing and Article 504 and 505 of NEC and CEC as applicable.
- The spacing between intrinsically safe and non intrinsically safe circuits is at least 50 mm.
- Use supply wires suitable for 5°C above
- To prevent ignition of explosive atmospheres, disconnect power before servicing.
- The device must be installed in a suitable enclosure.
  Warning: Substitution of components may impair intrinsic safety or suitability for Class I, Division 2.

INTRINSICALLY SAFE IS Class I / Div. 1 / Groups ABCD
- Installation should be in accordance with ANSI/ISA RP 12.6.01 "Installation of Intrinsically safe systems for Hazardous (classified) locations" and the National Electrical Code (ANSI/NFPA 70).
  Associated Apparatus must meet the following parameters:
  Uo ≤ Ui Io ≤ Ii Po ≤ Pi Ca ≥ Ci + Ccable La ≥ Li + Lcable
  Transmitter entity parameters are as follows:
  (Terminal 1 and 2)
  Ui or Vmax ≤ 30 V DC Ci = negligible small
  Ii or Imax ≤ 100 mA Li = negligible small
  Pi ≤ 750 mW

NONINCENDIVE NI Class I / Div. 2 / Groups ABCD
- Depending on location install per National Electrical Code (NEC) using wiring methods described in article 500 through article 510.
- The transmitter MCR-FL-HT-TS-I-Ex and RTD or TC Sensor is to be installed in Class I, Division 2 location.
- Intrinsic safety barrier not required. Vmax ≤ 35 V DC.
- Warning: Do not disconnect equipment unless power has been switched off or the area is known to be nonhazardous.
  Nonincendive field wiring installation
  The Nonincendive Field Wiring Circuit Concept allows interconnection of Nonincendive Field Wiring Apparatus with Associated Nonincendive Field Wiring Apparatus or Associated Intrinsically Safe Apparatus or Associated Apparatus not specifically examined in combination as a system using any of the wiring methods permitted for unclassified locations, when Voc ≤ Vmax, Ca ≥ Ci + Ccable, La ≥ Li + Lcable.
  Transmitter Nonincendive Field Wiring parameters are as follows:
  (Terminal 1 and 2)
  Ui or Vmax ≤ 30 V DC Ci = negligible small Li = negligible small
  Ii or Imax = see following note below
  For these current controlled circuits, the parameter Imax is not required and need not to be aligned with parameter Isc and It of the Associated Nonincendive Field Wiring Apparatus or Associated Apparatus.

Functional ratings
These ratings do not supersede Hazardous Location values
Unom ≤ 35 DC Inom ≤ 4 to 20 mA

Control Drawing No. 83035297