SD01632T/09/EN/02.23-00
71639677
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Special Documentation
Temperature field transmitter iTEMP TMT162

Functional Safety Manual

HART COMMUNICATION PROTOCOL

Endress+Hauser
People for Process Automation

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1 Declaration of Conformity

SIL_00020_03.23

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Herstellererklärung - Manufacturer Declaration
Funktionale Sicherheit - Functional Safety (IEC 61508:2010)
Beiblatt 1 / NE130 Formblatt B1 – Supplement 1 / NE130 From B.1

Endress+Hauser Wetzer GmbH+Co. KG Obere Wank 1, 87484 Nesselwang

erklärt als Hersteller, dass der folgende Temperaturtransmitter
declares as manufacturer, that the following temperature transmitter

iTEMP TM162

in sicherheitsrelevanten Anwendungen SIL2 (HFT=0) bzw. SIL3 (HFT=1) nach IEC61508:2010 eingesetzt werden kann.
is suitable for use in saftey relevant applications up to SIL2 (HFT=0) rep. SIL3 (HFT=1) according to IEC 61508:2010

Für einen Einsatz in sicherheitsrelevanten Anwendungen entsprechend IEC 61508 sind die Angaben des Handbuchs zur Funktionalen Sicherheit zu beachten.
In safety relevant applications according to IEC 61508, the instructions of the Safety Manual have to be followed.

Nesselwang, 17.11.2023
Endress+Hauser Wetzer GmbH+Co. KG

ppa. Harald Müller
Director Technology

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Head of Department Tech. Transmitter

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1.1 Safety-related characteristic values

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Allgemein			
Gerätebezeichnung und zulässige Ausführungen	TMT162 (Bestellmerkmal "Weitere Zulassungen": Option LA "SIL")		
Sicherheitsbezogene Ausgangssignale	4…20mA		
Fehlerstrom	≤ 3,6 mA oder ≥ 21,0 mA		
Bewertete Messgröße / Funktion	Temperatur / Spannung / Widerstand		
Sicherheitsfunktion(en)	sichere Messung		
Gerätetyp gem. IEC 61508-2	☐ Typ A	☑ Typ B	
Betriebsart	☑ Low Demand Mode	☑ High Demand	☐ Continuous Mode
Gültige Hardware-Version	04.01.00 oder höher		
Gültige Firmware-Version	04.01.00 oder höher		
Sicherheitshandbuch	SD01632T/09/		
Art der Bewertung (nur eine Variante wählbar)	☑	Vollständige entwicklungsbegleitende HW/SW Bewertung inkl. FMEDA und Änderungsprozess nach IEC 61508-2, 3	
	☐	Bewertung über Nachweis der Betriebsbewährung HW/SW inkl. FMEDA und Änderungsprozess nach IEC 61508-2, 3	
	☐	Auswertung von Felddaten HW/SW zum Nachweis "Frühere Verwendung" gem. IEC 61511	
	☐	Bewertung durch FMEDA gem. IEC 61508-2 für Geräte ohne Software	
Bewertung durch / Zertifikatsnummer	TÜV SÜD Rail GmbH, Germany / Zertifikat Nr. Z10 012833 0004		
Prüfungsunterlagen	Entwicklungsdokumente, Testreports, Datenblätter		

SIL - Integrität			
Systematische Sicherheitsintegrität		☐ SC 2 fähig	☑ SC 3 fähig
Hardware Sicherheitsintegrität	Einkanaliger Einsatz (HFT = 0)	☑ SIL 2 fähig	☐ SIL 3 fähig
	Mehrkanaliger Einsatz (HFT ≥ 1)	☐ SIL 2 fähig	☑ SIL 3 fähig

FMEDA	Transmitter
Sicherheitsfunktion(en)	sichere Messung
λ_{DU} 1),2)	29 FIT
λ_{DD} 1),2)	269 FIT
λ_{S} 1),2)	139 FIT
SFF - Safe Failure Fraction	93%
PFD_{avg} für T1 = 1 Jahr 2) (einkanalige Architektur)	$1.3 \cdot 10^{-4}$
PFD_{avg} für T1 = 5 Jahre 2) (einkanalige Architektur)	$6.4 \cdot 10^{-4}$
PFH	$2.9 \cdot 10^{-8} \cdot 1/h$
PTC 3)	96%
Fehlerreaktionszeit 4)	< 16,2 s
Diagnose-Testintervall 5)	4,3 min
Prozesssicherheitszeit 6)	7,2 h
MTTF 7)	142 Jahre

Erklärung	
☑	Unser firmeninternes Qualitätsmanagement stellt die Information von zukünftig bekanntwerdenden sicherheitsrelevanten systematischen Fehlern sicher.

1) FIT = Failure In Time, Anzahl der Ausfälle pro 10^9 h
2) Gültig für gemittelte Umgebungstemperaturen bis zu +40 °C (+104 °F)
Bei einer durchschnittlichen Dauereinsatztemperatur nahe +60 °C (+140 °F) sollte ein Faktor von 2,1 berücksichtigt werden
3) PTC = Proof Test Coverage (Diagnoseaufdeckungsgrad von Gerätefehlern bei manueller Wiederholungsprüfung)
4) Maximale Zeit zwischen Fehlererkennung und Fehlerreaktion
5) In dieser Zeit werden alle online Diagnosefunktionen mindestens 1x ausgeführt (26,1 min inkl. Speichertest)
6) Die Prozesssicherheitszeit beträgt: Diagnose-Testintervall x 100 (Berechnung nach IEC 61508)
7) MTTF (Mean Time To Failure) Dieser Wert berücksichtigt alle Ausfallarten der Elektronikkomponenten gemäß Siemens SN29500

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General			
Device designation and permissible types	TMT162 (Feature "additional approval": Option LA "SIL")		
Safety-related output signal	4...20 mA		
Fault current	≤ 3,6 mA or ≥ 21,0 mA		
Process variable/function	Temperature, Voltage, Resistance		
Safety function(s)	safe measurement		
Device type acc. to IEC 61508-2	☐ Type A	☑ Type B	
Operating mode	☑ Low Demand Mode	☑ High Demand	☐ Continuous Mode
Valid Hardware-Version	04.01.00 or higher		
Valid Software-Version	04.01.00 or higher		
Safety manual	SD01632T/09/		
Type of evaluation (check only one box)	☑	Complete HW/SW evaluation parallel to development incl. FMEDA and change request acc. to IEC 61508-2, 3	
	☐	Evaluation of "Proven-in-use" performance for HW/SW incl. FMEDA and change request acc. to IEC 61508-2, 3	
	☐	Evaluation of HW/SW field data to verify „prior use" acc. to IEC 61511	
	☐	Evaluation by FMEDA acc. to IEC 61508-2 for devices w/o software	
Evaluation through / certificate no.	TÜV SÜD Rail GmbH, Germany / certificate no. Z10 012833 0004		
Test documents	development documents, test reports, data sheets		

SIL - Integrity			
Systematic safety integrity		☐ SC 2 capable	☑ SC 3 capable
Hardware safety integrity	Single channel use (HFT = 0)	☑ SIL 2 capable	☐ SIL 3 capable
	Multi-channel use (HFT ≥ 1)	☐ SIL 2 capable	☑ SIL 3 capable

FMEDA	Head transmitter
Safety function	safe measurement
λ_{DU} 1) 2)	29 FIT
λ_{DD} 1) 2)	269 FIT
λ_{SU} 1) 2)	139 FIT
SFF - Safe Failure Fraction	93%
PFD_{avg} T1 = 1 year 2) (single channel architecture)	$1.3 \cdot 10^{-4}$
PFD_{avg} T1 = 5 years 2) (single channel architecture)	$6.4 \cdot 10^{-4}$
PFH	$2.9 \cdot 10^{-8} \cdot 1/h$
PTC 3)	96%
Fault reaction time 4)	< 16.2 s
Diagnostic test interval 5)	4.3 min
Process safety time 6)	7.2 h
MTTF 7)	142 Jahre

Declaration	
☑	Our internal company quality management system ensures information on safety-related systematic faults which become evident in the future

1) FIT = Failure In Time, Number of failures per 10^9 h
2) Valid for average ambient temperature up to +40 °C (+104 °F)
For continuous operation at ambient temperature close to +60 °C (+140 °F), a factor of 2.1 should be applied
3 PTC = Proof Test Coverage
4) Maximum time between error recognition and error response
5) All online diagnostic functions are performed at least once within the Diagnostic test interval (26.1 min incl. memory test)
6) The Process safety time is: Diagnostic test interval x 100 (calculated acc. to IEC 61508)
7) MTTF (Mean Time To Failure) is the predicted elapsed time between inherent failures of a system during operation in accordance to Siemens SN29500

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2 About this document

2.1 Document function

This supplementary Safety Manual applies in addition to the Operating Instructions, Technical Information and ATEX Safety Instructions. The supplementary device documentation must be observed during installation, commissioning and operation. The requirements specific to the protection function are described in this safety manual.

General information on functional safety (SIL) is available at: www.endress.com/SIL

2.2 Using this document

Information on the document structure

For the arrangement of the parameters according to the menu structure of the **Operation** menu, **Setup** menu, **Diagnostics** menu, along with short descriptions, see the Operating Instructions for the device

2.3 Symbols used

2.3.1 Safety symbols

DANGER
This symbol alerts you to a dangerous situation. Failure to avoid this situation will result in serious or fatal injury.

WARNING
This symbol alerts you to a dangerous situation. Failure to avoid this situation can result in serious or fatal injury.

CAUTION
This symbol alerts you to a dangerous situation. Failure to avoid this situation can result in minor or medium injury.

NOTICE
This symbol contains information on procedures and other facts which do not result in personal injury.

2.3.2 Symbols for certain types of information and graphics

Tip
Indicates additional information

Reference to documentation

Reference to graphic

▶
Notice or individual step to be observed

1., 2., 3.
Series of steps

↳
Result of a step

1, 2, 3, ...
Item numbers

A, B, C, ...
Views

2.4 Supplementary device documentation

For an overview of the scope of the associated Technical Documentation, refer to the following:
- *Device Viewer* (www.endress.com/deviceviewer): Enter the serial number from the nameplate
- *Endress+Hauser Operations app*: Enter serial number from nameplate or scan matrix code on nameplate.

The following document types are available in the download area of the Endress+Hauser website (www.endress.com/downloads):

2.4.1 Further applicable documents

- BA01801T
- KA00250R
- TI01344T
- XA00031R
- XA00032R
- XA00033R
- XA00065R
- XA01688T
- XA01689T

Technical Information (TI)

Planning aid
The document contains all the technical data on the device and provides an overview of the accessories and other products that can be ordered for the device.

Brief Operating Instructions (KA)

Guide that takes you quickly to the 1st measured value
The Brief Operating Instructions contain all the essential information from incoming acceptance to initial commissioning.

Operating Instructions (BA)

Your reference guide
These Operating Instructions contain all the information that is required in various phases of the life cycle of the device: from product identification, incoming acceptance and storage, to mounting, connection, operation and commissioning through to troubleshooting, maintenance and disposal.

Safety Instructions (XA)

Depending on the approval, the following Safety Instructions (XA) are supplied with the device. They are an integral part of the Operating Instructions.

The nameplate indicates the Safety Instructions (XA) that are relevant to the device.

Special Documentation (SD)

The document is part of the Operating Instructions and serves as a reference for application specific parameters and notes.

- General information about functional safety: SIL
- General information about SIL is available in the Download Area of the Endress +Hauser Internet site: www.de.endress.com/SIL

3 Permitted device types

The details pertaining to functional safety in this manual relate to the device versions listed below and are valid as of the specified firmware and hardware versions. Unless otherwise specified, all subsequent versions can also be used for safety functions.

A modification process according to IEC 61508 is applied for any device modifications. Valid device versions for safety-related use:

Feature	Designation	Version
010	Approval	All
...	...	...
590	Additional approval	LA
...	...	...

Order code:

<table>
<tr><td rowspan="3">TMT162 - x x x x x x x x + x x x x LA x x x x x
↑
A0034088
The full order code is saved electronically in the device. It is shortened on the nameplate due to space limitations.</td><td>Valid firmware version</td><td>as of 04.01.00</td></tr>
<tr><td>Valid hardware version (electronics)</td><td>as of 04.01.00</td></tr>
<tr><td>Valid device drivers</td><td>DTM as of version 1.8.120.3991
DD as of revision 0x01</td></tr>
</table>

SIL certified devices are identified by the following SIL symbol on the nameplate: (SIL)

3.1 Identification

SIL certified devices are labeled with SIL symbol (SIL) on the nameplate.

4 Safety function

4.1 Definition of the safety function

The device's safety function is:
Safe measurement → 📄 10

4.1.1 Safety-related output signal

The device's safety-related signal is the analog output signal 4 to 20 mA as per NAMUR NE43. All safety measures refer to this signal exclusively. In addition, the device also communicates via HART® for information purposes and comprises all the HART® features with additional device information. HART® communication is **not** part of the safety function.

The safety-related output signal is fed to a downstream logic unit, e.g. a programmable logic controller or a limit signal transmitter where it is monitored for the following:
- Overshooting and/or undershooting of a specified limit value
- The occurrence of a fault: e.g. failure current (≤ 3.6 mA, ≥ 21.0 mA, signal cable open circuit or short-circuit)

In the event of a fault, it must be ensured that the equipment under control achieves or maintains a safe state. See "Structure of the measuring system" section. → 📄 30

4.1.2 Safe measurement

The transmitter's safety function comprises a transmitted current output signal proportional to the voltage, resistance or temperature value.

The safety function can be used with all sensor configurations from the "Structure of the measuring system" section→ 6, 📄 31. Note here that only the measured value of one sensor or the value of a function (e.g. the mean value of or difference between the two measured values) can ever be displayed via the current output.

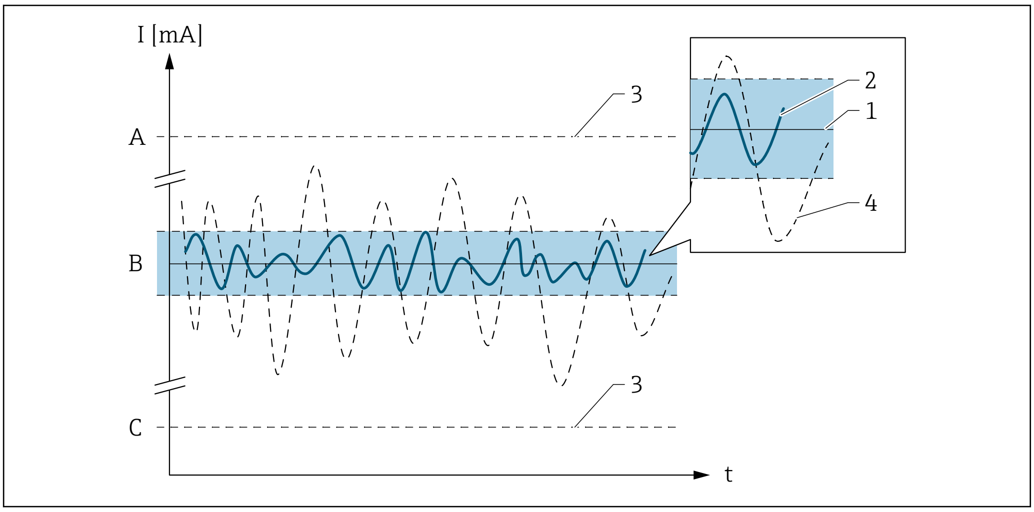
4.2 Basic conditions for use in safety-related applications

The measuring system must be used correctly for the specific application, taking into account the medium properties and ambient conditions. Carefully follow instructions pertaining to critical process situations and installation conditions from the Operating Instructions. The application-specific limits must be observed. The specifications in the Operating Instructions and the Technical Information must not be exceeded.

- Information on the safety-related signal. → 📄 10
- Compliance with the specifications in the Operating Instructions is mandatory. → 📄 8
- The ambient temperature of the device is −40 to +75 °C (−40 to +167 °F)
- Compliance with the ambient conditions as per IEC 61326-3-2 Appendix B is mandatory.
- Use of the FXA291 and TXU10 communication interface is not possible in the expert mode (only via HART® communication).
- The device may only be powered by a power unit with an energy-limited circuit in accordance with UL/EN/IEC 61010-1, Section 9.4 and the requirements of Table 18.
- Configure the mains frequency filter correctly (50 Hz/60 Hz).
- The fault response time must meet the safety requirements.
- Maximum permitted sensor cable resistance for voltage measurement: 1 000 Ω.
- The "Device temperature" measured value must not be output to the primary variable (PV) in safety-related mode.

- The "Sensor switching" and "Average with backup" functions both can **not** be used in safety-related mode.
- A shielded cable that is grounded on both sides must be used if the sensor cable is 30 m (98.4 ft) or longer. The use of shielded sensor cables is generally recommended.
- The following restriction also applies to safety-related use:
  Strong, pulse-like EMC interference on the power supply line can result in transient (< 1 s) deviations in the output signal (≥ ±1%). For this reason, filtering with a time constant of ≥ 1 s should be performed in the downstream logic unit.
  The specified error range (safety measured error → 13) is sensor-specific and is defined according to FMEDA (Failure Modes, Effects and Diagnostic Analysis) on delivery. It already includes all influencing factors described in the Technical Information TI (non-linearity, non-repeatability, hysteresis, zero error, temperature drift).
  According to IEC / EN 61508 the safety-related failures are classified into different categories, see the following table. The table shows the implications for the safety-related output signal and the measurement uncertainty.

4.2.1 Safety-related failures according to IEC/EN 61508



A High alarm ≥ 21 mA
B SIL error range ±2%
C Low alarm ≤3.6 mA

No device error
- No error
- Implications for the safety-related output signal: none
- Impact on the measurement uncertainty:
  1 – Within the specification, For detailed information, see TI/BA

λS (Safe)
- Safe failure
- No impact on the safety-related output signal:
  2 – Moves within the specified SIL error range
- Output signal enters the safe state
- Impact on the measurement uncertainty:
  2 – Moves within the specified SIL error range
  3 – Has no effect

λ_{DD} (Dangerous detected)
- Dangerous failure which can be detected
- Impact on the safety-related output signal: results in a failure mode at the output signal
- Impact on the measurement uncertainty:
  3 – Has no effect

λ_{DU} (Dangerous undetected)

- Dangerous failure which cannot be detected
- Implications for the safety-related output signal: can be outside the defined error range
- Impact on the measurement uncertainty:
  4 – May be outside the specified error range

4.3 Dangerous undetected failures in this scenario

An incorrect output signal that deviates from the value specified in this manual but is still in the range of 4 to 20 mA, is considered a "dangerous, undetected failure". → 📄 10

4.4 Safety measured error

Thermocouples

Standard	Description (index for unique identification)	Min. measuring span	Limited safety measuring range	Maximum measurement error		Long-term drift in °C/per year 1)
				Digital (+A/D), −40 to +70 °C (−40 to +158 °F) 2)	(D/A) 3)	
IEC 60584-1	Type A (W5Re-W20Re) (30)	50 K (90 °F)	0 to +2 500 °C (+32 to +4 532 °F)	12 K (21.6 °F)	0.5%	1.42
	Type B (PtRh30-PtRh6) (31)	50 K (90 °F)	+500 to +1 820 °C (+932 to +3 308 °F)	5.1 K (9.2 °F)		2.01
	Type E (NiCr-CuNi) (34)	50 K (90 °F)	−150 to +1 000 °C (−238 to +1 832 °F)	4.9 K (8.8 °F)		0.43
	Type J (Fe-CuNi) (35)	50 K (90 °F)	−150 to +1 200 °C (−238 to +2 192 °F)	4.9 K (8.8 °F)		0.46
	Type K (NiCr-Ni) (36)	50 K (90 °F)	−150 to +1 200 °C (−238 to +2 192 °F)	5.1 K (9.2 °F)		0.56
	Type N (NiCrSi-NiSi) (37)	50 K (90 °F)	−150 to +1 300 °C (−238 to +2 372 °F)	5.5 K (9.9 °F)		0.73
	Type R (PtRh13-Pt) (38)	50 K (90 °F)	+50 to +1 768 °C (+122 to +3 214 °F)	5.6 K (10.1 °F)		1.58
	Type S (PtRh10-Pt) (39)	50 K (90 °F)	+50 to +1 768 °C (+122 to +3 214 °F)	5.6 K (10.1 °F)		1.59
	Type T (Cu-CuNi) (40)	50 K (90 °F)	−150 to +400 °C (−238 to +752 °F)	5.2 K (9.4 °F)		0.52
IEC 60584-1; ASTM E988-96	Type C (W5Re-W26Re) (32)	50 K (90 °F)	0 to +2 000 °C (+32 to +3 632 °F)	7.6 K (13.7 °F)		0.94
ASTM E988-96	Type D (W3Re-W25Re) (33)	50 K (90 °F)	0 to +2 000 °C (+32 to +3 632 °F)	7.1 K (12.8 °F)		1.14
DIN 43710	Type L (Fe-CuNi) (41) Type U (Cu-CuNi) (42)	50 K (90 °F)	−150 to +900 °C (−238 to +1 652 °F) −150 to +600 °C (−238 to +1 112 °F)	4.3 K (7.7 °F) 5.0 K (9 °F)		0.42 0.52
GOST R8.8585-2001	Type L (NiCr-CuNi) (43)	50 K (90 °F)	−200 to +800 °C (−328 to +1 472 °F)	8.4 K (15.1 °F)		0.53
Voltage transmitter (mV)		5 mV	−20 to 100 mV	200 µV		27.39 µV/a

1) Values apply for 25 °C. For other values, the Arrhenius equation must be applied. This means a doubling of the drift for each 10 °C temperature increase.
2) Measured value transmitted via HART®.
3) Percentages based on the configured span of the analog output signal.

Resistance sensors

Standard	Designation	Min. measuring span	Limited safety measuring range	Maximum measurement error		Long-term drift in °C/per year 1)
				Digital (+A/D), −40 to +70 °C (−40 to +158 °F) 2)	(D/A) 3)	
IEC 60751:2008	Pt100 (1)	10 K (18 °F)	−200 to +600 °C (−328 to +1 112 °F)	1.1 K (2.0 °F)	0.5%	0.23
	Pt200 (2)	10 K (18 °F)	−200 to +600 °C (−328 to +1 112 °F)	1.6 K (2.9 °F)		0.92
	Pt500 (3)	10 K (18 °F)	−200 to +500 °C (−328 to +932 °F)	0.9 K (1.6 °F)		0.38

Standard	Designation	Min. measuring span	Limited safety measuring range	Maximum measurement error		Long-term drift in °C/per year 1)
				Digital (+A/D), −40 to +70 °C (−40 to +158 °F) 2)	(D/A) 3)	
	Pt1000 (4)	10 K (18 °F)	−200 to +250 °C (−328 to +482 °F)	0.6 K (1.1 °F)		0.19
JIS C1604:1984	Pt100 (5)	10 K (18 °F)	−200 to +510 °C (−328 to +950 °F)	1.0 K (1.8 °F)		0.32
DIN 43760 IPTS-68	Ni100 (6)	10 K (18 °F)	−60 to +250 °C (−76 to +482 °F)	0.4 K (0.7 °F)		0.22
	Ni120 (7)		−60 to +250 °C (−76 to +482 °F)	0.3 K (0.54 °F)		0.18
GOST 6651-94	Pt50 (8)	10 K (18 °F)	−180 to +600 °C (−292 to +1 112 °F)	1.3 K (2.34 °F)		0.61
	Pt100 (9)	10 K (18 °F)	−200 to +600 °C (−328 to +1 112 °F)	1.2 K (2.16 °F)		0.34
OIML R84: 2003, GOST 6651-2009	Cu50 (10)	10 K (18 °F)	−180 to +200 °C (−292 to +392 °F)	0.7 K (1.26 °F)		0.46
	Cu100 (11)	10 K (18 °F)	−180 to +200 °C (−292 to +392 °F)	0.5 K (0.9 °F)		0.23
	Ni100 (12)	10 K (18 °F)	−60 to +180 °C (−76 to +356 °F)	0.4 K (0.72 °F)		0.21
	Ni120 (13)	10 K (18 °F)	−60 to +180 °C (−76 to +356 °F)	0.3 K (0.54 °F)		0.18
OIML R84: 2003, GOST 6651-94	Cu50 (14)	10 K (18 °F)	−50 to +200 °C (−58 to +392 °F)	0.7 K (1.26 °F)		0.45
Resistance transmitter Ω	400 Ω	10 Ω	10 to 400 Ω	0.5 Ω		0.096 Ω/a
	2 000 Ω	100 Ω	10 to 2 000 Ω	2.1 Ω		0.51 Ω/a

1) Values apply for 25 °C. For other values, the Arrhenius equation must be applied. This means a doubling of the drift for each 10 °C temperature increase.
2) Measured value transmitted via HART®.
3) Percentages based on the configured span of the analog output signal.

These values do not take into account deviations caused by EMC. In the event of non-negligible EMC interference, an additional deviation of 1% from the span must be added to the values above.

⚠ CAUTION

When using a 2-wire resistance measurement:
- ▶ Make the necessary adjustment to the cable resistance values.

Sample calculation with Pt100 in 4-wire connection, measuring range 0 to +100 °C (+32 to +212 °F), ambient temperature +25 °C (+77 °F), supply voltage 24 V:

Measured error digital = 1.1 K (2.0 °F)
Measurement error D/A = 0.5 % x 100 °C (212 °F) = 0.5 K (0.9 °F)
Measured error: 1.6 K (2.9 °F); for safety measured errors, the most unfavorable values must be anticipated.

Validity of data for safety measured error:
- Total permitted temperature range of the transmitter in the SIL mode
- Defined range of the supply voltage
- Limited safety measuring range of sensor element

- Accuracy includes all linearization and rounding errors
- Observe the minimum span of each sensor.
- Values are 2σ values, i.e. 95.4 % of all measured values are within the specifications.

4.5 Useful lifetime of electrical components

The established failure rates of electrical components apply within the useful lifetime as per IEC 61508-2:2010 section 7.4.9.5 note 3.

In accordance with DIN EN 61508-2:2011 section 7.4.9.5, national footnote N3, appropriate measures taken by the manufacturer and operator can extend the useful lifetime.

This device does not contain any electronic components as per the "EMCRH Electrical & Mechanical Component Reliability Handbook" Third Edition (exida.com) that have a useful lifetime less than 50 years.

However, the useful lifetime can be significantly shorter if the device is operated at higher temperatures.

5 Use in safety instrumented systems

5.1 Device behavior during operation

After SIL locking, additional diagnostics are active and critical parameters in the safety path are set to safe values. Therefore, the device behavior in the "SIL mode" may deviate from the "normal mode". If a test phase takes place before the plant is finally put into production, it is recommended that this test phase be run in the "SIL mode" in order to obtain the most conclusive results possible.

5.1.1 Device behavior when switched on

After power-up, the device runs through a diagnostic phase. The current output is set to the failure current (Low alarm, ≤ 3.6 mA) during this time.

During the diagnostic phase, no communication is possible via the service interface (CDI) or via HART®, and the screen of the display is not active.

5.1.2 Device behavior when safety function is requested

The device outputs a current value corresponding to the limit value to be monitored. This value must be monitored and processed further in a connected logic unit.

5.1.3 Safe states

The system assumes one of the three states depending on the error detected.

Failure mode / Description	Safe state / Output current
Application errors are detected by the device, and the set failure current is output. The device can continue to communicate via HART® (device state: "Temporarily safe"). This state persists until all the application errors are resolved and the device can again supply a valid measured value at the current output. All parameters can be read. Example: A cable open circuit is detected in the sensor.	I ≤ 3.6 mA (Low-Alarm) or I ≥ 21.5 mA (High-Alarm)
The device can continue to communicate via HART® (device state: "Active safe"). However, the current output consistently outputs the set failure current. This state persists until the device is restarted. All parameters can be read. Example: Undervoltage detected at device.	
The device ceases operation immediately and restarts after 0.5 s at the latest. The device does not display any error messages. Example: An error is detected while the program is running.	

5.1.4 Device behavior in the event of alarms and warnings

The output current in the event of an alarm can be set to a value of ≤ 3.6 mA or ≥ 21.5 mA. In some cases (e.g. failure of power supply, open circuit in power supply line and faults in the current output itself, where the failure current ≥ 21.5 mA cannot be output), output currents ≤ 3.6 mAoccur irrespective of the failure current defined. → 32

In some cases (e.g. cabling short circuit), output currents ≥ 21.5 mA occur irrespective of the configured failure current.

NOTICE

Alarm monitoring

- For alarm monitoring, the downstream logic unit must be able to detect both High alarms (≥ 21.0 mA) and Low alarms (≤ 3.6 mA).

5.1.5 Alarm and warning messages

Additional information is provided by the alarm and warning messages in the form of error codes and associated plain text messages.

NOTICE

When SIL locking is active on the device, additional diagnostics are activated, e.g. the output current that is read back is compared against the rated value. If one of these diagnostics results in an error message (e.g. F261 electronics module), a failure current is output.

- ▶ In this case, briefly disconnect the device from the power supply, e.g. by unplugging the terminals.
- ▶ When the device is subsequently restarted, a self-check is carried out. The error message is reset.
- ▶ The relevant sensor input for these diagnostic events can be identified with the **Actual diag channel** parameter or on the display.

5.2 Device configuration for safety-related applications

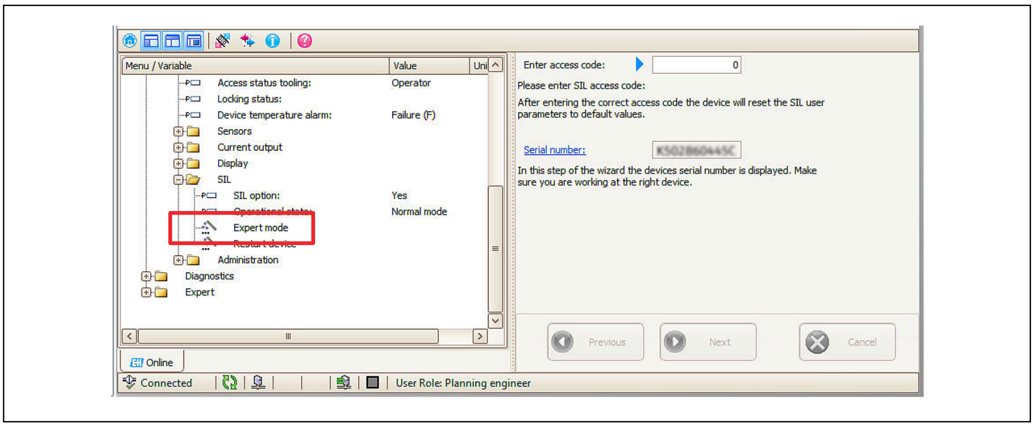
5.2.1 Configuration methods

When the devices are used in safety instrumented systems, the device configuration must meet two requirements:

- Confirmation concept:
  Proven, independent testing of safety-related parameters entered.
- Locking concept:
  Locking of the device following parameter configuration (as per IEC 61511-1 section 11.6.4).

To activate the SIL mode, the device must run through an operating sequence, during which it can be operated in the operating/configuration tool (e.g. FieldCare, DeviceCare, Pactware, AMS, PDM, Field Communicator 375/475) for which device driver files (DD or DTM) are available.

"Expert mode" (SIL mode activation = SiMA)
Here, the current transmitter settings are adopted for the SIL mode (for restrictions, see "Parameters and default settings for the SIL mode" section → 📄 22). This means that defined or preconfigured settings can be used for the appropriate application.



1 *Device parameter configuration method: Expert mode*

ℹ A detailed description is provided in the following sections. The expert mode can be implemented exclusively via HART only in the case of SIL devices (order code 590: "Additional approvals", option LA "SIL"). For this reason, only these devices can be used for safety instrumented systems.

NOTICE

The configuration of the parameters for a SIL device must be documented!

▶ Enter the configured parameters in the 'Set value' column. The date, time and the SIL checksum that is subsequently displayed must be documented.

All the safety-related parameters (SRP) and their settings can be saved locally and printed out using the "Save results as PDF" button. → 2, 20

The 'Commissioning or proof testing report' is suitable for this purpose → 34

The SIL checksum can be used to verify the configured parameters of several devices.

5.2.2 Locking in the expert mode, SIL mode activation = SiMA

The user interface can differ from the screens shown here depending on the operating tool used and the selected language.

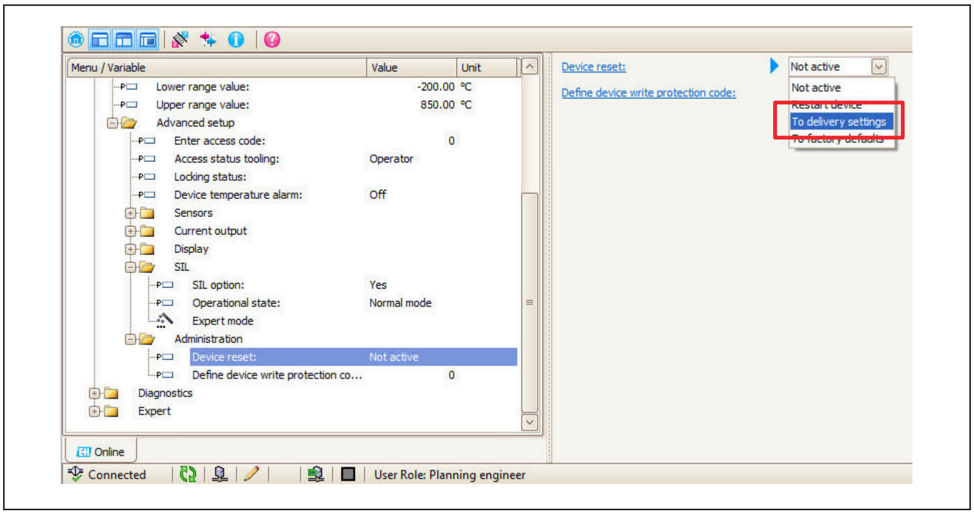
NOTICE

Interruption to SIL mode activation

▶ In the course of the SIL mode activation process in the expert mode, the transmitter outputs a failure current ≥ 21.5 mA(High alarm). If an error occurs during SIL mode activation in the expert mode or if the process is interrupted, SIL mode activation is not completed successfully and must be performed again.

SIL mode activation process

1.



A0053701

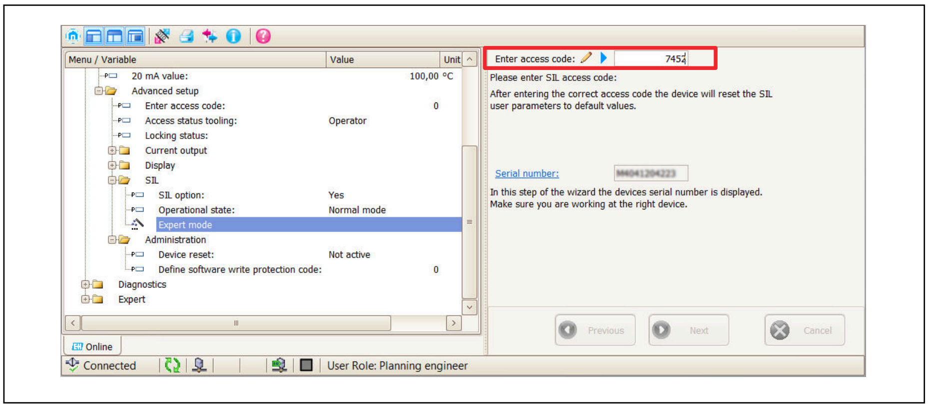
If the transmitter is not in the original as-delivered state, proceed as follows:

In the menu Setup → Extended setup → Administration, select 'To delivery settings' in the **Reset device** option.

2. Press ENTER to confirm.

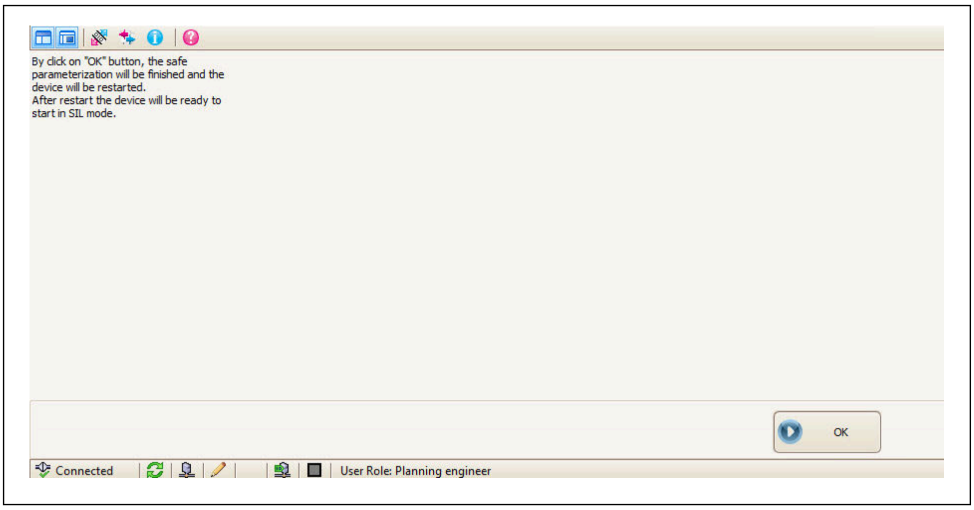
3. Configure all parameters as required for use in the safety instrumented system.

4. SIL mode activation can be performed via HART® communication in the online mode only.
   In the submenu Setup → Extended setup → SIL: start the **Expert mode** wizard.
   ↳ The **Expert mode** wizard opens.



A0053702

5. In the **Enter access code** input window, enter **7452** and press ENTER to confirm. Then press NEXT to continue.
   ↳ The parameters relevant to the safety of the device (SRP), which must not be changed in the SIL mode, are reset to the default setting. See the table of "Parameters and default settings for the SIL mode" (→ 22). All other safety-related parameters are adopted by the device and protected against tampering.

6. 

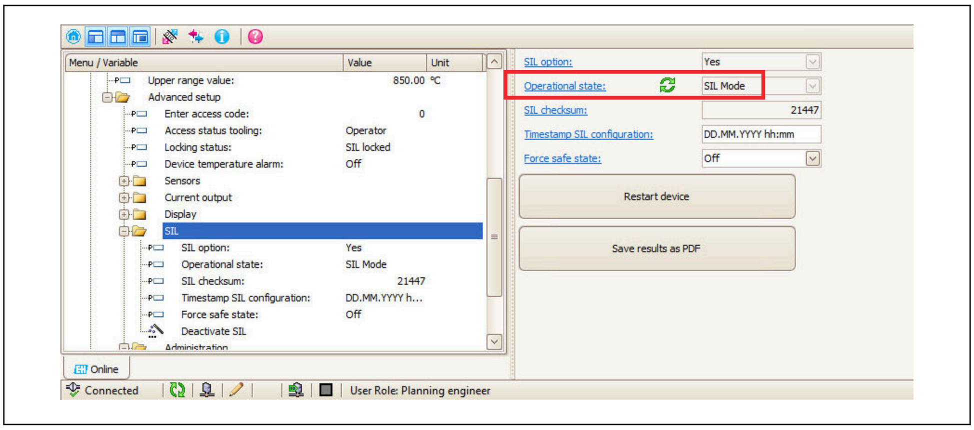
A0053703

   The device restarts automatically in the SIL mode once the OK button is pressed.
   ↳ SIL mode activation in the expert mode is complete.

7. Take note of the **SIL checksum** in the commissioning report. This can be used to verify the configuration of several devices.

Checking the operational state

8.



A0053704

2 *Operational state indicated*

Check the operational state of the transmitter (**SIL mode**) prior to use in safety instrumented systems.

9. A commissioning check must be performed prior to commissioning the transmitter in safety instrumented systems. → 25

The current configuration of the transmitter in the SIL mode can be checked using the handheld operating device FC475, for example.

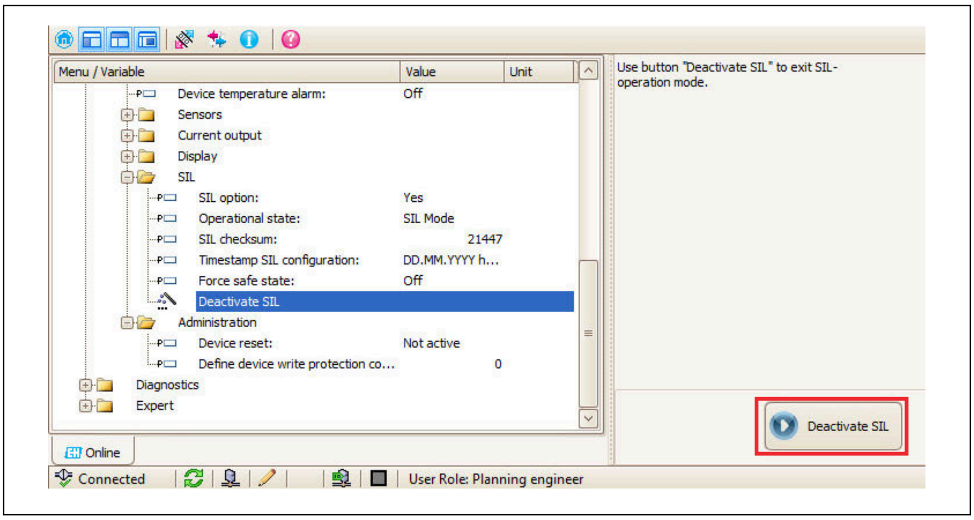
Parameters to be tested	Use of function key sequence on the FC475 (HART7)
Operational state (SIL mode)	3 → 3
Lower measuring range (4 mA)	3 → 6 → 1
Upper measuring range (20 mA)	3 → 6 → 2
PV	1 → 3
Sensor type 1	1 → 7
Sensor type 2	3 → 5 → 3 → 1
Connection type 1	1 → 8
Connection type 2	3 → 5 → 3 → 2
Sensor offset 1	1 → 9
Sensor offset 2	3 → 5 → 3 → 3
Unit	1 → 2
Mains frequency filter	3 → 4 → 4

5.2.3 Deactivating the SIL mode

There is only one way to deactivate the SIL mode. First switch off the transmitter's write protection (if it is active).

The procedure for doing so is described in the associated Operating Instructions BA01801T/09.

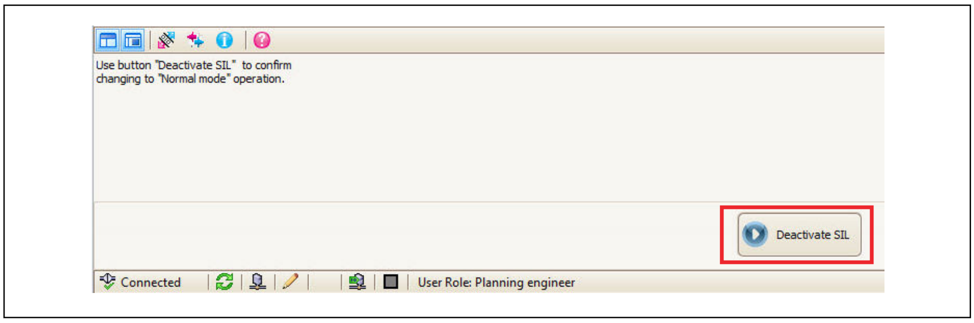
1.



A0053705

In the submenu **Setup → Extended setup → SIL**, start the **Deactivate SIL** wizard.

2.



A0053706

Enable the **Deactivate SIL** button again. This confirms the switch to the "normal mode".

↳ After an automatic restart, the device is in the non-safe mode (normal mode).

⚠ CAUTION

No safety function

▶ When the SIL mode is ended, diagnostics are disabled and the device can no longer perform the safety function. Therefore, suitable measures must be taken to ensure that no danger can arise while the SIL mode is disabled.

5.2.4 Device protection

The devices can be protected against external influences as follows:

- Hardware write protection
- Software write protection

For detailed information regarding device write protection, see the Operating Instructions → 8

5.3 Parameters and default settings for the SIL mode

The following parameters affect the safety function. **It is recommended** that configured or changed values be noted down.

Parameters and default settings for the expert mode	
Firmware version	Use this function to view the device firmware version installed. Display max. 6-digit character string in the format xx.yy.zz. The firmware version that is currently valid can be taken from the nameplate or the Operating Instructions associated with the device.
Serial number	Use this function to display the serial number of the device. It can also be found on the nameplate. Max. 11-digit character string comprising letters and numbers.
Enter access code	Use this function to enable the service parameters via the operating tool. Factory setting: **0**
Device reset	Use this function to reset the device configuration - either entirely or in part - to a defined state. Factory setting: **Not active** (default setting for SIL mode, cannot be changed)
Hardware revision	Use this function to display the hardware revision of the device.
Simulation current output	Use this function to switch simulation of the current output on and off. The display alternates between the measured value and a diagnostics message of the "function check" category (C) while simulation is in progress. Factory setting: **Off** (default setting for SIL mode, cannot be changed)
Value simulation current output	Use this function to set a current value for the simulation. In this way, users can verify the correct adjustment of the current output and the correct function of downstream switching units. Factory setting: **3.58 mA** (default setting for SIL mode, cannot be changed)
Current trimming 20 mA	Use this function to set the correction value for the current output at the end of the measuring range at 20 mA . Factory setting: **20.000 mA** (default setting for SIL mode, cannot be changed)
Current trimming 4 mA	Use this function to set the correction value for the current output at the start of the measuring range at 4 mA . Factory setting: **4 mA** (default setting for SIL mode, cannot be changed)
Lower range value	Use this function to assign a measured value to the current value 4 mA. Factory setting: **0**
Upper range value	Use this function to assign a measured value to the current value 20 mA. Factory setting: **100**
Error current	Use this function to set the value the current output adopts in an alarm condition. Factory setting: **22.5 mA**
Failure mode	Use this function to select the signal on alarm level of the current output in the event of an error. Factory setting: **High alarm**
HART® address	Definition of the HART® address of the device. Factory setting: **0** (default setting for SIL mode, cannot be changed)
Device revision	Use this function to view the device revision with which the device is registered with the HART® Communication Foundation. It is needed to assign the appropriate device description file (DD and DTM) to the device. Factory setting: **4** (fixed value)

Parameters and default settings for the expert mode	
Sensor type n	Use this function to select the sensor type for the sensor input n in question: ▪ Sensor type 1: settings for sensor input 1 ▪ Sensor type 2: settings for sensor input 2 Factory setting: ▪ **Sensor type 1: Pt100 IEC751** ▪ **Sensor type 2: no sensor**
Sensor n upper limit	Displays the maximum physical full scale value. Factory setting: ▪ For sensor type 1 = Pt100 IEC751: **+850 °C (+1 562 °F)** ▪ Sensor type 2 = no sensor
Sensor n lower limit	Displays the minimum physical full scale value. Factory setting: ▪ For sensor type 1 = Pt100 IEC751: **–200 °C (–328 °F)** ▪ Sensor type 2 = no sensor
Sensor offset n	Use this function to set the zero point correction (offset) of the sensor measured value. The value indicated is added to the measured value. Factory setting: **0.0**
Connection type n	Use this function to select the connection type for the sensor. Factory setting: ▪ Sensor 1 (connection type 1): **4-wire** ▪ Sensor 2 (connection type 2): **2-wire**
Reference junction n	Use this function to select reference junction measurement for temperature compensation of thermocouples (TC). Factory setting: **internal measurement**
RJ preset value n	Use this function to define the fixed preset value for temperature compensation. The **Preset value** parameter must be set if the **Reference junction n** (= fixed value) option is selected. Factory setting: **0.00**
Call./v. Dusen coeff. A, B and C	Use this function to set the coefficients for sensor linearization based on the Callendar/Van Dusen method. Prerequisite: the RTD platinum (Callendar/Van Dusen) option is enabled in the **Sensor type** parameter. Factory setting: ▪ **Coefficient A: 3.910000e-003** ▪ **Coefficient B: -5.780000e-007** ▪ **Coefficient C: -4.180000e-012**
Call./v. Dusen coeff. R0	Use this function to set the R0 Value only for linearization with the Callendar/Van Dusen polynomial. Prerequisite: the RTD platinum (Callendar/Van Dusen) option is enabled in the **Sensor type** parameter. Factory setting: **100 Ω**
Polynomial coeff. A, B	Use this function to set the coefficients for sensor linearization of copper/nickel resistance thermometers. Prerequisite: The RTD Polynomial Nickel or RTD Polynomial Copper option is enabled in the **Sensor type** parameter. Factory setting: ▪ **Polynomial coeff. A = 5.49630e-003** ▪ **Polynomial coeff. B = 6.75560e-006**
Polynomial coeff. R0	Use this function to set the R0 Value only for linearization of nickel/copper sensors. Prerequisite: The RTD Polynomial Nickel or RTD Polynomial Copper option is enabled in the **Sensor type** parameter. Factory setting: **100 Ω**
2-wire compensation	Use this function to set the 2-wire compensation value. Prerequisite: 2-wire must be selected in the **Connection type** parameter. Factory setting: **0** (default setting for SIL mode, cannot be changed)

Parameters and default settings for the expert mode	
Sensor trimming	Use this function to select the linearization method to be used for the connected sensor. Factory setting: **FactoryTrim** (default setting for SIL mode, cannot be changed)
Alarm delay	Use this function to set the time delay before an alarm is issued at the current output. Factory setting: **0 s** (default setting for SIL mode, cannot be changed)
Unit	Use this function to select the engineering unit for all the measured values. Factory setting: **°C**
Mains filter	Use this function to select the mains filter for A/D conversion. Factory setting: **50 Hz**
Drift/difference mode	Use this function to choose whether the device reacts to the drift/ difference set point being exceeded or undershot. Can only be selected for 2-channel operation. Factory setting: **Off**
Drift/difference set point	Use this function to configure the maximum permissible measured value deviation between sensor 1 and sensor 2 which results in drift/difference detection. Prerequisite: The **Drift/difference mode** parameter must be activated with the **Out band (drift)** or **In band** option. Factory setting: **999.0**
Drift/difference alarm delay	Alarm delay for drift detection monitoring. Prerequisite: The **Drift/difference mode** parameter must be activated with the **Out band (drift)** or **In band** option. Factory setting: **5 s** (default setting for SIL mode, cannot be changed)
Force safe state	During the commissioning check or proof testing, this parameter can be used to test error detection and the safe state of the device. Prerequisite: The **Operational state** parameter displays **SIL mode**. Factory setting: **Off**
Assign current output (PV)	Use this function to assign a measured variable to the primary HART® value (PV). Factory setting: **sensor 1**
Assign SV	Use this function to assign a measured variable to the secondary HART® value (SV) Factory setting: **device temperature**
Assign TV	Use this function to assign a measured variable to the tertiary HART® value (TV). Factory setting: **sensor 1**
Assign QV	Use this function to assign a measured variable to the quaternary HART® value (QV). Factory setting: **sensor 1**
Damping	Use this function to set the time constant for current output damping. Factory setting: **0 s** (default setting for SIL mode, cannot be changed)
Burst mode	Activation of the HART® burst mode for burst message X. Message 1 has the highest priority, message 2 the second-highest priority, etc. Factory setting: **Off** (default setting for SIL mode, cannot be changed)

Those parameters which are not mentioned do not affect the safety function and can be configured to any meaningful values. Whether or not the above-mentioned parameters are visible in the operating menu depends in part on the user role, the firmware options ordered and on the configuration of other parameters.

5.4 Commissioning test and proof testing

The functional integrity of the transmitter in the SIL mode must be verified during commissioning, when changes are made to safety-related parameters, as well as at appropriate time intervals.

NOTICE

Performing a commissioning check

- ▶ This must be performed in order to commission the device!

⚠ CAUTION

The safety function is not guaranteed during a commissioning or proof test. Suitable measures must be taken to guarantee process safety during the test.

- ▶ The safety-related output signal 4 to 20 mA must not be used for the safety instrumented system during testing.
- ▶ Any test performed must be documented. The template in the Appendix can be used for this purpose. → 🗎 34

The operator specifies the test interval and this must be taken into account when determining the probability of failure PFD_{avg} of the sensor system.

If no operator-specific proof-testing requirements have been defined, the following is a possible alternative for testing the transmitter depending on the measured variable used for the safety function. The individual proof test coverages (PTC) that can be used for calculation are specified for the test sequences described below.

The device can be tested as follows:
- Test sequence A: complete test with HART operation
- Test sequence B: complete test without HART operation
- Test sequence C: simplified test with or without HART operation

Note the following for the test sequences:
- Test sequence C is **not** permitted for a commissioning test.
- The transmitter can be tested without a sensor using an appropriate sensor simulator (resistance decade, reference voltage source, etc.).
- The accuracy of the measuring device used must meet the transmitter specifications.
- If both transmitter input channels are used, the test for the second sensor must be repeated accordingly.
- A three-point calibration must be performed when customized linearization (e.g. with CvD coefficients) is used. In addition, the **Upper sensor limit** and **Lower sensor limit** must be checked.

In the case of a commissioning check, observe the following in addition to test sequences A and B:
If both of the transmitter's input channels are used, the two-channel functions such as **Sensor drift** or **Backup** (channel assignment at current output) must also be tested.
If thermocouples are used, the setting for the **Reference junction** option and its preset value must be checked.
The function of the "Out of range category" must be tested to its limits, 3.8 mA or 20.5 mA.
The operational state of the transmitter must be checked (SIL mode).

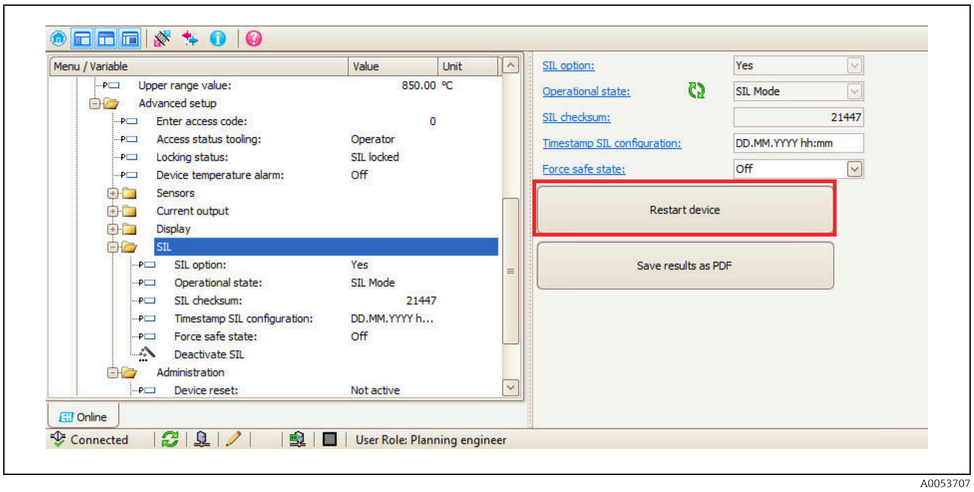
5.4.1 Test sequence A

1. Two-point calibration

   Test the current output by applying the reference temperature at the sensor or a corresponding reference signal (resistance, voltage) at 2 points. Select **4 to 6 mA** for lower-range value and **18 to 20 mA** for upper-range value.

   ↳ The measurement results must be within the specified safety inaccuracy range. Otherwise the test has not been passed.

2.



3 *Trigger a device restart using the appropriate function in the operating tool used or via HART command 42.*

Check the safe state (High and Low alarm). If the transmitter's hardware or software write protection is enabled, switch it off first.

Check both alarm states (High and Low) by restarting the device using the appropriate function in the operating tool used or via HART command 42.

↳ The alarm states, High alarm (≥ 21.0 mA) and Low alarm (≤ 3.6 mA), are output consecutively for longer than 4 s in each case.
Both current values must be checked.

96% of dangerous, undetected failures are detected using this test (proof test coverage, PTC = 0.96). During the test sequence, the device's current output typically behaves as illustrated in → 4, 27.

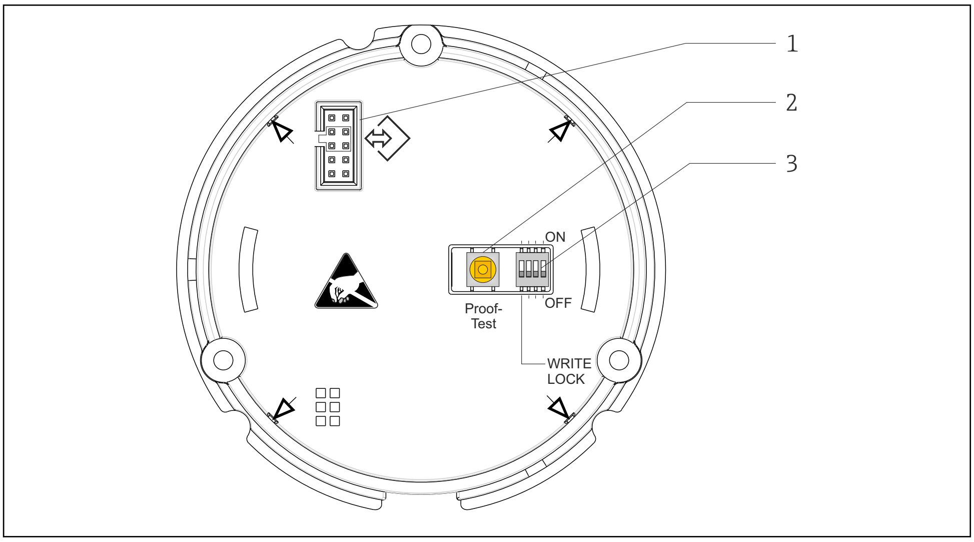
5.4.2 Test sequence B

1. Two-point calibration

Test the current output by applying the reference temperature at the sensor or a corresponding reference signal (resistance, voltage) at 2 points. Select **4 to 6 mA** for the lower-range value and **18 to 20 mA** for the upper-range value.

↳ The measurement results must be within the specified safety inaccuracy range. Otherwise the test has not been passed.

2.



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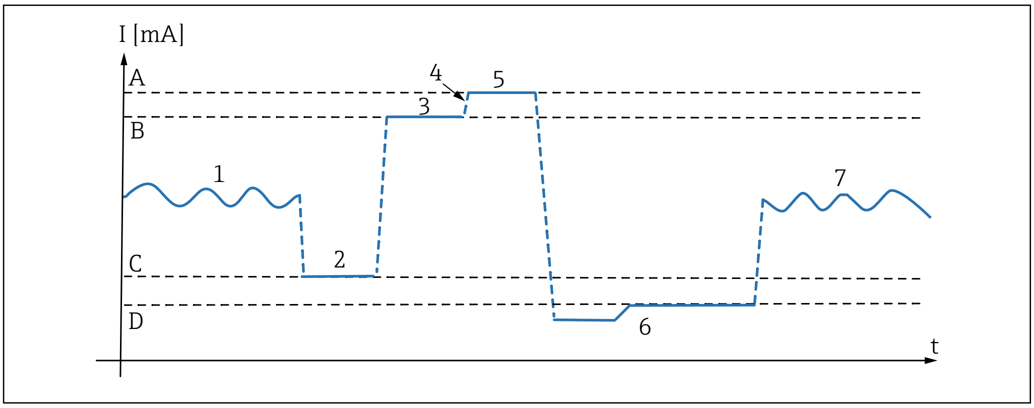
1 *Electrical connection for the display module*
2 *Proof-test button for testing in SIL mode without HART operation*
3 *DIP switch for activating or deactivating device write protection*

Check both alarm states (High and Low) by restarting the device using the proof-test button (see diagram above). To do this, press the proof-test button for at least 3 s.

↳ The alarm states, High alarm (≥ 21.0 mA) and Low alarm (≤ 3.6 mA), are output consecutively for longer than 4 s in each case.
Both current values must be checked.

94% of dangerous, undetected failures are detected using this test (proof test coverage, PTC = 0.94). During the test sequence, the device's current output typically behaves as illustrated in → 4, 27.



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4 *Current pattern during proof test A and B*

A *High alarm (≥ 21.0 mA)*
B *20 mA*
C *4 mA*
D *Low alarm (≤ 3.6 mA)*
1 *Measuring mode*
2 *Lower range value adjustment (two-point calibration)*
3 *Upper range value adjustment (two-point calibration)*
4 *Restart device (via HART or proof-test button)*
5 *High alarm (≥ 21.0 mA)*
6 *Low alarm (≤ 3.6 mA)*
7 *Measuring mode*

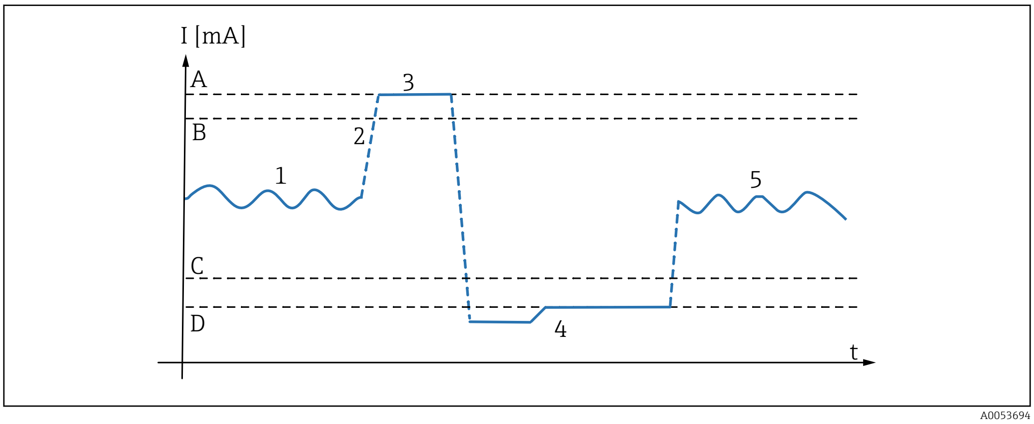
5.4.3 Test sequence C

Test sequence C

1. Check the plausibility of the current measuring signal. The measured value must be assessed on the basis of empirical values deriving from the operation of the plant. This is the responsibility of the operator.
2. Check the safe state (High and Low alarm).
   Check the two alarm states (High and Low) by restarting the device via proof-test button → 27. Alternatively, you can also check the restart using the corresponding function in the operating tool used or via HART command 42 (disabling any device write protection for this). → 25 or → 26
   ↳ The alarm states, High alarm (≥ 21.0 mA) and Low alarm (≤ 3.6 mA), are output consecutively for longer than 4 s in each case.
   Both current values must be checked.
   During the test sequence, the current output of the device typically behaves as illustrated in the graphic above. Point 2 and 3 are dispensed with. → 4, 27

The restart must not be carried out by powering down the device.

58% of dangerous, undetected failures are detected using this test (proof test coverage, PTC = 0.58). **Test sequence C is not permitted for a commissioning check.**



5 Current pattern during proof test C

- A High alarm (≥ 21.0 mA)
- B 20 mA
- C 4 mA
- D Low alarm (≤ 3.6 mA)
- 1 Measuring mode
- 2 Restart device (via HART or proof-test button)
- 3 High alarm (≥ 21.0 mA)
- 4 Low alarm (≤ 3.6 mA)
- 5 Measuring mode

NOTICE

▶ The purpose of proof-testing is to detect dangerous undetected device failures (λ_{du}).
The impact of systematic faults on the safety function is not covered by this test and must be assessed separately. Systematic faults can be caused, for example, by substance properties, operating conditions, buildup or corrosion.

For test sequences A, B, C: If one of the test criteria is not fulfilled, the device may no longer be used as part of a safety instrumented system.

6 Life cycle

6.1 Requirements of the personnel

The personnel for installation, commissioning, diagnostics and maintenance must fulfill the following requirements:

- ▶ Trained, qualified specialists: must have a relevant qualification for this specific function and task
- ▶ Are authorized by the plant owner/operator
- ▶ Are familiar with federal/national regulations
- ▶ Before beginning work, the specialist staff must have read and understood the instructions in the manuals and supplementary documentation as well as in the certificates (depending on the application).
- ▶ They must follow instructions and comply with basic conditions.

The operating personnel must fulfill the following requirements:

- ▶ be instructed and authorized according to the requirements of the task by the plant owner/operator
- ▶ follow the instructions in this manual.

6.2 Installation

The mounting and wiring of the device and the permitted orientations are described in the Operating Instructions pertaining to the device. → 🗎 8

6.3 Commissioning

The commissioning of the device is described in the Operating Instructions pertaining to the device. → 🗎 8 A commissioning check must be performed prior to operating the device in a safety system. → 🗎 25

6.4 User operation

The operation of the device is described in the Operating Instructions pertaining to the device. → 🗎 8

6.5 Maintenance

Maintenance instructions and instructions regarding recalibration may be found in the Operating Instructions pertaining to the device. → 🗎 8

Alternative monitoring measures must be taken to ensure process safety during configuration, proof-testing and maintenance work on the device.

6.6 Repair

NOTICE

Repair means restoring functional integrity by replacing defective components. Components of the same type must be used for this purpose.

- ▶ We recommend that you document the repair. This includes specifying the device serial number, the repair date, the type of repair and the individual who performed the repair.

The following components may be replaced by the customer's technical staff if genuine spare parts are used and the appropriate installation instructions are followed:

Component	Checking the device after repair
Display	Visual inspection to establish if all parts are present and mounted correctly and to verify that the device is in the "Good" state.
Housing cover	
Seal kits for housing covers	
Securing clamps, housing	
Overvoltage protection module	

Installation instructions for the spare parts are available in the Download area at www.endress.com

The replaced component or the defective device must be sent to the manufacturer for the purpose of fault analysis in cases where the device has been operated in a safety instrumented system and a device error cannot be ruled out. In this case, always enclose the "Declaration of Hazardous Material and Decontamination" with the note "Used as SIL device in safety instrumented system" when returning the defective device. For more information, please refer to the "Return" section in the Operating Instructions. → 📄 8

6.7 Modification

NOTICE

Modifications are changes to SIL devices that are already delivered or installed.

- ▶ Modifications to SIL devices are usually performed at the manufacturing center.
- ▶ Modifications to SIL devices may be performed onsite at the user's plant following approval by the manufacturing center. In this case, the modifications must be performed and documented by a service technician from the manufacturing center.
- ▶ Modifications to SIL devices by the user are not permitted.

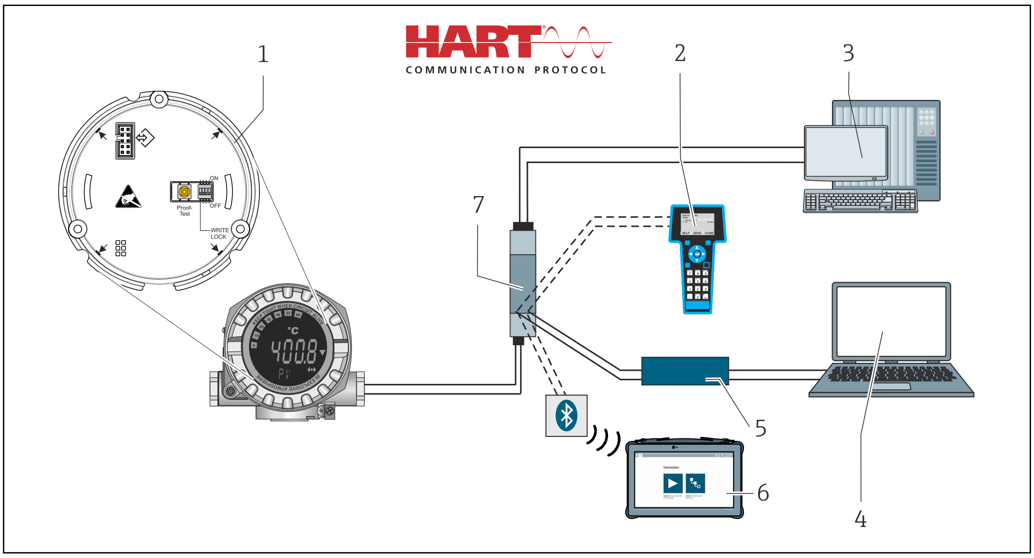
6.8 Taking out of service

When decommissioning, the requirements according to IEC 61508-1:2010 section 7.17 must be observed.

7 Appendix

7.1 Structure of the measuring system

An example of the devices in the measuring system is shown in the following graphic.



6 *HART® connection with device from the Endress+Hauser RN Series product family, including integrated communication resistor*

1 *Temperature field transmitter*
2 *HART® handheld communicator*
3 *PLC/Process Control System*
4 *Configuration software, e.g. FieldCare*
5 *Configuration via Field Xpert SFX350/370*
6 *RN Series device*

An analog signal (4 to 20 mA) in proportion to the relevant sensor value is generated in the transmitter. This is sent to a downstream logic unit (e.g. PLC, limit signal transmitter) where it is monitored to determine whether it is above or below a specified limit value. For fault monitoring, the logic unit must be able to recognize and analyze both High alarms (≥ 21.0 mA) and Low alarms (≤ 3.6 mA).

NOTICE

- The optional display is not part of the safety function. Neither the hardware nor the software of the display has a verifiable influence on the defined safety functions of the transmitter. The CDI interface is not safe and therefore may not be used in safety-related applications. The interface cannot be used for the expert mode.

Correct installation is a prerequisite for safe operation of the device.

7.1.1 Measurement function

NOTICE

Galvanic isolation

- When two sensors are connected to the transmitter, make sure the sensors are galvanically isolated from one another.

Two-channel functions

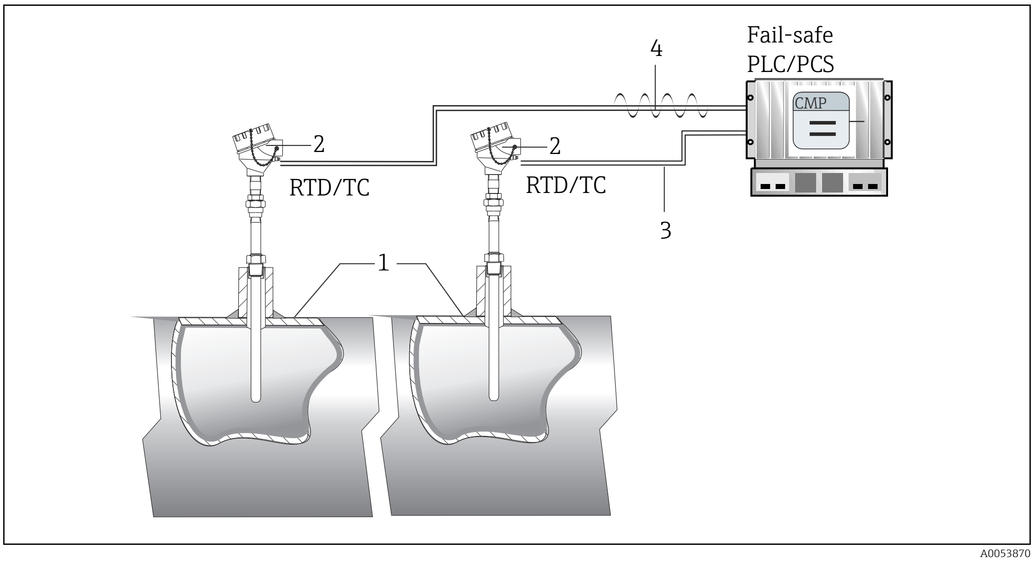
Two sensors can be connected to the transmitter and the transmitter can be operated in the following safe functions:

- **Averaging** function:
  The measured values M1 and M2 of the two sensors are output as an arithmetic average (M1+M2)/2.
- **Difference** function
  The measured values M1, M2 of the two sensors are output as a difference (M1-M2).
- **Backup** function:
  If a sensor fails, the transmitter automatically switches to the other measuring channel. For this the sensor types must be identical, e.g. two 3-wire RTD Pt100 sensors. The backup function is used to increase availability or improve the diagnostic capabilities. The following sensor types are therefore permitted in the SIL mode:
  - 2x thermocouple (TC)
  - 2x RTD, 2/3-wire
- **Sensor drift** function
  If redundant sensors are used, the long-term drift of a sensor can be detected, for instance. This is a diagnostic measure as the signal of the second sensor is only used for this diagnostic. If identical sensors are used, the **backup** function can also be used. Recommendation: set the "Drift/difference alarm delay" parameter to 5 seconds.

The configured drift/difference set point should be at least twice the safety accuracy value.

SIL 3 configuration: homogeneous redundancy

Two temperature transmitters with one sensor per transmitter are required for a SIL 3 measuring point. The measured values of the two transmitters are evaluated in a logic unit using a safe voter. → 7, 32



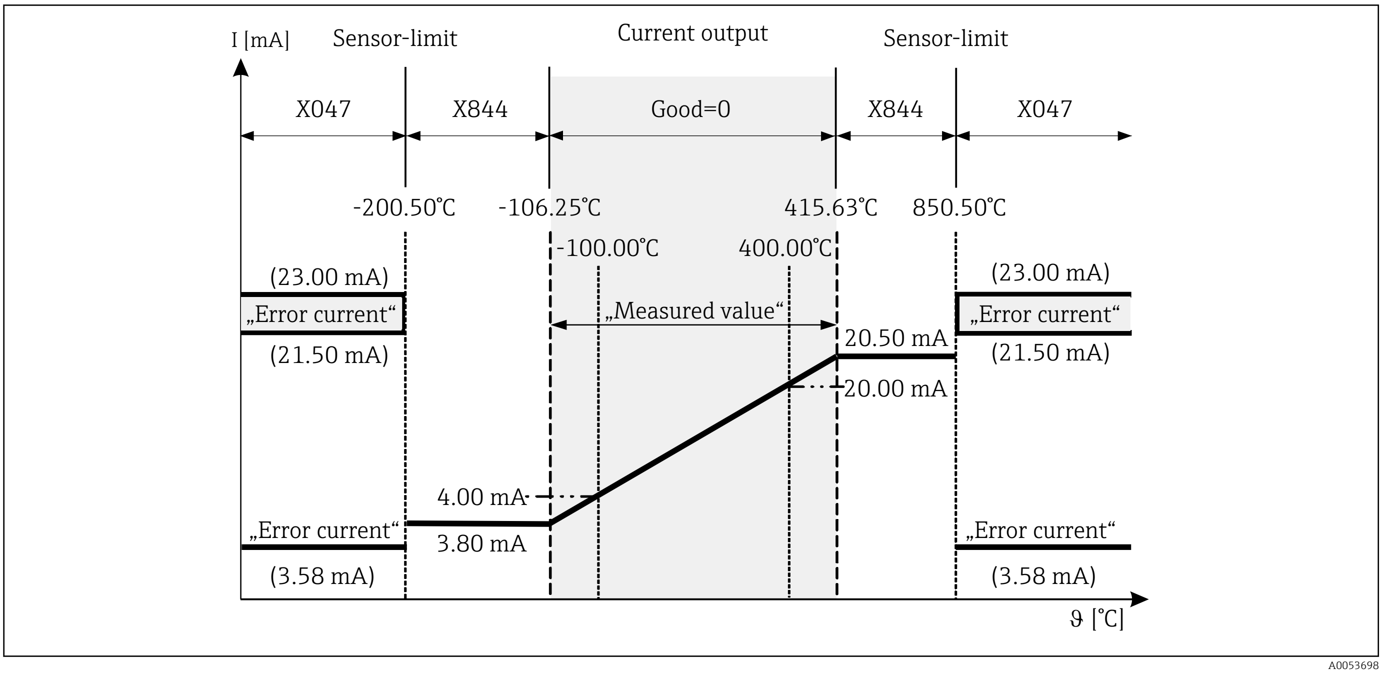
7 Example with current output at the first transmitter and current output and HART® communication at the second transmitter. PLC/Process Control System voting of both sensor values: SIL 3

1 *2 temperature sensors*
2 *2 temperature transmitters*
3 *4 to 20 mA current output*
4 *4 to 20 mA current output, optionally with HART® communication*

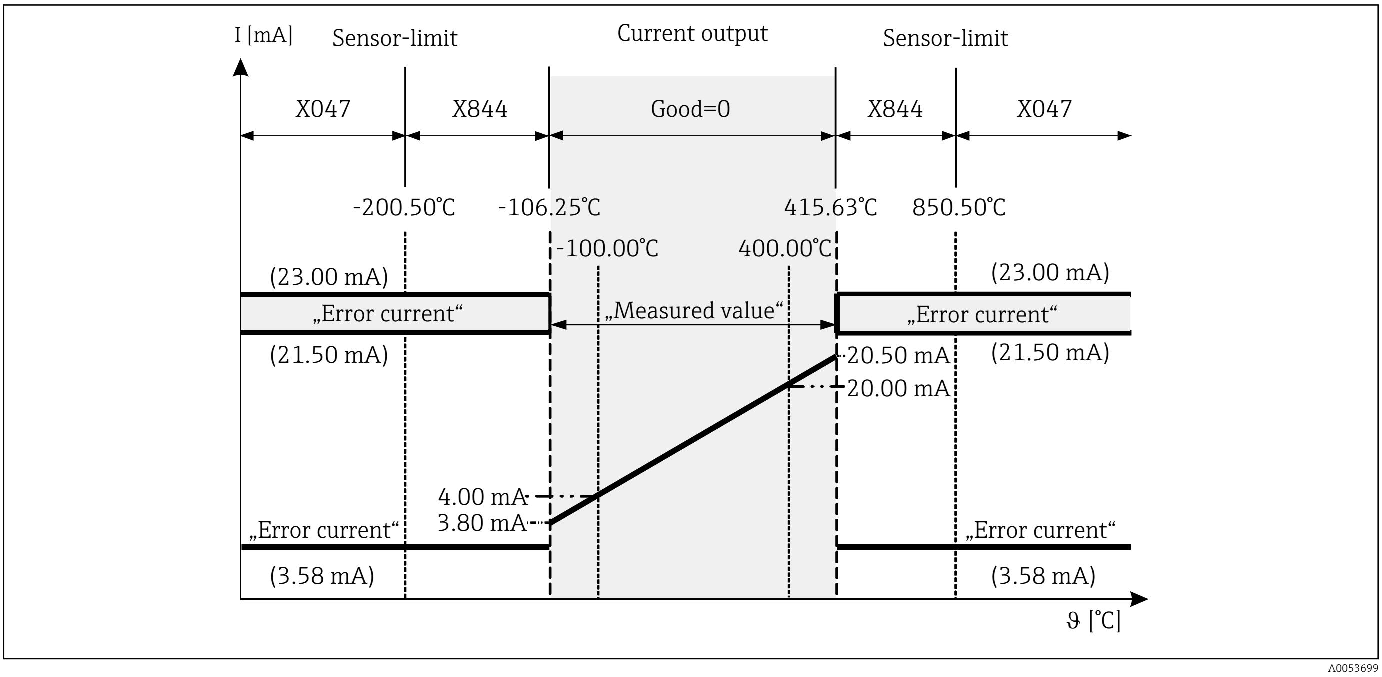
7.1.2 Device behavior in the event of range violation category (F, S, M)

The safety function is used to monitor the measured value. In the SIL mode, a failure current or saturation current is output in the event of a measurement outside a user-defined measuring range (4 to 20 mA), depending on the configuration of the "Range violation category" parameter (F, S, M).

Example in diagram: $I_{4\,mA}$ = -100 °C, $I_{20\,mA}$ = +400 °C, sensor type Pt100 IEC



8 *Output signals in the event of a warning*



9 *Output signals in the event of an alarm*

7.2 Commissioning or proof test report

Company / contact person	**/**
Tester	

Device information	
Plant	Measuring point/TAG no.:
Device type/order code	
Serial number	Firmware version
Access code (if individual to each device)	SIL checksum

Verification information
Date / time
Performed by

Verification result		
Overall result	☐ Pass	☐ Fail

Comment:

Date	Signature of customer	Signature of tester

Type of safety function
☐ Safe measurement

Commissioning check
☐ Device parameter configuration via SIL mode activation (SiMA) ☐ Commissioning check, test sequence A ☐ Commissioning check, test sequence B

Proof testing
☐ Test sequence A ☐ Test sequence B ☐ Test sequence C

Proof test report			
Test step	Target value	Actual value	Pass
1. Lower range value adjustment, sensor 1			☐ Pass ☐ Fail ☐ Not applicable
2. Upper range value adjustment, sensor 1			☐ Pass ☐ Fail ☐ Not applicable
3. Lower range value adjustment, sensor 2			☐ Pass ☐ Fail ☐ Not applicable
4. Upper range value adjustment, sensor 2			☐ Pass ☐ Fail ☐ Not applicable
5. Current value alarm			☐ Pass ☐ Fail
6. Restart via HART			☐ Pass ☐ Fail ☐ Not applicable
7. Restart via proof-test button			☐ Pass ☐ Fail ☐ Not applicable

Protocol for commissioning check			
Test step	Target value	Actual value	Pass
1. Lower range value adjustment, sensor 1			☐ Pass ☐ Fail
2. Upper range value adjustment, sensor 1			☐ Pass ☐ Fail
3. Lower range value adjustment, sensor 2			☐ Pass ☐ Fail ☐ Not applicable
4. Upper range value adjustment, sensor 2			☐ Pass ☐ Fail ☐ Not applicable
5. Two-channel function, sensor drift			☐ Pass ☐ Fail ☐ Not applicable
6. Two-channel function, backup			☐ Pass ☐ Fail ☐ Not applicable
7. Channel assignment, current output			☐ Pass ☐ Fail
8. Out of range category			☐ Pass ☐ Fail
9. Reference junction / Preset value			☐ Pass ☐ Fail ☐ Not applicable
10. Current value alarm			☐ Pass ☐ Fail

Protocol for commissioning check			
11. Restart via HART			☐ Pass ☐ Fail ☐ Not applicable
12. Restart via proof-test button			☐ Pass ☐ Fail ☐ Not applicable

Comment:

7.2.1 Parameter settings for the SIL mode

Parameter name	Default setting	Set value	Checked
Enter access code	0		
Lower measuring range (4 mA)	0		
Upper measuring range (20 mA)	100		
Failure current	22.5 mA		
Fault mode	Low alarm		
Sensor type 1	Pt100 IEC60751		
Sensor type 2	No sensor		
Upper sensor limit 1 [1)]	+850 °C		
Lower sensor limit 1 [1)]	−200 °C		
Upper sensor limit 2 [1)]	-		
Lower sensor limit 2 [1)]	-		
Sensor offset 1	0		
Sensor offset 2	0		
Connection type 1	4-wire (RTD)		
Connection type 2	2-wire (TC)		
Reference junction 1,2	Internal measurement (TC)		
RJ preset value 1,2	0 (for **Preset value** setting)		
Call./v. Dusen coeff. A, B and C sensor 1 [1)]	A: 3.910000e-003 B: -5.780000e-007 C: -4.180000e-012		
Call./v. Dusen coeff. A, B and C sensor 2 [1)]	A: 3.910000e-003 B: -5.780000e-007 C: -4.180000e-012		
Call./v. Dusen coeff. R0 sensor 1 [1)]	100 Ω		
Call./v. Dusen coeff. R0 sensor 2 [1)]	100 Ω		
Polynomial coeff. A, B sensor 1 [1)]	A = 5.49630e-003 B = 6.75560e-006		
Polynomial coeff. A, B sensor 2 [1)]	A = 5.49630e-003 B = 6.75560e-006		
Polynomial coeff. R0 sensor 1 [1)]	100 Ω		
Polynomial coeff. R0 sensor 2 [1)]	100 Ω		
Unit	°C		
Mains frequency filter	50 Hz		
Drift/difference mode	Disable		
Drift/difference alarm delay	5 s		
Drift/difference set point	999		
Force safe state	Disable		
Assign current output (PV)	Sensor 1		
Assign SV	Device temperature		

Parameter name	Default setting	Set value	Checked
Assign TV	Sensor 1		
Assign QV	Sensor 1		

1) Only for Call./v. Dusen or polynomial Cu/Ni sensors

7.3 Miscellaneous

7.3.1 Use as a safe measuring system

The temperature transmitter must be combined with a suitable sensor to implement a safe measuring system. The code numbers required for the system design for one year can be found in the following tables.

Single channel operation

Transmitter	λ_{du}	λ_{dd}	λ_{su}	λ_{sd}	SFF	PFD_{avg}
	40 FIT	**258 FIT**	**129 FIT**	**4 FIT**	**91%**	**$1.8 \cdot 10^{-4}$**

		low stress		high stress		low stress		high stress	
		closed coupled				extention wire			
		Sensor	Sensor + Field Transmitter	Sensor	Sensor + Field Transmitter	Sensor	Sensor + Field Transmitter	Sensor	Sensor + Field Transmitter
Thermocouple	λ_{du}	6 FIT	46 FIT	119 FIT	159 FIT	109 FIT	149 FIT	2180 FIT	2220 FIT
	λ_{dd}	94 FIT	352 FIT	1881 FIT	2139 FIT	891 FIT	1149 FIT	17820 FIT	18078 FIT
	λ_{su}	0 FIT	129 FIT	0 FIT	129 FIT	0 FIT	129 FIT	0 FIT	129 FIT
	λ_{sd}	0 FIT	4 FIT	0 FIT	4 FIT	0 FIT	4 FIT	0 FIT	4 FIT
	SFF	**94%**	**94% / 91%**	**94%**	**94% / 91%**	**89%**	**89% / 91%**	**89%**	**89% / 91%**
	PFD_{avg}		**$2.0 \cdot 10^{-4}$**		**$7.0 \cdot 10^{-4}$**		**$6.5 \cdot 10^{-4}$**		**$9.7 \cdot 10^{-3}$**
RTD 2/3 wire	λ_{du}	9 FIT	49 FIT	181 FIT	221 FIT	99 FIT	139 FIT	1976 FIT	2016 FIT
	λ_{dd}	39 FIT	297 FIT	779 FIT	1037 FIT	376 FIT	634 FIT	7524 FIT	7782 FIT
	λ_{su}	0 FIT	129 FIT	0 FIT	129 FIT	0 FIT	129 FIT	0 FIT	129 FIT
	λ_{sd}	0 FIT	4 FIT	0 FIT	0 FIT	0 FIT	0 FIT	0 FIT	4 FIT
	SFF	**81%**	**81% / 91%**	**81%**	**81% / 91%**	**79%**	**79% / 91%**	**79%**	**79% / 91%**
	PFD_{avg}		**$2.1 \cdot 10^{-4}$**		**$9.7 \cdot 10^{-4}$**		**$6.1 \cdot 10^{-4}$**		**$8.8 \cdot 10^{-3}$**
RTD 4 wire	λ_{du}	6 FIT	46 FIT	129 FIT	169 FIT	74 FIT	114 FIT	1486 FIT	1526 FIT
	λ_{dd}	44 FIT	302 FIT	871 FIT	1129 FIT	426 FIT	684 FIT	8514 FIT	8772 FIT
	λ_{su}	0 FIT	129 FIT	0 FIT	129 FIT	0 FIT	129 FIT	0 FIT	129 FIT
	λ_{sd}	0 FIT	4 FIT	0 FIT	4 FIT	0 FIT	4 FIT	0 FIT	4 FIT
	SFF	**87%**	**87% / 91%**	**87%**	**87% / 91%**	**85%**	**85% / 91%**	**85%**	**85% / 91%**
	PFD_{avg}		**$2.0 \cdot 10^{-4}$**		**$7.4 \cdot 10^{-4}$**		**$5.0 \cdot 10^{-4}$**		**$6.7 \cdot 10^{-3}$**

SFF	Typ	A			B		
	HFT	0	1	2	0	1	2
< 60%		SIL1	SIL2	SIL3	---	SIL1	SIL2
60% - < 90%		SIL2	SIL3	SIL4	SIL1	SIL2	SIL3
90% - < 99%		SIL3	SIL4	SIL4	SIL2	SIL3	SIL4
>99%		SIL3	SIL4	SIL4	SIL3	SIL4	SIL4

1 FIT = $1 \cdot 10^{-9}$h

PFD_{avg}

- $< 2.5 \cdot 10^{-3}$
- $> 2.5 \cdot 10^{-3}$
- $> 1 \cdot 10^{-2}$

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Two channel operation

Transmitter

λ_{du}	λ_{dd}	λ_{su}	λ_{sd}	SFF	PFD_{avg}
40 FIT	258 FIT	129 FIT	4 FIT	91%	$1.8 \cdot 10^{-4}$

		low stress		high stress		low stress		high stress	
		closed coupled				extention wire			
		Sensor	Sensor + Transmitter	Sensor	Sensor + Transmitter	Sensor	Sensor + Transmitter	Sensor	Sensor + Transmitter
2 x Thermo-couple	λ_{du}	11 FIT	51 FIT	70 FIT	110 FIT	158 FIT	198 FIT	3160 FIT	3200 FIT
	λ_{dd}	189 FIT	447 FIT	3786 FIT	4044 FIT	1842 FIT	2100 FIT	36840 FIT	37098 FIT
	λ_{su}	0 FIT	129 FIT	0 FIT	129 FIT	0 FIT	129 FIT	0 FIT	129 FIT
	λ_{sd}	0 FIT	4 FIT	0 FIT	4 FIT	0 FIT	4 FIT	0 FIT	4 FIT
	SFF	95%	95% / 91%	98%	98% / 91%	92%	92% / 91%	92%	92% / 91%
	PFD_{avg}		$2.2 \cdot 10^{-4}$		$4.8 \cdot 10^{-4}$		$8.7 \cdot 10^{-4}$		$1.4 \cdot 10^{-2}$
2 x RTD 2/3-wire	λ_{du}	8 FIT	48 FIT	154 FIT	194 FIT	84 FIT	124 FIT	1672 FIT	1712 FIT
	λ_{dd}	88 FIT	346 FIT	1662 FIT	2024 FIT	866 FIT	1124 FIT	17328 FIT	17586 FIT
	λ_{su}	0 FIT	129 FIT	0 FIT	129 FIT	0 FIT	129 FIT	0 FIT	129 FIT
	λ_{sd}	0 FIT	4 FIT	0 FIT	4 FIT	0 FIT	4 FIT	0 FIT	4 FIT
	SFF	92%	92% / 91%	92%	92% / 91%	91%	91% / 91%	91%	91% / 91%
	PFD_{avg}		$2.1 \cdot 10^{-4}$		$8.5 \cdot 10^{-4}$		$5.4 \cdot 10^{-4}$		$7.5 \cdot 10^{-3}$
RTD 2/3-wire + TC	λ_{du}	9 FIT	49 FIT	184 FIT	224 FIT	121 FIT	161 FIT	2416 FIT	2456 FIT
	λ_{dd}	139 FIT	397 FIT	2776 FIT	3034 FIT	1354 FIT	1612 FIT	27084 FIT	27342 FIT
	λ_{su}	0 FIT	129 FIT	0 FIT	129 FIT	0 FIT	129 FIT	0 FIT	129 FIT
	λ_{sd}	0 FIT	4 FIT	0 FIT	4 FIT	0 FIT	4 FIT	0 FIT	4 FIT
	SFF	94%	94% / 91%	94%	94% / 91%	92%	92% / 91%	92%	92% / 91%
	PFD_{avg}		$2.2 \cdot 10^{-4}$		$9.8 \cdot 10^{-4}$		$7.0 \cdot 10^{-4}$		$1.1 \cdot 10^{-2}$

SFF	Typ	A			B		
	HFT	0	1	2	0	1	2
< 60%		SIL1	SIL2	SIL3	---	SIL1	SIL2
60% - < 90%		SIL2	SIL3	SIL4	SIL1	SIL2	SIL3
90% - < 99%		SIL3	SIL4	SIL4	SIL2	SIL3	SIL4
>99%		SIL3	SIL4	SIL4	SIL3	SIL4	SIL4

1 FIT = $1 \cdot 10^{-9}$h

PFD_{avg}

$< 2.5 \cdot 10^{-3}$

$> 2.5 \cdot 10^{-3}$

$> 1 \cdot 10^{-2}$

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- Low stress: < ⅔ utilization of the maximum thermometer acceleration (vibration)
- High stress: > ⅔ utilization of the maximum thermometer acceleration (vibration)
- Closed coupled: < 30 cm
- Extension wire: > 30 cm
- Diagnosis for 2-channel operation: sensor drift

7.4 Further information

General information about functional safety (SIL) is available at: www.de.endress.com/SIL (German) or www.endress.com/SIL (English) and in the technical brochure CP01008Z/11/EN: "Functional safety in process instrumentation for risk reduction".

7.5 Version history

Version of manual	Modifications	Valid as of firmware version	Valid from hardware version	Reference to NE 53 customer information
SD01632T/09/EN/01.17	First version	04.01.00	04.01.00	
SD01632T/09/EN/02.23	-	04.01.11	04.01.00	

This document must be archived for up to 10 years following delivery of the last device.

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