

## TT 51 SERIES Technical Datasheet

2-wire transmitter for temperature, resistance or voltage measurement

- High accuracy and long-term stability
- Proven reliability due to robust design and dual sensor backup
- Sensor isolation monitoring (SmartSense)



The documentation is only complete when used in combination with the relevant documentation for the sensor.

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## 1.1 The universal, dual-input 2-wire temperature transmitter

The TT 51 series is a universal, isolated, dual-input transmitter for temperature, resistance or voltage measurements of solids, fluids and gases in an industrial environment.

The TT 51 series consists of 2 different versions. TT 51 C is primarily intended to be mounted in a DIN-B housing whereas TT 51 R is the rail-mount version. This transmitter family utilizes a modular design in hardware as well as in software to ensure the quality and reliability of the transmitter signal output.

The transmitters are compatible with the HART® 6 protocol offering extended diagnostic information (device error, sensor and wiring conditions) . Typical characteristics are the high accuracy, stability and reliability combined with a robust housing. The double inputs enable new safety features such as sensor backup and sensor drift monitoring.



- ① In-head transmitter
- ② Rail-mount transmitter

## Highlights

### High measurement accuracy

- Long-term stability: drift over 5 years is the maximum of  $\pm 0.05^{\circ}\text{C}$  or  $\pm 0.05\%$  of span
- High precision:  $\pm 0.1^{\circ}\text{C}$  /  $\pm 0.18^{\circ}\text{F}$  or 0.05% of span (example Pt100)
- Low temperature drift:  $\pm 0.005\%$  of span per  $^{\circ}\text{C}$  or  $^{\circ}\text{F}$

### High reliability

- Dual sensor input with for example Pt100, 2-,3- & 4-wire (TT 51 R), T/C, resistance and voltage
- Sensor drift detection: one sensor with double elements, monitoring the temperature difference
- Sensor backup: automatic switchover to backup sensor
- Robust design: 10g vibrations, 95% RH and robust terminals

### High safety

- SIL 2 (according to IEC 61508-2)
- NAMUR compliant to NE 21, NE 43, NE 53, NE 89 and NE 107
- ATEX (intrinsically safe and non-incendive); In preparation: GOST

### High user efficiency

- Easy configuration, installation and maintenance with ConSoft, HART<sup>®</sup>6 protocol, EDD plus DTM/FDT enabled systems

## Industries

- Chemicals
- Oil & Gas
- Power industry
- Iron, Steel & Metal
- Pulp & Paper
- Food & Beverage
- Pharmaceuticals

## 1.2 Options and variants

### TT 51 C: in-head transmitter



The TT 51 C is an intelligent, universal HART®-compatible 2-wire in-head transmitter for temperature, resistance or voltage measurements in an industrial environment.

The TT 51 C is optionally available in a non-incendive version for use in potentially explosive atmosphere zone 2 and in an intrinsically safe version for use in zone 0, 1 and 2.

All versions are intended for installation in a "B connection head" or larger according to DIN 43729.

### TT 51 R: rail-mount transmitter



The TT 51 R is an intelligent, universal HART®-compatible 2-wire rail-mount transmitter for temperature, resistance or voltage measurements in an industrial environment.

The TT 51 R is optionally available in a non-incendive version for use in potentially explosive atmosphere zone 2 and in an intrinsically safe version for use in zone 1 and 2.

All versions are intended for installation on a rail according to DIN 50022.

## 1.3 Measuring principle

### 1.3.1 Resistance thermometer

The measuring insert with a resistance thermometer features a temperature-sensitive sensor made from a platinum RTD, whose value at 0°C / +32°F is 100 Ω. That is where the name "Pt100" comes from.

It is generally valid that the electric resistance of metals increases according to a mathematical function as the temperature rises. This effect is taken advantage of by resistance thermometers to measure temperature. The "Pt100" thermometer features a measuring resistance with defined characteristics, standardised in IEC 60751. The same is true for the tolerances. The average temperature coefficient of a Pt100 is  $3.85 \times 10^{-3} \text{ K}^{-1}$  in the range from 0...+100°C / +32...+212°F.

During operation, a constant current  $I (\leq 1 \text{ mA})$  flows through the Pt100 RTD, which brings about a voltage drop  $U$ . The resistance  $R$  is calculated using Ohm's Law ( $R=U/I$ ). As the voltage drop  $U$  at 0°C / +32°F is 100 mV, the resulting resistance of the Pt100 thermometer is 100 Ω (100 mV / 1 mA = 100 Ω).

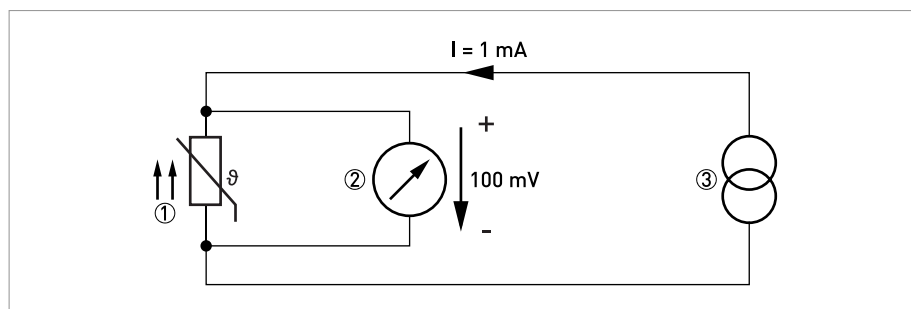


Figure 1-1: Pt100 resistance thermometer in 4-wire connection at 0°C / +32°F, schematic.

- ① Pt100 RTD
- ② Voltage meter
- ③ Current source

### 1.3.2 Thermocouples

The thermocouple features two electric conductors made from different metals, connected at one end. Each free end is connected to a compensation cable which is then connected to a millivolt meter. This circuitry forms a "thermal circuit". The point at which the two electric conductors connect is called the measuring point and the point at which the compensation cables connect to the conductors of the millivolt meter is called the cold junction.

If the measuring point of this thermal circuit is heated up, a small electrical voltage (thermal voltage) can be measured. If, however, the measuring point and the cold junction are at the same temperature, no thermoelectric voltage is generated. The degree of thermoelectric voltage, also known as electromotive force (EMF), depends on the thermocouple material and the extent of the temperature difference between the measuring point and the cold junction. It can be measured using the millivolt meter with no auxiliary power.

Simply put, the thermocouple behaves like a battery, the voltage of which also increases as the temperature rises.

*The characteristic curves and tolerances of commercially available thermocouples are standardised in IEC 60584.*

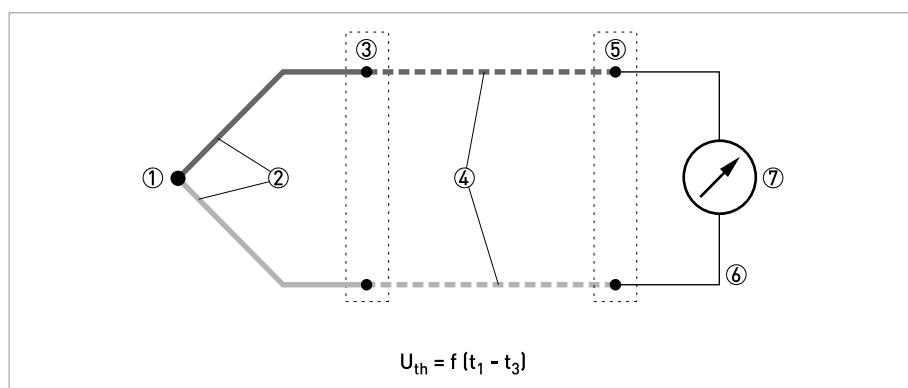


Figure 1-2: Thermocouple measuring circuit, schematic.

- ① Measuring point  $t_1$  (hot junction)
- ② Thermocouple
- ③ Transition junction  $t_2$
- ④ Compensation cable / extension cable
- ⑤ Reference junction  $t_3$  (cold junction)
- ⑥ Copper conductor
- ⑦ Voltage meter  $U_{th}$

## 2.1 Technical data

- *The following data is provided for general applications. If you require data that is more relevant to your specific application, please contact us or your local sales office.*
- *Additional information (certificates, special tools, software,...) and complete product documentation can be downloaded free of charge from the website (Download Center).*

### Measuring system

Application range	Temperature, resistance or voltage measurements of solids, liquids and gases in industrial environment.
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### Design

Versions	
TT 51 C	In-head transmitters which are intended for installation in a "B connection head" or larger according to DIN 43729. This transmitter is optionally available in a non-incendive version (zone 2) and in an intrinsically safe version (zone 0, 1 and 2) for installation in potentially explosive atmospheres.
TT 51 R	Rail-mount transmitters which are intended for installation on a rail according to DIN 50022 / EN 60715. This transmitter is optionally available in a non-incendive version (zone 2) and in an intrinsically safe version (zone 1 and 2) for installation in potentially explosive atmospheres.
Features	
SIL 2 compliance	Based on a hardware assessment acc. to IEC 61508-2, consisting of a FMEDA done by exida, the transmitters are suitable for use in SIL 2 rated Safety Instrumented Systems (SIS).
HART® 6 compliance	The transmitters are fully compliant with the HART® 6 protocol as well as the previous HART® 5. HART® 6 offers the possibility to receive diagnostic information such as sensor errors or sensor conditions, input wiring resistance too high, sensor backup mode, transmitter error, etc.
Sensor backup	Dual-sensor input allows for backup between two sensors. Should a lead break or short-circuit be detected on one of the sensor circuits, an automatic switchover to the intact sensor will occur.
Sensor drift monitoring	If an RTD or thermocouple with double sensor elements is used, sensor drift can be detected by checking the reading from both elements. If the difference is above a user-defined level, this will be indicated in ConSoft and with a diagnostic HART® message, and the output signal can be forced upscale or downscale.
Sensor isolation monitoring	The isolation resistance of thermocouples and RTD's as well as the cabling between sensor and transmitter is being monitored. If the isolation is below a user-defined level, this will be indicated in ConSoft and with a diagnostic HART® message, and the output signal can be forced upscale or downscale. This feature requires an extra lead inside the thermocouple or RTD.
Customized linearization	For resistance and mV inputs, the 50-point customized linearization can provide a correct process value, in a choice of engineering units, for a sensor with non-linear input/output relation.



## Measuring accuracy

Accuracy	RTD and thermocouple: for detailed information refer to <i>RTD and T/C accuracy table</i> on page 17.
	Resistance digital accuracy: 0...1000 Ω: max. of ±20 mΩ or ±0.02% of measured value 1000...4000 Ω: ±0.025% of measured value; max. 0.5 Ω
	Resistance analogue accuracy: ±0.03% of span
	Voltage digital accuracy: ±5 μV or ±0.01% of measured value
	Voltage analogue accuracy: ±0.03% of span
	Total accuracy = sum of digital and analogue accuracy, calculated as an RMS (Root Mean Square) value
Temperature influence	RTD and Thermocouple: for detailed information refer to <i>RTD and T/C accuracy table</i> on page 17.
	Resistance: ±0.005% of span per °C or °F
	Voltage: ±0.005% of span per °C or °F
Cold Junction Compensation (CJC)	<b>In-head transmitter:</b> ±0.5°C within ambient temperature -40...+85°C / ±0.9°F within ambient temperature -40...+185°F
	<b>Rail-mount transmitter:</b> ±0.5°C within ambient temperature -20...+70°C / ±0.9°F within ambient temperature -4...+158°F
Temperature influence CJC	±0.005°C per °C / ±0.005°F per °F
Sensor wire influence	RTD and resistance, 2-wire: adjustable wire resistance compensation
	RTD and resistance, 3-wire: negligible, with equal wire resistance
	RTD and resistance, 4-wire: negligible
	Thermocouple and voltage: negligible
Supply voltage influence	<±0.001% of span per V within specified limits
Long-term drift	Max. of ±0.01°C or ±0.01% of span per year / Max. of ±0.02°F or ±0.01% of span per year

## Operating conditions

<b>Temperature</b>	
In-head transmitter	<b>Operating and storage temperature:</b> Standard version: -40...+85°C / -40...+185°F
	IS version: for detailed information refer to <i>Temperature data for areas with potentially explosive atmospheres</i> on page 14.
Rail-mount transmitter	<b>Storage temperature:</b> Standard version: -40...+85°C / -40...+185°F
	<b>Operating temperature:</b> Standard version: -20...+70°C / -4...+158°F
	IS version: for detailed information refer to <i>Temperature data for areas with potentially explosive atmospheres</i> on page 14.
Humidity	5...95% RH (non-condensing)
<b>Protection category</b>	
In-head transmitter	Housing: IP65
	Terminals: IP00
Rail-mount transmitter	Housing: IP20
	Terminals: IP00

**Installation conditions**

Mounting	In-head transmitter: DIN B-head or larger, DIN-rail (with adapter)
	Rail-mount transmitter: rail acc. to DIN 50022 / EN 60715, 35 mm / 1.38"
	For detailed information refer to chapter "Installation".
Weight	In-head transmitter: 50 g / 0.11 lb
	Rail-mount transmitter: 70 g / 0.15 lb
Dimensions	For detailed information refer to <i>Dimensions</i> on page 13.

**Materials**

Housing	PC/ABS
Flammability acc. to UL	In-head transmitter: V0
	Rail-mount transmitter: V0/HB

**Electrical connections**

Power supply	Standard: 10...36 VDC
	IS version: 10...30 VDC
Line frequency rejection	Selectable: 50 Hz, 60 Hz or 50/60 Hz
Isolation	1500 VAC, 1 min
Connection	Single/stranded wires: max. 1.5 mm <sup>2</sup> / AWG 16

**Inputs / Outputs**

<b>Input - RTD</b>	
Pt100 (IEC 60751, $\alpha=0.00385$ )	-200...+850°C / -328...+1562°F
Pt100 (JIS C 1604-8, $\alpha=0.003916$ )	
Pt X ( $10 \leq X \leq 1000$ ) (IEC 60751, $\alpha=0.00385$ )	Corresponding to max. 4000 $\Omega$
Ni100 (DIN 43760, $\alpha=0.006180$ )	-60...+250°C / -76...+482°F
Ni120 (Edison Curve No. 7)	
Ni1000 (DIN 43760, $\alpha=0.006180$ )	-50...+180°C / -58...+356°F
Cu10 (Edison Copper Windings No. 15)	-50...+200°C / -58...+392°F
Sensor current	$\leq 300 \mu\text{A}$
Maximum sensor wire resistance	3-wire and 4-wire connection: 50 $\Omega$ /wire
	2-wire connection: compensation for 0 to 40 $\Omega$ loop resistance
<b>Input - resistance / potentiometer</b>	
Range, resistance	0...4000 $\Omega$
Range, potentiometer	100...4000 $\Omega$
Minimum span	10 $\Omega$
Customized linearization	Up to 50 points
Sensor current	$\leq 300 \mu\text{A}$
Maximum sensor wire resistance	25 $\Omega$ /wire

<b>Input - thermocouples</b>	
T/C type B - Pt30Rh-Pt6Rh (IEC 60584)	+400...+1800°C / +752...+3272°F
T/C type C - W5Re-W26Re (ASTM E 988)	0...+2315°C / +32...+4199°F
T/C type D - W3Re-W25Re (ASTM E 988)	
T/C type E - NiCr-CuNi (IEC 60584)	-200...+1000°C / -328...+1832°F
T/C type J - Fe-CuNi (IEC 60584)	
T/C type K - NiCr-NiAl (IEC 60584)	-200...+1350°C / -328...+2462°F
T/C type N - NiCrSi-NiSiMg (IEC 60584)	-100...+1300°C / -148...+2372°F
T/C type R - Pt13Rh-Pt (IEC 60584)	-50...+1750°C / -58...+3182°F
T/C type S - Pt10Rh-Pt (IEC 60584)	
T/C type T - Cu-CuNi (IEC 60584)	-200...+400°C / -328...+752°F
Input impedance	>10 MΩ
Maximum wire loop resistance	10000 Ω (including T/C sensor)
Cold Junction Compensation (CJC)	Internal, external (Pt100) or fixed
<b>Input - voltage</b>	
Range	-10...+1000 mV
Minimum span	2 mV
Customized linearization	Up to 50 points
Input impedance	>10 MΩ
Maximum wire loop resistance	500 Ω
<b>Double inputs for RTD and thermocouple</b>	
Measure mode	Single temperature: T1 or T2
	Differential temperature: T1 - T2 or T2 - T1
	Average temperature: 0.5 x (T1 + T2)
	Minimum temperature: lowest of T1 and T2
	Maximum temperature: highest of T1 and T2
Sensor backup	Single or average mode: failure on one sensor activates automatic switchover to the other sensor
Sensor drift monitoring	Single or average mode: adjustable acceptance level of the differential temperature of sensor 1 and 2

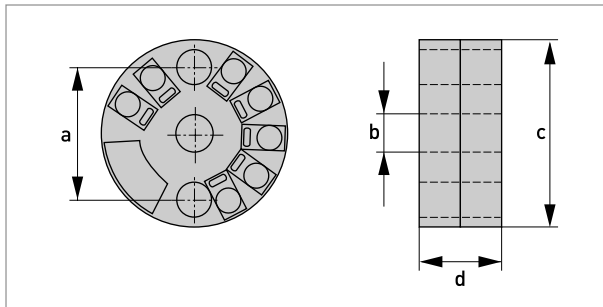
<b>Output</b>	
Output signal	4...20 mA, 20...4 mA or customized Temperature linear for RTD & T/C
HART® protocol	HART® 6
HART® physical layer	FSK 1200
Representation	T1 or T2 or difference, average, min. or max. of T1 and T2
Update time	Single input: ≈800 ms; Double input: ≈1600 ms
Adjustable output filtering	0...60 s (time constant)
Permissible load	635 Ω at 24 VDC incl. 250 Ω loop resistance
NAMUR compliance	Current limitations and failure currents acc. to NAMUR NE 43
<b>Configuration</b>	
ConSoft	The PC configuration software, ConSoft, is a versatile and user-friendly tool for transmitter configuration, loop check-up and sensor diagnostics. It runs on Windows 2000, XP and Vista. ConSoft is part of the complete configuration kit ICON, which also contains a USB Interface and necessary cables.
Alternatives	Hand held communicator, e.g. FC375/FC475 (Emerson)
	Management systems, e.g. AMS (Emerson) and PDM (Siemens)
	EDD enabled systems
	DTM/FDT enabled systems

### Approvals and certifications

CE	The device fulfils the statutory requirements of the EC directives. The manufacturer certifies that these requirements have been met by applying the CE marking.
<b>Ex approvals</b>	
Standard version	Without
Non-incendive version	ATEX: II 3 G Ex nL IIC T4...T6
Intrinsically safe (IS) version	ATEX: II 1 G Ex ia IIC T4...T6 (only in-head transmitter)
	ATEX: II 2(1) G Ex ia IIC T4...T6 (only rail-mount transmitter)
Others	In preparation: FM, CSA, IECEx and GOST
<b>Other standards and approvals</b>	
Electromagnetic compatibility	Directive: 2004/108/EC
	Harmonized standards: EN 61326-1:2006; EN 61326-3-1:2009; NAMUR NE 21
	Immunity performance: criteria A; surge test influence max. ±0.5% of span
Vibration resistance	Acc. to IEC 60068-2-6, test Fc, 10...2000 Hz, 10 g
Shock resistance	Acc. to IEC 60068-2-31, test Ec

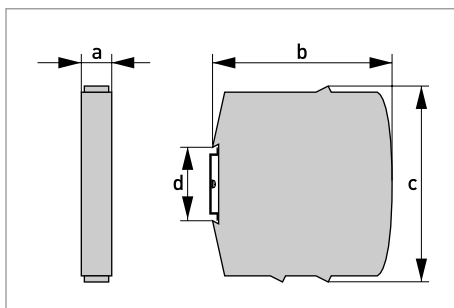
## 2.2 Dimensions

### In-head transmitter



	Dimensions	
	[mm]	[inches]
a	33.0	1.30
b	7.0	0.28
c	44.5	1.75
d	23.0	0.91

### Rail-mount transmitter



	Dimensions	
	[mm]	[inches]
a	17.5	0.69
b	81.3	3.20
c	90.0	3.54
d	35	1.38

## 2.3 Temperature data for areas with potentially explosive atmospheres

### In-head transmitter

#### Non-incendive transmitter

Temperature class	Ambient temperature $T_a$
T6	$-40^{\circ}\text{C} \leq T_a \leq +65^{\circ}\text{C}$ / $-40^{\circ}\text{F} \leq T_a \leq +149^{\circ}\text{F}$
T5	$-40^{\circ}\text{C} \leq T_a \leq +80^{\circ}\text{C}$ / $-40^{\circ}\text{F} \leq T_a \leq +176^{\circ}\text{F}$
T4	$-40^{\circ}\text{C} \leq T_a \leq +85^{\circ}\text{C}$ / $-40^{\circ}\text{F} \leq T_a \leq +185^{\circ}\text{F}$

#### Intrinsically safe transmitter

Temperature class	Ambient temperature $T_a$
T6	$-40^{\circ}\text{C} \leq T_a \leq +60^{\circ}\text{C}$ / $-40^{\circ}\text{F} \leq T_a \leq +140^{\circ}\text{F}$
T5	$-40^{\circ}\text{C} \leq T_a \leq +75^{\circ}\text{C}$ / $-40^{\circ}\text{F} \leq T_a \leq +167^{\circ}\text{F}$
T4	$-40^{\circ}\text{C} \leq T_a \leq +85^{\circ}\text{C}$ / $-40^{\circ}\text{F} \leq T_a \leq +185^{\circ}\text{F}$

### Rail-mount transmitter

#### Non-incendive transmitter

Temperature class	Ambient temperature $T_a$
T6	$U_i \leq 30 \text{ VDC}$ : $-20^{\circ}\text{C} \leq T_a \leq +60^{\circ}\text{C}$ / $-4^{\circ}\text{F} \leq T_a \leq +140^{\circ}\text{F}$ $U_i \leq 36 \text{ VDC}$ : $-20^{\circ}\text{C} \leq T_a \leq +55^{\circ}\text{C}$ / $-4^{\circ}\text{F} \leq T_a \leq +131^{\circ}\text{F}$
T5	$-20^{\circ}\text{C} \leq T_a \leq +70^{\circ}\text{C}$ / $-4^{\circ}\text{F} \leq T_a \leq +158^{\circ}\text{F}$
T4	$-20^{\circ}\text{C} \leq T_a \leq +70^{\circ}\text{C}$ / $-4^{\circ}\text{F} \leq T_a \leq +158^{\circ}\text{F}$

#### Intrinsically safe transmitter

Temperature class	Ambient temperature $T_a$
T6	$-20^{\circ}\text{C} \leq T_a \leq +50^{\circ}\text{C}$ / $-4^{\circ}\text{F} \leq T_a \leq +122^{\circ}\text{F}$
T5	$-20^{\circ}\text{C} \leq T_a \leq +65^{\circ}\text{C}$ / $-4^{\circ}\text{F} \leq T_a \leq +149^{\circ}\text{F}$
T4	$-20^{\circ}\text{C} \leq T_a \leq +70^{\circ}\text{C}$ / $-4^{\circ}\text{F} \leq T_a \leq +158^{\circ}\text{F}$

## 2.4 Output load diagram

Formula for the maximum permissible output load:  
 permissible  $R_{Load} [\Omega] = (U-10)/0.022$

### Non-incendive transmitter

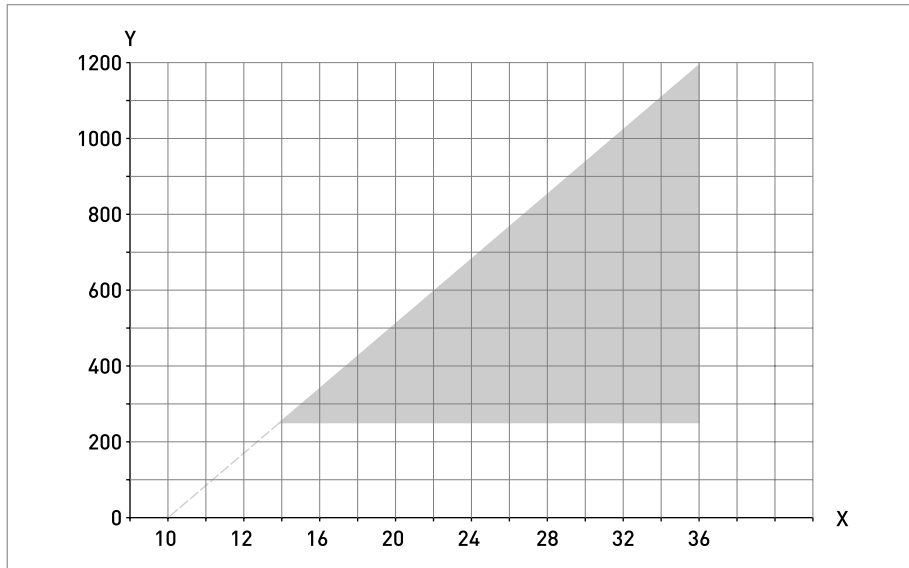


Figure 2-1: Output load diagram

X: Power supply U [VDC]  
 Y: Total output load R [Ω]

### Intrinsically safe transmitter

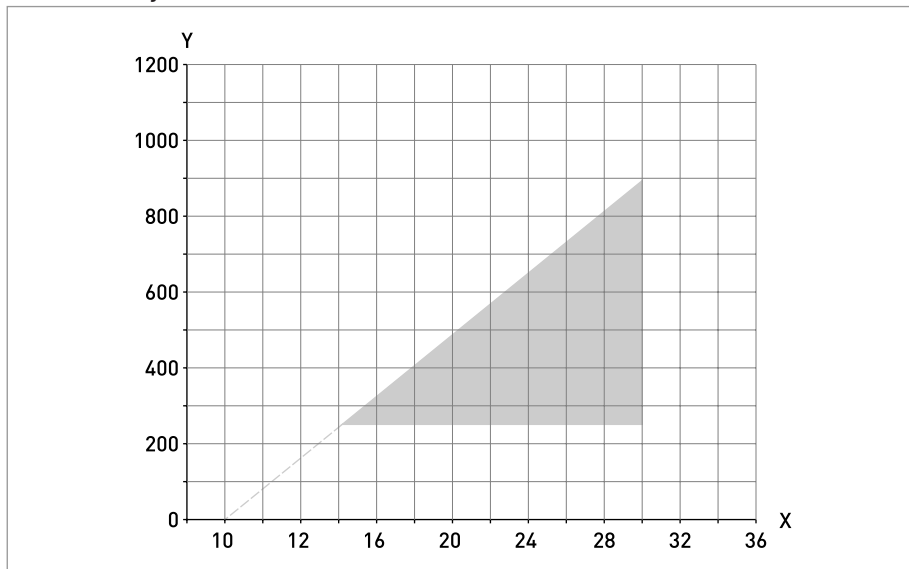


Figure 2-2: Output load diagram

X: Power supply U [VDC]  
 Y: Total output load R [Ω]

## 2.5 Electrical data for outputs and inputs

### In-head transmitter

#### Non-incendive transmitter

Output terminals 6, 7		Input terminals 1, 2, 3, 4, 5	
$U_i = V_{\max}$	$\leq 36$ VDC	$U_0 = U_{0C}$	$\leq 3.3$ VDC
$I_i = I_{\max}$	-	$I_0 = I_{SC}$	$\leq 1.8$ mA
$P_i = P_{\max}$	-	$P_0$	$\leq 1.5$ mW
$L_i$	$10 \mu\text{H}$	$L_0$	$500$ mH
$C_i$	$12.1$ nF	$C_0$	$500 \mu\text{F}$

#### Intrinsically safe transmitter

Output terminals 6, 7		Input terminals 1, 2, 3, 4, 5	
$U_i = V_{\max}$	$\leq 30$ VDC	$U_0 = U_{0C}$	$\leq 6.6$ VDC
$I_i = I_{\max}$	$\leq 100$ mA	$I_0 = I_{SC}$	$\leq 26.4$ mA
$P_i = P_{\max}$	$\leq 900$ mW	$P_0$	$\leq 46$ mW
$L_i$	$10 \mu\text{H}$	$L_0$	$25$ mH
$C_i$	$12.1$ nF	$C_0$	$11 \mu\text{F}$

### Rail-mount transmitter

#### Non-incendive transmitter

Output terminals 21, 22		Input terminals 1 to 8	
$U_i = V_{\max}$	$\leq 36$ VDC	$U_0 = U_{0C}$	$\leq 3.3$ VDC
$I_i = I_{\max}$	-	$I_0 = I_{SC}$	$\leq 1.8$ mA
$P_i = P_{\max}$	-	$P_0$	$\leq 1.5$ mW
$L_i$	$10 \mu\text{H}$	$L_0$	$500$ mH
$C_i$	$12.1$ nF	$C_0$	$500 \mu\text{F}$

#### Intrinsically safe transmitter

Output terminals 21, 22		Input terminals 1 to 8	
$U_i = V_{\max}$	$\leq 30$ VDC	$U_0 = U_{0C}$	$\leq 6.6$ VDC
$I_i = I_{\max}$	$\leq 100$ mA	$I_0 = I_{SC}$	$\leq 27.3$ mA
$P_i = P_{\max}$	$\leq 900$ mW	$P_0$	$\leq 46$ mW
$L_i$	$10 \mu\text{H}$	$L_0$	$25$ mH
$C_i$	$12.1$ nF	$C_0$	$11 \mu\text{F}$



## 2.6 RTD and T/C accuracy table

Conformance level 95% ( $2\sigma$ )

CJC = Cold Junction Compensation

### Accuracies in °C

Input type	Temp. range	Min. span	Accuracy	Temp. influence (Dev. from ref. temp. 20°C)
	[°C]	[°C]	[°C]	
RTD Pt100	-200...+850	10	$\pm 0.10^\circ\text{C}$ or $\pm 0.05\%$ of span	$\pm 0.005\%$ of span per °C
RTD PtX ①	Corresp. to max. 4 k $\Omega$	10	$\pm 0.10^\circ\text{C}$ or $\pm 0.05\%$ of span	$\pm 0.005\%$ of span per °C
RTD Ni100	-60...+250	10	$\pm 0.10^\circ\text{C}$ or $\pm 0.05\%$ of span	$\pm 0.005\%$ of span per °C
RTD Ni120	-60...+250	10	$\pm 0.10^\circ\text{C}$ or $\pm 0.05\%$ of span	$\pm 0.005\%$ of span per °C
RTD Ni1000	-50...+180	10	$\pm 0.10^\circ\text{C}$ or $\pm 0.05\%$ of span	$\pm 0.005\%$ of span per °C
RTD Cu10	-50...+200	83	$\pm 1.5^\circ\text{C}$ or $\pm 0.1\%$ of span	$\pm 0.01\%$ of span per °C
T/C type B	+400...+1800	700	$\pm 1.0^\circ\text{C}$ or $\pm 0.1\%$ of span ②	$\pm 0.005\%$ of span per °C
T/C type C	0...+2315	200	$\pm 1.0^\circ\text{C}$ or $\pm 0.1\%$ of span ②	$\pm 0.005\%$ of span per °C
T/C type D	0...+2315	200	$\pm 1.0^\circ\text{C}$ or $\pm 0.1\%$ of span ②	$\pm 0.005\%$ of span per °C
T/C type E	-200...+1000	50	$\pm 0.25^\circ\text{C}$ or $\pm 0.1\%$ of span ②	$\pm 0.005\%$ of span per °C
T/C type J	-200...+1000	50	$\pm 0.25^\circ\text{C}$ or $\pm 0.1\%$ of span ②	$\pm 0.005\%$ of span per °C
T/C type K	-200...+1350	50	$\pm 0.25^\circ\text{C}$ or $\pm 0.1\%$ of span ②	$\pm 0.005\%$ of span per °C
T/C type N	-100...+1300	100	$\pm 0.25^\circ\text{C}$ or $\pm 0.1\%$ of span ②	$\pm 0.005\%$ of span per °C
T/C type N	-250...+100	100	$\pm 1.0^\circ\text{C}$ ②	$\pm 0.05\%$ of span per °C
T/C type R	-50...+1750	300	$\pm 1.0^\circ\text{C}$ or $\pm 0.1\%$ of span ②	$\pm 0.005\%$ of span per °C
T/C type S	-50...+1750	300	$\pm 1.0^\circ\text{C}$ or $\pm 0.1\%$ of span ②	$\pm 0.005\%$ of span per °C
T/C type T	-200...+400	50	$\pm 0.25^\circ\text{C}$ or $\pm 0.1\%$ of span ②	$\pm 0.005\%$ of span per °C

① ( $10 \leq X \leq 1000$ )

② CJC error is not included

## Accuracies in °F

Input type	Temp. range	Min. span	Accuracy	Temp. influence (Dev. from ref. temp. 68°F)
	[°F]	[°F]	[°F]	
RTD Pt100	-328...+1562	50	±0.18°F or ±0.05% of span	±0.005% of span per °F
RTD PtX ①	Corresp. to max. 4 kΩ	50	±0.18°F or ±0.05% of span	±0.005% of span per °F
RTD Ni100	-76...+482	50	±0.18°F or ±0.05% of span	±0.005% of span per °F
RTD Ni120	-76...+482	50	±0.18°F or ±0.05% of span	±0.005% of span per °F
RTD Ni1000	-58...+356	50	±0.18°F or ±0.05% of span	±0.005% of span per °F
RTD Cu10	-58...+392	181	±2.7°F or ±0.1% of span	±0.01% of span per °F
T/C type B	+752...+3272	1292	±1.8°F or ±0.1% of span ②	±0.005% of span per °F
T/C type C	+32...+4199	392	±1.8°F or ±0.1% of span ②	±0.005% of span per °F
T/C type D	+32...+4199	392	±1.8°F or ±0.1% of span ②	±0.005% of span per °F
T/C type E	-328...+1832	122	±0.45°F or ±0.1% of span ②	±0.005% of span per °F
T/C type J	-328...+1832	122	±0.45°F or ±0.1% of span ②	±0.005% of span per °F
T/C type K	-328...+2462	122	±0.45°F or ±0.1% of span ②	±0.005% of span per °F
T/C type N	-148...+2372	212	±0.45°F or ±0.1% of span ②	±0.005% of span per °F
T/C type N	-418...+212	212	±1.8°F ②	±0.05% of span per °F
T/C type R	-58...+3182	572	±1.8°F or ±0.1% of span ②	±0.005% of span per °F
T/C type S	-58...+3182	572	±1.8°F or ±0.1% of span ②	±0.005% of span per °F
T/C type T	-328...+752	122	±0.45°F or ±0.1% of span ②	±0.005% of span per °F

① (10 ≤ X ≤ 1000)

② CJC error is not included

### 3.1 Intended use

#### TT 51 C

The TT 51 C is an intelligent, universal HART®-compatible 2-wire in-head transmitter for temperature, resistance or voltage measurements in an industrial environment.

The TT 51 C is optionally available in a non-incendive version for use in potentially explosive atmosphere zone 2 and in an intrinsically safe version for use in zone 0, 1 and 2. These devices are labelled with the "Ex" symbol.

All versions are intended for installation in a "B connection head" or larger according to DIN 43729.

#### TT 51 R

The TT 51 R is an intelligent, universal HART®-compatible 2-wire rail-mount transmitter for temperature, resistance or voltage measurements in an industrial environment.

The TT 51 R is optionally available in a non-incendive version for use in potentially explosive atmosphere zone 2 and in an intrinsically safe version for use in zone 1 and 2. These devices are labelled with the "Ex" symbol.

All versions are intended for installation on a rail according to DIN 50022.

### 3.2 Rail-mount transmitter

These transmitters are intended for installation on a rail according to DIN 50022.

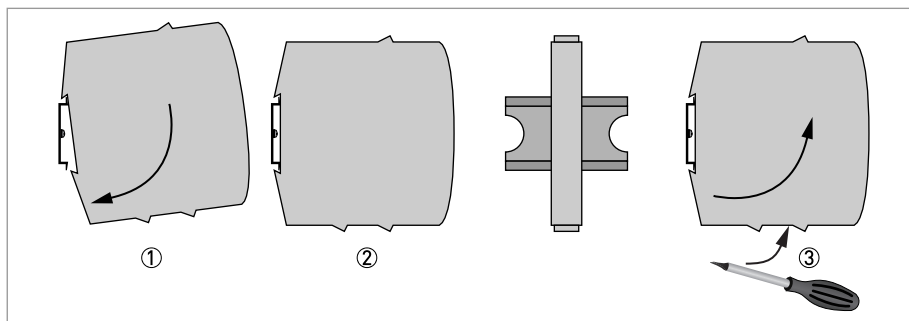


Figure 3-1: Rail installation

- ① Fix the upper part of the transmitter onto the rail.
- ② Press the lower part of the transmitter against the rail.
- ③ To remove the transmitter, use a screwdriver to bend the locking device using a small screwdriver. Carefully pull the transmitter in the forward direction.

### 3.3 In-head transmitter

These transmitters are intended for installation in DIN B connection heads or larger. The large  $\varnothing 7$  mm / 0.28" center hole facilitates the electrical connection of the measurement sensor and the installation. For detailed information refer to the chapter "Dimensions and weights".

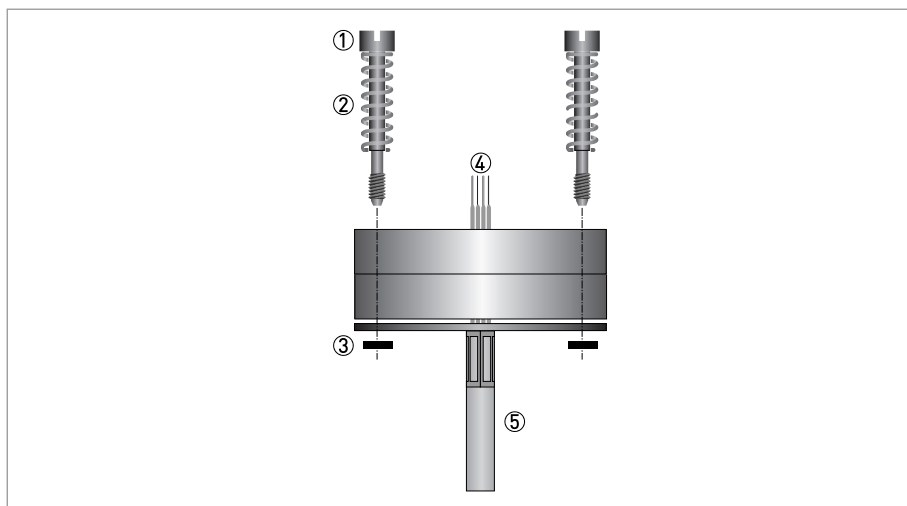


Figure 3-2: Connection head installation kit

- ① M4 screw
- ② Spring
- ③ Lock washer
- ④ Pt100
- ⑤ Thermowell

*The TT 51 C transmitter is optionally available in a non-incendive version (zone 2) and in an intrinsically safe version (zone 0, 1 and 2) for installation in potentially explosive atmospheres. The intrinsically safe version must be supplied by an intrinsically safe power supply unit or Zener barrier placed outside of the potentially explosive zone. The Ex transmitter must be installed in a housing with the protection rating IP20 or better according to EN 60529 / IEC 60529.*

*The TT 51 C transmitter has been developed for an ambient temperature of  $-40...+85^{\circ}\text{C}$  /  $-40...+185^{\circ}\text{F}$ . Please also note that the ambient temperature is also dependent on the temperature category. For detailed information refer to Ex data of the ambient temperature. The process temperature is also transferred to the transmitter housing via the thermowell. If the process temperature is close to or exceeds the maximum specified process temperature, then the temperature in the transmitter housing can rise above the maximum permissible ambient temperature. Always check that the ambient temperature where the transmitter is installed is always within the permissible range. One way to decrease heat transfer via the thermowell is to make the thermowell longer or in general to install the transmitter farther away from the heat source. The same safety measures can be taken if the temperature is below the specified minimum temperature.*

## 4.1 Safety instructions

*All work on the electrical connections may only be carried out with the power disconnected. Take note of the voltage data on the nameplate!*

*Observe the national regulations for electrical installations!*

*The transmitter is protected against polarity reversal. No damage will occur to the device if the polarity of the supply voltage is switched. The output will then indicate 0 mA.*

*The TT 51 C / TT 51 R are optionally available in a non-incendive version for use in potentially explosive atmosphere zone 2. For zone 2 applications a class 2 power supply placed in safe area is needed. In other potentially explosive areas, the intrinsically safe versions must be used.*

*The TT 51 C (intrinsically safe) can be installed in potentially hazardous area zone 0, 1 and 2.*

*The TT 51 R (intrinsically safe) can be installed in potentially hazardous area zone 1 and 2 and the input may be connected to zone 0.*

*The intrinsically safe versions must be supplied by an intrinsically safe power supply unit or Zener barrier placed outside of the potentially explosive zone.*

*Observe without fail the local occupational health and safety regulations. Any work done on the electrical components of the measuring device may only be carried out by properly trained specialists.*

*Look at the device nameplate to ensure that the device is delivered according to your order. Check for the correct supply voltage printed on the nameplate.*

## 4.2 Electrical connections of in-head transmitter

The input and output signals and the power supply must be connected in accordance with the following illustrations. The transmitter is easy to install with the connection head installation kit. To avoid measuring errors, all cables must be connected properly and the screws tightened correctly.

**RTD and potentiometer measurement**

<p>Pt100...Pt1000, Ni100, Ni120, Cu10 2-wire connection</p>	<p>Pt100...Pt1000, Ni100, Ni120, Cu10 3-wire connection</p>	<p>Pt100...Pt1000, Ni100, Ni120, Cu10 4-wire connection</p>
<p>RTD, redundant sensor elements 2 x 3-wire connection</p>	<p>RTD, redundant sensor elements 2 x 2-wire connection</p>	<p>Resistance, 2-wire connection</p>
<p>Resistance, 3-wire connection</p>	<p>Resistance, 4-wire connection</p>	<p>Potentiometer, 3-wire connection</p>

① SmartSense wire

**Thermocouple and voltage measurement**

<p>Thermocouple</p>	<p>Thermocouple, redundant sensor elements</p>	<p>Voltage</p>
<p>Voltage, redundant sensor elements</p>	<p>Thermocouple with remote reference junction compensation</p>	

① SmartSense wire

### 4.3 Connection diagram of in-head transmitter (non-incendive)

To enable HART<sup>®</sup> communication, the output circuit must have an output load of at least 250  $\Omega$ .

This transmitter is a category 3 equipment and may not be operated in areas with potentially explosive atmospheres other than zone 2!

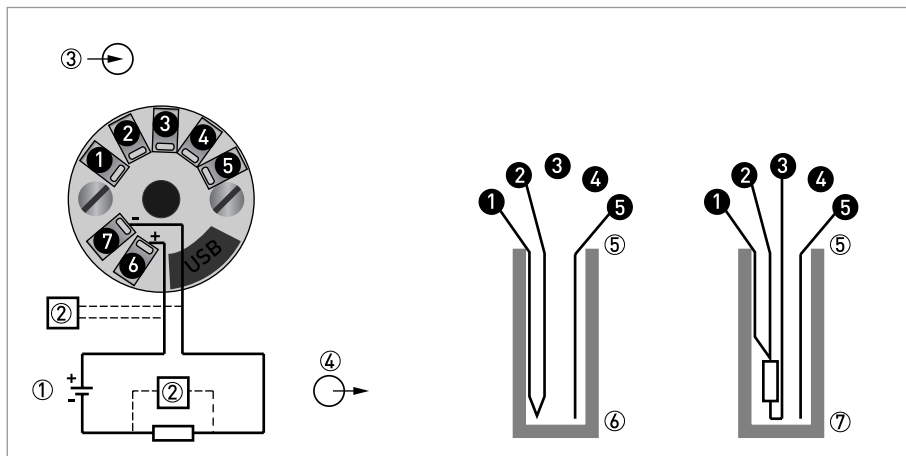


Figure 4-1: Connection diagram

- ① Voltage supply 10...36 VDC (terminals 6, 7)
- ② Modem
- ③ Input
- ④ Output
- ⑤ SmartSense temperature sensor
- ⑥ Thermocouple
- ⑦ Pt100 3-wire connection

The HART<sup>®</sup> modem is connected parallel to the output load or parallel to the output of the transmitter.

This transmitter may be operated in areas with potentially explosive atmospheres (zone 2) if the power supply has a protection ensuring that the power supply terminals of the transmitters are limited to transients not exceeding 140% of the rated power supply.

## 4.4 Connection diagram of in-head transmitter (intrinsically safe)

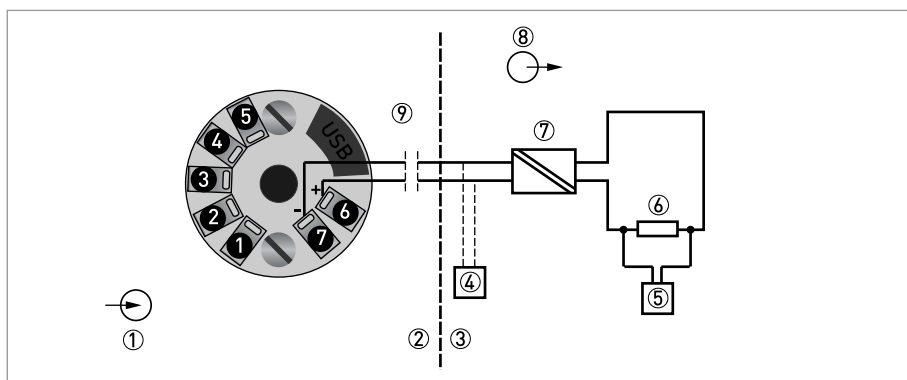


Figure 4-2: Connection diagram

- ① Input
- ② Potentially explosive area
- ③ Safe area
- ④ Modem, Ex-approved
- ⑤ Modem
- ⑥  $R_{Load}$ ,  $R \geq 250 \Omega$
- ⑦ Zener barrier or voltage supply 10...30 VDC (intrinsically safe)
- ⑧ Output
- ⑨ See chapter "cable length"

*The HART<sup>®</sup> modem is connected parallel to the output load or parallel to the output of the transmitter.*

*The transmitter may be operated in areas with potentially explosive atmospheres if the voltage supply is ensured by means of an appropriate power supply unit or a Zener barrier!*

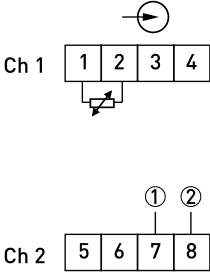
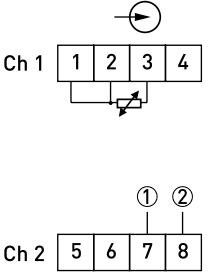
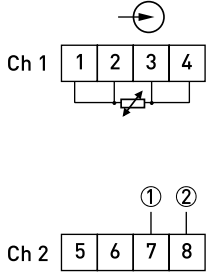
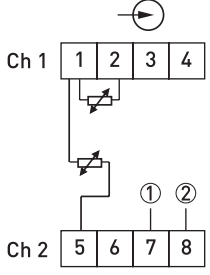
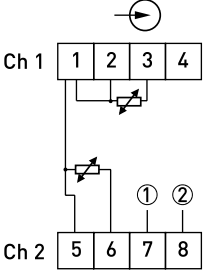
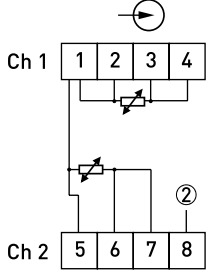
*In potentially explosive areas only Ex approved HART<sup>®</sup> modems may be used. The safety instructions for operation in potentially explosive areas must be observed.*

*In order to ensure reliable HART<sup>®</sup> communication with this transmitter, the maximum cable length of the output circuit must be observed. For detailed information refer to Cable length on page 29.*



## 4.5 Electrical connections of rail-mount transmitter

### RTD measurement

Pt100...Pt1000, Ni100, Ni120, Cu10 2-wire connection Ch1	Pt100...Pt1000, Ni100, Ni120, Cu10 3-wire connection Ch1	Pt100...Pt1000, Ni100, Ni120, Cu10 4-wire connection Ch1
		
RTD, redundant sensor elements 2 x 2-wire connection Ch1 + Ch2	RTD, redundant sensor elements 2 x 3-wire connection Ch1 + Ch2	RTD, redundant sensor elements 2 x 4-wire connection Ch1 + Ch2
		

- ① SmartSense wire
- ② GND (input cable screen(s))

**Resistance measurement**

Resistance, 2-wire connection Ch 1	Resistance, 3-wire connection Ch 1	Resistance, 4-wire connection Ch 1
Dual resistance, 2-wire connection on Ch 1 and Ch 2	Dual resistance, 3-wire connection on Ch 1 and Ch 2	Dual resistance, 4-wire connection on Ch 1 and Ch 2

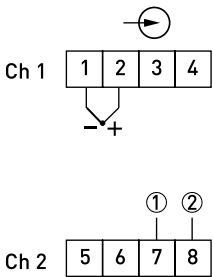
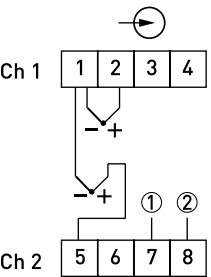
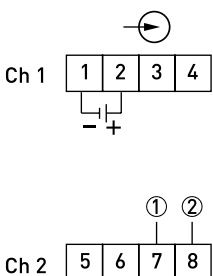
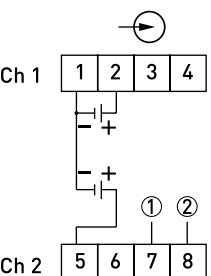
- ① SmartSense wire
- ② GND (input cable screen(s))

**Potentiometer and combined thermocouple and RTD measurement**

Potentiometer, 3-wire connection	Thermocouple and redundant 4-wire RTD elements	Thermocouple with 3-wire RTD elements as external CJC

- ① SmartSense wire
- ② GND (input cable screen(s))

**Thermocouple and voltage measurement**

Thermocouple	Thermocouple, redundant sensor elements
	
Voltage	Voltage, redundant sensor elements
	

- ① SmartSense wire
- ② GND (input cable screen(s))

## 4.6 Connection diagram of rail-mount transmitter (non-incendive)

*This transmitter is a category 3 equipment and may not be operated in areas with potentially explosive atmospheres other than zone 2 or it may be installed in safe area and connected to a sensor located in an area with a potentially explosive atmosphere zone 2!*

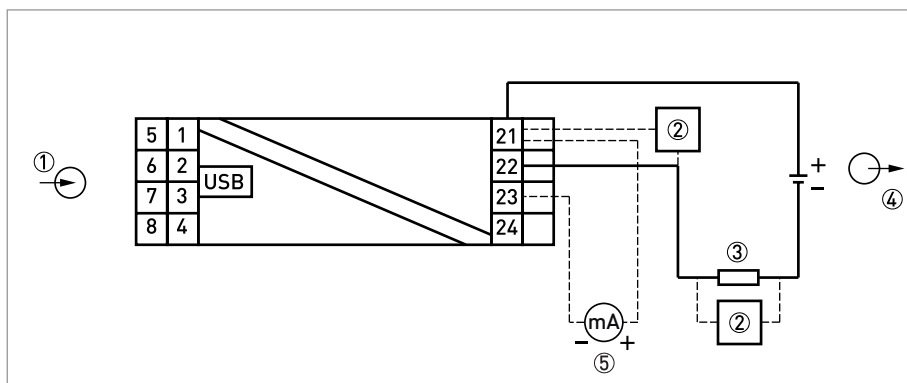


Figure 4-3: Connection diagram

- ① Input
- ② Modem
- ③  $R_{Load}$ ,  $R \geq 250 \Omega$
- ④ Voltage supply 10...36 VDC
- ⑤ Test connection [ $R_i \leq 10 \Omega$ ]

*The HART<sup>®</sup> modem is connected parallel to the output load or parallel to the output of the transmitter.*

## 4.7 Connection diagram of rail-mount transmitter (intrinsically safe)

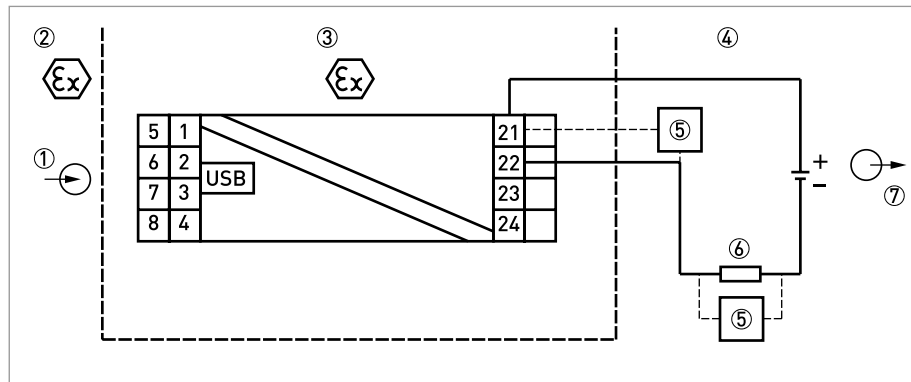


Figure 4-4: Connection diagram

- ① Input (intrinsically safe)
- ② Classified hazardous area (potentially explosive area e.g. zone 0, 1 or 2)
- ③ Classified hazardous area (potentially explosive area e.g. zone 1 or 2)
- ④ Safe area
- ⑤ Modem / Ex (intrinsically safe)
- ⑥  $R_{Load}$  (intrinsically safe)
- ⑦ Voltage supply 10...30 VDC (intrinsically safe - terminals 21, 22)

## 4.8 Cable length

In order to ensure reliable HART<sup>®</sup> communication, the maximum cable length of the output circuit must be observed.

*In the Ex version, please note that the maximum cable length is determined by a resistance, an inductance and a capacitance of the cable. The total capacitance and inductance of the cable must be within the limits for the transmitter described in the Ex certificate.*

To calculate the maximum cable length for the output circuit, determine the total resistance of the output loop (load resistance + approximate cable resistance). Find out the capacitance of the cable being used. In the following tables you can find the maximum cable length based on the typical values for 1 mm<sup>2</sup> cables. CN is the abbreviation for "Capacitance Number" which is multiple of 5000 pF present in the device.

Field device	Cable insulation					
	PVC		Polyethylene		Polyethylene foam	
	[m]	[ft]	[m]	[ft]	[m]	[ft]
1 (CN = 1)	600	1969	1100	3609	2000	6562
10 Multidrop (CN = 1)	500	1640	900	2953	1600	5249
10 Multidrop (CN = 4.4)	85	279	150	492	250	820

Insulation	Capacitance [pF/m]
PVC	300...400
Polyethylene	150...200
Polyethylene foam	75...100

Conductors			Resistance [ $\Omega$ /km] (both conductors in series)
Area [mm <sup>2</sup> ]	Diameter [mm]	AWG	
2.0	1.6	14	17
1.3	1.3	16	28
1.0	1.15	17	36
0.8	1.0	18	45
0.5	0.8	20	70
0.3	0.6	22	110
0.2	0.5	24	160

For multiple connections (Multidrop mode), the following formula shall be used:

$$L = [(65 \times 10^6) / R \times C] \times (C_n \times 5000 + 10000) / C$$

with

L: cable length [m or ft]

R: load resistance (incl. the resistance of any Zener barrier) + cable resistance [ $\Omega$ ]

C: cable capacitance [pF/m or pF/ft]

C<sub>n</sub>: number of transmitters in the loop

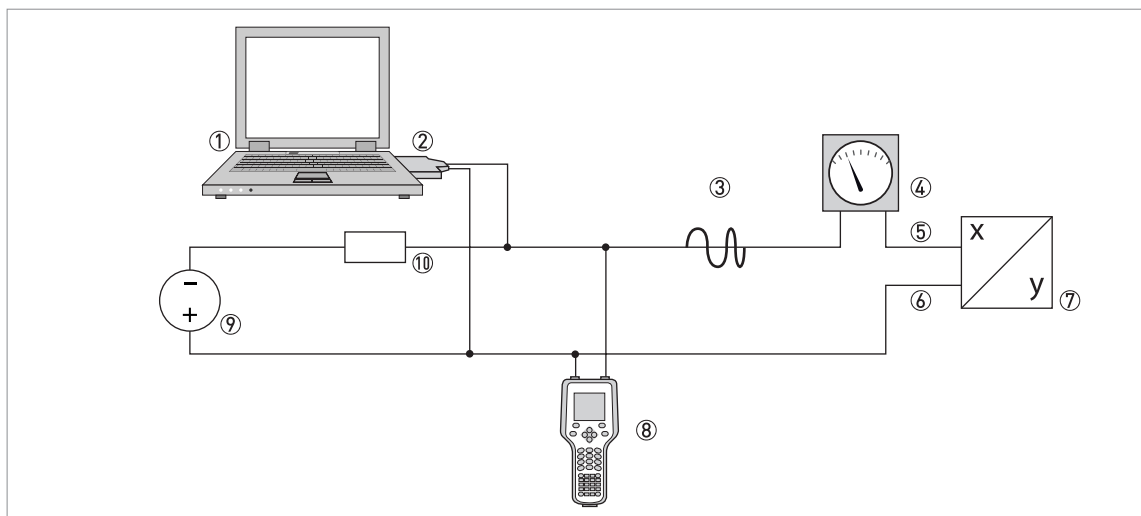
## 4.9 HART<sup>®</sup> networks

*In order to ensure reliable HART<sup>®</sup> communication with this transmitter, the loop resistance must be at least 250 Ω!*

### 4.9.1 Point-to-point connection analog / digital mode

Point-to-point connection between the transmitter and the HART<sup>®</sup> master.

The current output of the device may be active or passive.



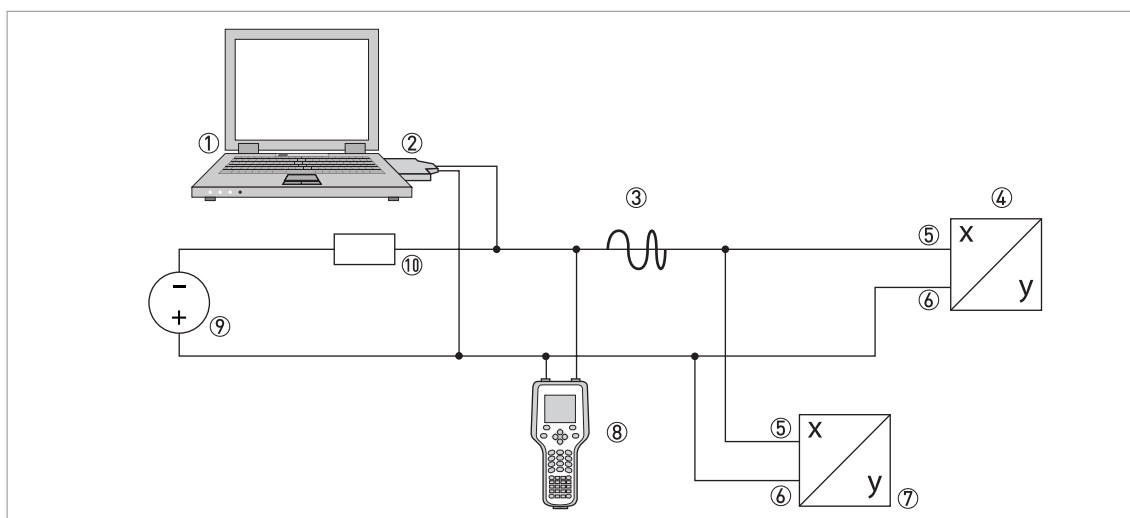
- ① Primary Master
- ② HART<sup>®</sup> modem
- ③ HART<sup>®</sup> signal
- ④ Analog indicator
- ⑤ Terminal 7
- ⑥ Terminal 6
- ⑦ Device with address = 0 and passive or active current output
- ⑧ Secondary Master
- ⑨ Power supply for devices (slaves) with passive current output
- ⑩ Load  $\geq 250 \Omega$  (Ohm)

### 4.9.2 Multi-drop connection (2-wire connection)

As a multipoint connection (Multidrop) with up to 64 devices in parallel (this transmitter or other HART<sup>®</sup> devices).

The current outputs of the devices must be passive!

Burst mode is not supported.



- ① Primary master
- ② HART<sup>®</sup> modem
- ③ HART<sup>®</sup> signal
- ④ Other HART<sup>®</sup> devices or this transmitter (refer also to ⑦)
- ⑤ Terminal 7
- ⑥ Terminal 6
- ⑦ Device with address > 0 and passive current output, connection of max. 64 devices (slaves)
- ⑧ Secondary Master
- ⑨ Power supply for devices (slaves) with passive current output
- ⑩ Load  $\geq 250 \Omega$  (Ohm)



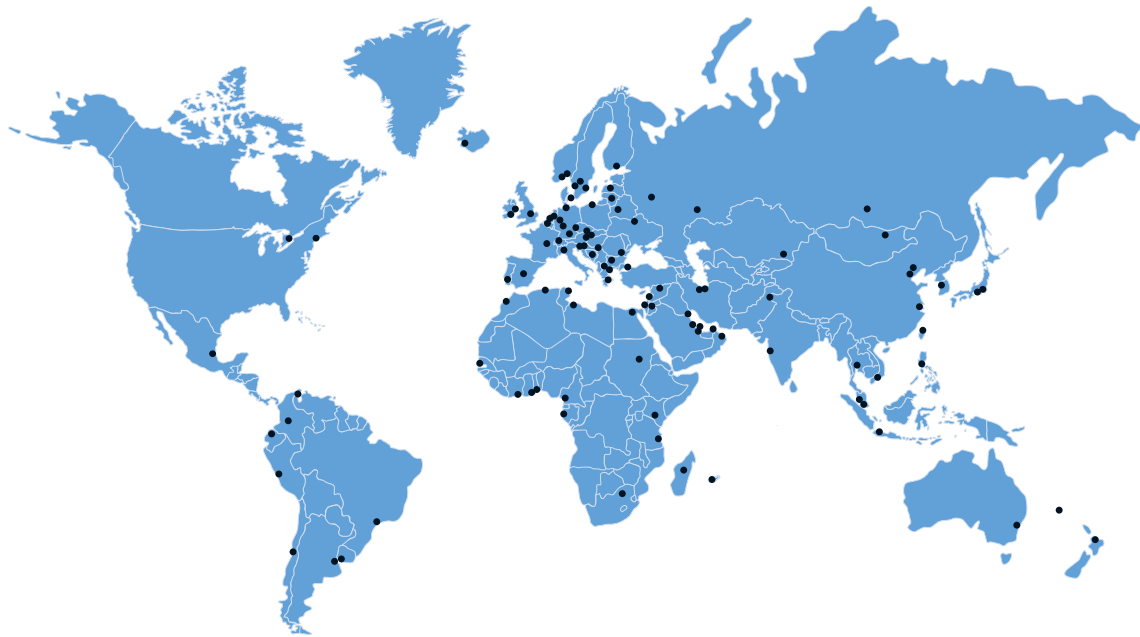
## 5.1 Order code

The characters of the order code highlighted in light grey describe the standard.

VTT1	4	<b>Design</b>
	1	Head mounting (type C)
	2	DIN-rail mounting; 35 mm / 1.38" (type R)
		<b>Type</b>
	U	TT 51; digital, HART <sup>®</sup> and also SIL2; 4...20 mA
		<b>Approvals</b>
	0	Without
	1	ATEX: II 1 G Ex ia IIC T4...T6 (only type C)
	2	ATEX: II 3 G Ex nL IIC T4...T6
	7	ATEX: II 2(1) G Ex ia IIC T4...T6 (only type R)
		<b>Sensor type</b>
	0	Without
	1	Pt10
	2	Pt50
	3	Pt100
	6	Pt200
	7	Pt500
	8	Pt1000
	A	Potentiometer
	B	Thermocouple type B
	C	Thermocouple type C
	E	Thermocouple type E
	H	Thermocouple type J
	K	Thermocouple type K
	L	Thermocouple type L
	N	Thermocouple type N
	R	Thermocouple type R
	S	Thermocouple type S
	T	Thermocouple type T
	U	Cu10
	V	Ni50
	W	Ni100
	X	Ni120
	Y	Ni1000
	Z	Customised



																				<b>Manuals</b>	
																				0	Without
																				1	German
																				3	English
																				4	French
																				5	Spanish
																				G	German / English
																				<b>Private Label</b>	
																				0	KROHNE standard version
																				B	Neutral (in preparation)
<b>VTT1</b>	<b>4</b>																			0	0



## KROHNE product overview

- Electromagnetic flowmeters
- Variable area flowmeters
- Ultrasonic flowmeters
- Mass flowmeters
- Vortex flowmeters
- Flow controllers
- Level meters
- Temperature meters
- Pressure meters
- Analysis products
- Products and systems for the oil & gas industry
- Measuring systems for the marine industry

Head Office KROHNE Messtechnik GmbH  
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Tel.: +49 (0)203 301 0  
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info@krohne.de

The current list of all KROHNE contacts and addresses can be found at:  
[www.krohne.com](http://www.krohne.com)

**KROHNE**