SIEMENS

SITRANS T

SITRANS TH320/TH420/TR320/TR420/TF320 /TF420/TS500 with HART

Functional Safety Manual

This safety manual is valid for the following product versions:

TH320/TH420: 01.00.00 – 01.99.99

TR320/TR420: 01.00.00 – 01.99.99

TF320/TF420: 01.00.00 – 01.99.99

TS500 with TH320/TH420: 01.00.00 – 01.99.99

7NG031.. (TH320 with HART)
7NG041.. (TH420 with HART)
7NG032.. (TR320 with HART)
7NG042.. (TR420 with HART)
7NG034.. (TF320 single chamber housing with HART)
7NG044.. (TF420 single chamber housing with HART)
7NG035.. (TF320 dual chamber housing with HART)
7NG045.. (TF420 dual chamber housing with HART)
7MC75.. (TS500 Portfolio Europe)
7MC65.. (TS500 Portfolio North America)
7MC55.. (TS500 Portfolio Asia)

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

DANGER
indicates that death or severe personal injury **will** result if proper precautions are not taken.

WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

CAUTION
indicates that minor personal injury can result if proper precautions are not taken.

NOTICE
indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

WARNING
Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

Trademarks

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Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

Siemens AG
Division Process Industries and Drives
Postfach 48 48
90026 NÜRNBERG
GERMANY

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1 Introduction

1.1 Links to Operating Instructions

You can find the Operating Instructions for **SITRANS TH/TR/TF** in the internet:
https://support.industry.siemens.com/cs/ww/en/view/109793149

You can find the Operating Instructions for **SITRANS TS500** in the internet:
https://support.industry.siemens.com/cs/ww/en/view/109781321

1.2 Observed standards

Standard	Description
IEC 61508	Functional Safety of electrical / electronic / programmable electronic safety-related systems
IEC 61508-2:2010	Part 2: Requirements for electrical / electronic / programmable electronic safety-related systems
IEC 61508-3:2010	Part 3: Software requirements
SITRANS TH320/TH420/TR320/TR420: IEC 61326-3-1:2008 SITRANS TF320/TF420/TS500 with TH320/420: EN IEC 61326-3-2:2018 EN 61000-6-7:2015	Immunity requirements for safety-related systems

1.3 Acronyms and abbreviations

Acronym / Abbreviation	Designation	Description
Element		Term defined by IEC 61508 as “part of a subsystem comprising a single component or any group of components that performs one or more element safety functions”
PFD	Probability of Failure on Demand	This is the likelihood of dangerous safety function failures occurring on demand.
PFH	Probability of dangerous Failure per Hour	The term “Probability” is misleading, as IEC 61508 defines a Rate.
SFF	Safe Failure Fraction	Safe Failure Fraction summarizes the fraction of failures which lead to a safe state and the fraction of failures which will be detected by diagnostic measures and lead to a defined safety action.
SIF	Safety Integrity Function	Function that provides fault detection (to ensure the necessary safety integrity for the safety functions)
SIL	Safety Integrity Level	The international standard IEC 61508 specifies four discrete safety integrity levels (SIL 1 to SIL 4). Each level corresponds to a specific probability range regarding the failure of a safety function.
FMEDA	Failure Modes, Effects and Diagnostic Analysis	From the FMEDA, failure rates are determined and consequently the SFF, PFD and PFH figures can be calculated, and thereby the achieved Functional Safety.

1.4 Purpose of the product

2-wire HART temperature transmitters and temperature sensors for temperature measurement with TC and RTD sensors. True dual input with high density 7 terminal design allows measurement of two 4-wire RTDs. Sensor redundancy allows automatic switch to secondary sensor in the event of primary sensor failure and sensor drift detection issues an alert when sensor differential exceeds predefined limits.
The device has been designed, developed and produced for use in SIL 2/3 applications according to the requirements of IEC 61508 : 2010

2 Assumptions and restrictions for use of the product

2.1 Basic safety specifications

Ambient operating temperature range.. -40...+80°C
Storage temperature range .... -50...+85°C
Storage temperature range SITRANS TF single/dual chamber..... -40...+85°C
Supply voltage, non-Ex .... 7.5*...48** VDC (at terminals)

Supply voltage, Ex ia .... 7.5*...30** VDC (at terminals)
Supply voltage SITRANS TF single chamber housing non-Ex ...... Without display: 7.5...48** VDC
.... With display: 10…48** VDC
Supply voltage SITRANS TF dual chamber housing non-Ex......... Without display: 8.2...48** VDC
.... With display: 10.7…48** VDC

Supply voltage SITRANS TF single chamber housing Ex ia .... Without display: 7.5...30** VDC
.... With display: 10…30** VDC
Supply voltage SITRANS TF dual chamber housing Ex ia .... Without display: 8.2...30** VDC
.... With display: 10.7…30** VDC

Additional min. supply voltage when using test terminals............. 0.8 V
Max. internal power dissipation........ ≤ 850 mW
Min. load resistance at > 37 V supply .... (Supply voltage – 37) / 23 mA
Mounting area........ Zone 0, 1, 2 / Division 2 or safe area
Mounting environment........ Pollution degree 2 or better
Max. wire size........ 1 x 1.5 mm^2 stranded wire
Screw terminal torque........ 0.4 Nm

* Note: Observe that the minimum Supply Voltage must be as measured at the terminals of the SITRANS TH/TR/TF/TS500, i.e. all external voltage drops must be considered. An additional voltage drop of 0.8 V shall be considered when using the test terminals.

** Note: Make sure to protect the device from over-voltages by using a suitable power supply or by installing overvoltage protecting devices.

2.2 Useful lifetime

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, or as determined by users own statistics.
The device contains no components that are especially sensitive to environmental conditions, neither does it contain any unmanaged memory components with suspected retention times.
Limiting factors for the useful lifetime of the temperature sensors in use shall be taken into account by the user.

2.3 Safety accuracy

The analog output corresponds to the applied input within the safety accuracy.
Safety accuracy........ ±2%

2.3.1 Minimum span

The selected range *(PV Upper Range - PV Lower Range)* shall be larger or equal to the values below:

Configured input type	Minimum span	Unit
Pt100-Pt10000, Ni100-Ni1000, Cu100-Cu1000	25	°C
Pt50, Ni50, Cu50	50	°C
Pt20, Ni20, Cu20	125	°C
Pt10, Ni10, Cu10	250	°C
Cu5	500	°C
TC: E, J, K, L, N, T, U	100	°C
TC: Lr, R, S, W3, W5, B	400	°C
Voltage -20...100 mV	1.3	mV
Voltage -0.1...1.7 V	0.12	V
Voltage ±0,8 V	0.12	V
Linear Ohms 0...400 Ohm	10	Ohm
Linear Ohms 0...100 kOhm	1	kOhm
Potentiometer	10	%

2.3.2 Range limitations

For Functional Safety applications, TC input type B shall not be used below +400°C since the accuracy will be lower than the specified safety accuracy.

2.4 Associated equipment

2.4.1 RTD, or linear resistance sensor wiring

If *Input 1 Wiring Configuration* / *Input 2 Wiring Configuration* is configured to 2 or 3, and *Input Type 1 / Input Type 2* is RTD, Ohm or kOhm, the end user must ensure that the applied sensor wiring does not introduce failures exceeding the requirements for the safety application.

2.4.2 Potentiometer sensor wiring

If *Wiring Configuration* is configured to 3 or 4, and *Input Type* is Potentiometer, the end user must ensure that the applied sensor wiring does not introduce failures exceeding the requirements for the safety application.

2.4.3 Sensor short circuit errors

Detection of short-circuited sensors, or short-circuited sensor wires, is ignored for both Input 1 and Input 2 if either of their Input Types is configured as listed below:

- Ohms or kOhms
- Pt50 or Ptx and RTD Factor < 100
- Nix and RTD Factor < 50
- Cu10, Cu50 or Cux and Sensor Custom RTD Resistance < 100
- Potentiometer and *Input 1 Upper Limit* (potentiometer size) < 18 Ohm

For Potentiometer there is no short circuit detection on potentiometer arm.
Detection of short-circuited sensor or short-circuited sensor wires is ignored for Input 1 or Input 2 if its *Input Type* is configured as listed below:

- Micro-Volts, Milli-Volts or Volts (bipolar or unipolar)
- Any TC type (detection of shorted External CJC sensor is NOT ignored)

If any of these input types shall be used in a Safety Application, the user must ensure that the applied sensors, including wiring, have failure rates that qualify them, without detection of short-circuited sensors or wires.

2.4.4 Extension port

Connecting equipment to the extension port is not approved for the customer.

2.4.5 Process calibration (input calibration)

If a process calibration on either Input 1 or Input 2 has been carried out before entering Functional Safety-mode operation, it is mandatory that the accuracy of the device (and sensor, if applicable) is tested by the end user after Functional Safety-mode is entered, in addition to the normal functional test. Refer to section 13.2 Process calibration (input calibration).

2.4.6 Analog output

The connected safety PLC shall be able to detect and handle the fault indications on the analog output of the SITRANS TH/TR/TF transmitter or SITRANS TS500 with SITRANS TH transmitter by having a NAMUR NE43-compliant current input. The safety PLC must be able to detect and react to error signals according to NE43 within 1 second.
If Output Limit Check is disabled (see section 13.3.2 Output) in Functional Safety mode, the connected Safety PLC shall also be able to detect and react to a current in the extended range acc. to NAMUR NE43, within 1 second. The limits for the detection shall be <20.5 mA and >3.8 mA.

2.5 Failure rates

The basic failure rates from the Siemens standard SN 29500 are used as the failure rate database.
Failure rates are constant, wear-out mechanisms are not included.
External power supply failure rates are not included.

2.6 Safe parameterization

The user is responsible for verifying the correctness of the configuration parameters. (See section 14 Safe parameterization - user responsibility).
After parametrization it is not possible to simulate any measurements or the analog output.
The following restrictions applies to the configuration parameters:

Function / Parameter	Functional Safety Requirements
Sensor 1/2 Input Type	Cannot be “Callendar Van Dusen” or “Custom”
Output Range 0%	Must be 4.0 mA
Output Range 100%	Must be 20.0 mA
Limit Check Configuration	Must be “Limit Check Enabled on Input Range” or “Limit Check Enabled on Input and Output Range”
Output Limit - Error Value	Must be ≤ 3.6 mA or ≥ 21.0 mA (if enabled on output)

Output Lower Limit	Must be 3.8 mA
Output Upper Limit	Must be 20.5 mA
Sensor Error Action	Must be set to “Broken and Shorted”
Broken Sensor - Error Value	Must be ≤ 3.6 mA or ≥ 21.0 mA
Shorted Sensor - Error Value	Must be ≤ 3.6 mA or ≥ 21.0 mA
Sensor Drift - Error Value	Must be ≤ 3.6 mA or ≥ 21.0 mA (if enabled)
Input Limits - Error Value	Must be ≤ 3.6 mA or ≥ 21.0 mA
Analog Output Calibration Gain	Must be 1.0 (calibration of output current is not allowed)
Analog Output Calibration Offset	Must be 0.0 (calibration of output current is not allowed)
Loop Current Mode	Must be “Enabled” (HART 7 only)
HART Polling Address	Must be 0 (HART 5 only)
Write Protection	Must be “The configuration is protected by user PIN”

For detailed description of the configuration parameters, see sections 13 Configuration of the transmitter and 14 Safe parameterization - user responsibility.

2.7 Jumpers/Switch

For Functional Safety applications, any detected device error must force the analog output to a value below 3.6 mA. In Functional Safety mode the HW jumper from P7-P8 must NOT be inserted.
For SITRANS TF and SITRANS TS500 with display the switch "FO" must be set to position "LO".
The HW write protection by inserting a jumper from P1-P2 can be applied as an extra write protection, after configuration and after Functional Safety mode is entered.
Still for Functional Safety applications, the user PIN and Write protection must be applied. (See section 14 Safe parameterization - user responsibility)

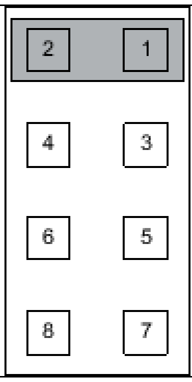
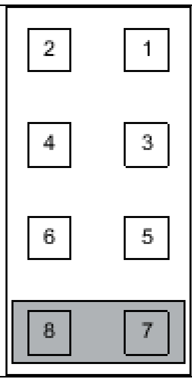
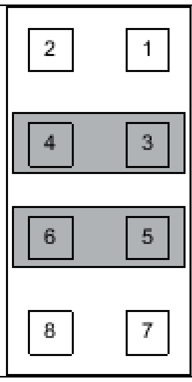
		
Write protection enabled (Write Protect)	Fault current ≥ 21 mA in accordance with NAMUR NE43 (Safe State) A fault current ≥ 21 mA is not permissible for operation of the device with functional safety. Functional safety may not be activated with a fault current ≥ 21 mA.	Delivery state (No Function) Fault current ≤ 3.6 mA in accordance with NAMUR NE43

*Figure 1 Meaning of the jumper positions **SITRANS TH/TR** and **SITRANS TS500 without display***

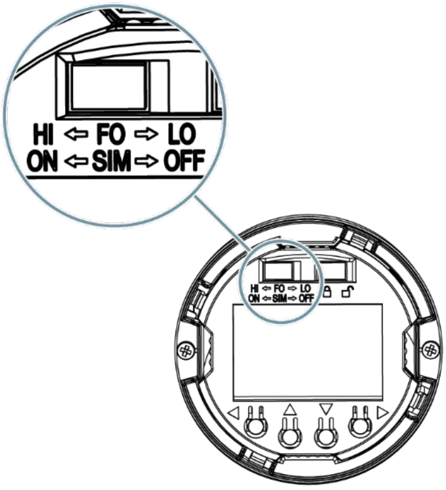
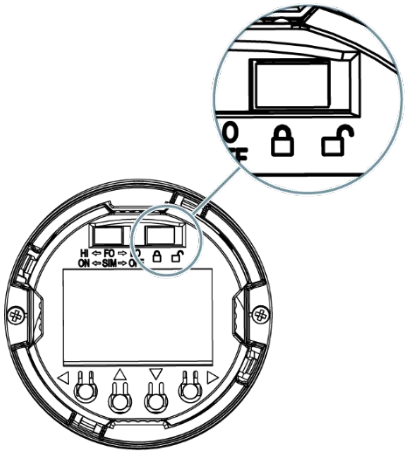
<table>
<tr><td colspan="2">
</td><td></td></tr>
<tr><td colspan="2">Fault current in accordance with NAMUR NE43 (Safe State)</td><td rowspan="5">Write protection enabled (Write Protect)</td></tr>
<tr><td>FO</td><td>Fault current</td></tr>
<tr><td>LO</td><td>Lower fault current ≤ 3.6 mA</td></tr>
<tr><td>HI</td><td>Upper fault current ≥ 21 mA
A fault current ≥ 21 mA is not permissible for operation of the device with functional safety. Functional safety cannot be activated with a fault current ≥ 21 mA.</td></tr>
<tr><td>SIM</td><td>Reserved for devices with PA (simulation mode)</td></tr>
</table>

Figure 2 Meaning of the switch positions ***SITRANS TF*** *and* ***SITRANS TS500 with display***

2.8 Installation in hazardous areas

The IECEx, ATEX, CSA, Inmetro and FM Installation drawing shall be followed if the products are installed in hazardous areas.

2.9 Safety properties

Information on the Functional Safety properties can be found in the manufacturer's SIL declaration of conformity for the device (Functional Safety declaration of conformity, Functional Safety according to IEC 61508). The declaration lists information on all failure rates and failure categories as resulting from the product FMEDA.

You find the SIL declaration of conformity for the SITRANS TH/TR/TF/TS500 in the internet:
https://support.industry.siemens.com/cs/ww/en/view/109759389

For further information refer to the website for Functional Safety in process instrumentation:
http://www.siemens.com/SIL

Scroll down to “Temperature Measurement” and locate the line of your specific temperature transmitter. The links to the declaration, certificate and manuals are listed there. Click on the link of the document and you will be forwarded to the Siemens Industry Online Support website. Click on “Download” for the PDF documents.

3 Device states

The states of the device are defined as shown in the table below, specific failure rates for each mode:

Device state	Description
Normal operation (4-20 mA)	The safe current output is within the defined safety accuracy range.
Detected failure (Safe state)	The safe current output is ≤ 3.6 mA (defined as a failure signal) or ≥ 21 mA.
Dangerous state	Dangerous state applies when current output is within the range 4...20 mA and deviates from the correct process value by more than the defined safety accuracy range for longer than 60 seconds.

4 Device modes

The device can operate in various modes:

- Normal Mode: Non-Safety Operation is for use in non-safety related applications.
- Functional Safety Mode: Safety Operation and Safety Error are for use in safety related applications.

The following table describes the different Device modes:

Mode	Description	Functional Safety Status	Current output value	Safe current output
Reset/Startup	The device has just been started up or reset, and is determining the next mode. The device will leave this mode after maximum 2 seconds.	INIT	Failure signal ≤ 3.5 mA	Yes
Non-Safety Operation (Normal Mode)	The device is operating without user-validated safe parameterization. The device may operate with factory default configuration, or with a specific ordered configuration. This mode is valid for use in non-safety related applications only. The user shall assign safety related parameters to the device in this mode.	OPEN	Operation signal (4 to 20 mA)	No
Safety Validation mode (Transfer from Normal mode to SIL Mode)	The device is in the process of validating the entered safety parameters and the safety function. See section “14 Safe parameterization - user responsibility” for more information. The device will leave this mode when the user either accepts or rejects the safety parameterization.	INIT	Failure signal ≤ 3.5 mA	Yes
Safety Operation (Functional Safety Mode)	The device operates in safe mode and delivers safe measurement output on the current output. When operating in this mode, the device is valid for safety related applications.	LOCK	Operation signal (4 to 20 mA)	Yes
Safe Parametrization failed	The device has failed the validation of the current configuration for safety operation.	FAIL	Failure signal ≤ 3.5 mA	Yes
Safety Error (Functional Safety Mode)	The device enters this mode if the system detects a safety related error in Safety Operation mode. The possible errors are listed in the error list of the device.	LOCK	Failure signal ≤ 3.6 mA or ≥ 21 mA	Yes

5 Functional specification of the safety function

All safety functions relate exclusively to the analog 4...20 mA current output signal.
Conversion of voltage signals, potentiometer, linear resistance, RTD sensor signals or thermocouple sensor signals in hazardous areas to the output signal within specified accuracy.
For RTD, potentiometer and linear resistance inputs, wire resistances of up to 50 Ohm per wire can be compensated if 3- or 4-wire connection is configured (4- or 5-wire for potentiometer).
For thermocouple sensors, cold junction temperature errors can be compensated, either by an internally mounted temperature sensor, by an external temperature sensor or by a fixed temperature value. For the SITRANS TS500 only the internal cold junction compensation and use of a fixed temperature value are available. The selection of CJC measurement must be done and verified by the end user.
The SITRANS TH/TR/TF or SITRANS TS500 with SITRANS TH will detect if any of the applied sensors or their connection wires are short-circuited or broken with the restrictions given in section 2.4.3 Sensor short circuit errors.

One or two inputs can be measured in combinations. The failure rates are determined by the FMEDA for the following configurations:

5.1 Single

Only one input is measured, the signal is evaluated to control the current output. For SITRANS TH/TR/TF or SITRANS TS500 with SITRANS TH one of the inputs is not used.

5.2 Dual

Two (both) inputs are measured. The evaluation of the signals includes a mathematical combination such as difference or average of the two signals. The result of the evaluation controls the current output.

5.3 Redundant

Two (both) inputs are measured and evaluated. The two results are compared; the current output is set to the safe state if the difference between the evaluated values exceeds a defined (configured) limit.

6 Functional specification of the non-safety functions

LED outputs and Process Values delivered using HART or Extension Port communication are not suitable for use in any Safety Instrumented Function.

7 Safety parameters

A link where you can find information on all failure rates and failure categories is included in chapter 9, **SIL-compliant product version**.

Common Safety Parameters	
Demand response time (if "Damping" is configured to 0.0 sec.)	< 75 ms
Demand mode	Low, High or Continuous
Mean Time To Repair (MTTR)	24 hours
Fault detection and reaction time	60 seconds
Process safety time	120 seconds
Systematic capability	SC 3
Component Type (Complexity)	B
Description of the "Safe State", analog output	Output ≤ 3.6 mA or Output ≥ 21 mA
SIL 2 capability	
Hardware Fault Tolerance (HFT)	0
Operation	Single transmitter operation 1oo1 (see Figure 3)
SIL 3 capability Due to the systematic capability of the transmitter for SC 3, it is possible to use the instrument in homogenous redundant systems up to SIL 3.	
Hardware Fault Tolerance (HFT)	1
Operation	Two transmitter operation 1oo2 (see Figure 4)

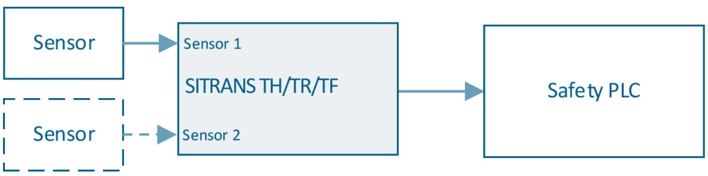


Figure 3 Single transmitter 1oo1 operation (SIL 2)

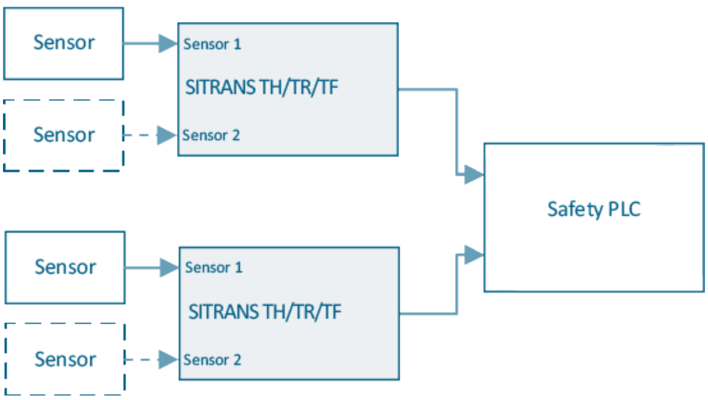


Figure 4 Two transmitter 1oo2 operation (SIL 3)

8 Hardware and software configuration

All configurations of software and hardware versions are fixed from factory, and cannot be changed by end-user or reseller. This manual only covers products labeled with the product version (or range of versions) specified on the front page.

9 SIL-compliant product version

Information on specific versions that are permitted for use in safety instrumented systems according to IEC 61508 can be found in the manufacturer's SIL Declaration of Conformity for the device (Functional Safety declaration of conformity, Functional Safety according to IEC 61508). The declaration lists information on all failure rates and failure categories as resulting from the product FMEDA.

SIL Declaration of Conformity: https://support.industry.siemens.com/cs/ww/en/view/109759389
General functional safety: http://www.siemens.com/safety
Functional safety in process instrumentation: http://www.siemens.com/SIL

10 Periodic proof test procedure

This test will detect approximately 90% of possible “du” (dangerous undetected) failures in the device. See FMEDA report issued by Siemens, specified in chapter: 2.9 Safety properties.

The proof test is equivalent to the functional test so this procedure shall be followed when a functional test must be carried out, as described in chapter: 14.5 Functional test.

Step	Action
1	Bypass the safety PLC or take other appropriate action to avoid a false trip/measurement.
2	Disconnect the input signal(s) from the input terminals and connect instead a simulator suited for simulating the actual input setup for each active input channel.
3	Apply input value(s) to each active channel, corresponding to 0% and 100% output range.
4	Observe whether the output acts as expected.
5	Restore the input terminals to normal operation, i.e. re-connect the input signal(s).
6	Measure the process value (temperature) at the connected input(s) and observe that the output current corresponds to the applied input value(s).
7	Remove the bypass from the safety PLC or otherwise restore normal operation.

Additional proof test procedure for SITRANS TF and SITRANS TS500
Checking the seals

Inspect the seals at regular intervals

1. Clean the enclosure and seals.
2. Check the enclosure and the seals for cracks and damage.
3. If necessary, lubricate the seals or replace them. Use only original seals.

Checking the cable glands

1. Check the tightness of the cable glands at regular intervals.
2. Tighten the cable glands if necessary.

Checking temperature sensor

1. Check measurement value against real temperature value.
2. Replace temperature sensor if necessary.

11 Procedures to repair or replace the product

Any failures that are detected and that compromise functional safety should be reported to the sales department at Siemens AG.
Repair of the device must be done by Siemens AG only.

12 Maintenance
No maintenance required.

13 Configuration of the transmitter
The SITRANS TH/TR/TF or SITRANS TS500 with SITRANS TH can be configured by use of a HART configurator or a HART modem. Only the connection of HART devices according to the Operating Instructions is permitted.
Independent of the tools used, the configuration parameters are the same, and for safety applications all parameters described in section 14.1 Safety-related configuration parameters must be configured correctly. Although most parameters are simple and the description is understandable, some parameters require special descriptions given in the sections below.

13.1 Write protection
Write protection of the configuration is possible using either HW jumper or using user PIN protection. During configuration of the device parameters, both write protection mechanisms must be disabled.
For valid Functional Safety mode, the write protection must be set to active, see section 14.1.6 HART parameters and entering Functional Safety mode is not possible if this is not done. The configuration tool must support write protection if Functional Safety mode is required.
After Functional Safety mode is entered, it is optional to set the HW protection jumper for extra protection.

13.1.1 Changing user PIN
For protection from unauthorized change of configuration, change the default user PIN.
The user PIN used for write protection must consist of exactly 5 numbers. Any number from 0 to 9 can be used and will be supported by the configuration tool.
The default configured user PIN is 2457 (5 numbers #42).
To change the user PIN, locate the menu “Write Protection” in the configuration tool. Select “Change user PIN” on the tool used.
When prompted, the already configured user PIN must be entered for access.

13.1.2 Enabling write protection
For enabling write protection, locate the menu “Write Protection” in the configuration tool. Select “Enable” on the tool used.
When prompted, the already configured user PIN must be entered for access.

13.1.3 Disabling write protection
For disabling write protection, locate the menu “Write Protection” in the configuration tool. Select “Disable” on the tool used.
When prompted, the already configured user PIN must be entered for access.
The configuration tool will not support disabling write protection if the device is in Functional Safety mode.
Note: if the device is in Functional Safety mode this will be exited if the write protection is disabled!

13.2 Process calibration (input calibration)
If a sensor is not accurate, or anything else in the process being monitored is affecting the measurement linearly, this can be compensated by the transmitter by entering up to two reference values for Input 1 and Input 2 independently.
A process calibration (input calibration) can be done by the end user. A known process signal must be applied for either low – or for both low and high - end of the input measurement range for each input.
Process calibration/input calibration is optional for Functional Safety mode. If used, the required accuracy must be verified by the end user and it must be verified by test that the applied process calibration does not introduce failures exceeding the requirements for the safety application.

13.2.1 Lower calibration point (offset/taring)
If only an offset adjustment or a taring of the input shall be done, this procedure shall be followed:

a. Remove the output current from any automatic control application.
b. Locate the menu “Calibration” in the configuration tool and select “One point calibration”.
c. Acknowledge all warnings, and select whether Input 1 or Input 2 shall be calibrated.
d. Apply the input corresponding to 0% input, e.g. 0.0% for a potentiometer input.
   The input value must be within the configured limits for the input (Input 1 or Input 2).
   Press OK to proceed.
e. Wait for the **calibration** to be performed.

f. Re-apply the output current to the control application. Repeat the above procedure for both inputs.

13.2.2 Lower and upper calibration point

If both the lower and upper range shall be calibrated, this procedure shall be followed:

a. Remove the output current from any automatic control application.
b. Locate the menu “Calibration” in the configuration tool and select “Two point calibration”.
c. Acknowledge all warnings, and select whether Input 1 or Input 2 shall be calibrated.
d. Apply the input where the low point of the calibration range shall be performed, e.g. 10.03% for a potentiometer input.
   The input value must be within the configured limits for the input (Input 1 or Input 2). Press OK to proceed.
e. The previously calibrated lower point value is shown, and the currently applied input value is monitored continuously and shown, e.g. 10.47% for a potentiometer input.
   When the currently applied value reading is stable, press OK to proceed.
f. Enter the reference value of the applied input value, e.g. 10.03% for a potentiometer input.
g. The currently applied calibrated input value is now monitored and shown. If the value is matching the entered reference value, press “Yes” and proceed to step h.
   If not, press “No”, and step d to g will be repeated.
h. Repeat step d to g for the upper calibration point of the calibration range, e.g. 90.04% for a potentiometer input.
i. Select whether the other input should be calibrated at this time, or if the calibration should be repeated, and the steps c to g will be repeated for the selected sensor.

Repeat the above procedure until both lower and upper point show the applied input value correctly for both inputs.

Note: The procedure can be aborted at any step, but after step f, a partial calibration may have been applied, and a previous calibration thereby lost. See Section 13.2.3 Restore factory calibration.

13.2.3 Restore factory calibration

Any user-performed process calibration/input calibration can be reset to factory calibration values. This can be done independently for both Input 1 and Input 2.

Be aware that any performed process calibration/input calibration will be lost for the sensor selected.

a. Locate the menu “Calibration” in the configuration tool and select “Restore factory calibration”.
b. Acknowledge all warnings, and select whether Input 1 or Input 2 shall be restored.
c. Any previously performed upper and lower calibration points will be shown. Press “Yes” to proceed or “No” to abort the operation.
d. The resulting upper and lower calibration points will be set to 0.

13.3 Limit Check

13.3.1 Input

If the input (1 or 2) that is mapped to PV, and thereby the Analog Output, exceeds either of the input range limits configured in the *Input 1 Lower/Upper Limit or Input 2 Lower/Upper Limit*, this will be indicated as an error on the analog output current. This is also the case if the input is indirectly mapped to PV (e.g. Average or Difference).

In Functional Safety mode, Input Limit Check *must* be enabled.

13.3.2 Output

If the calculated analog output value exceeds either of the *Output Lower Limit* or *Output Upper Limit* this will be indicated as an error on the analog output current (See also restrictions described in 2.4.6 Analog output).

13.4 Backup functionality

Applicable for variants SITRANS TH/TR/TF or SITRANS TS500 with SITRANS TH (dual input types).
If both Inputs are enabled (*Input 2 Input Type* is different from “None”), and the *Primary Variable* parameter are configured to any of the DV 10 to DV 14, a backup function is enabled.
These DV’s will all have:

- the value of Input 1 when a sensor error is detected on Input 2
- the value of Input 2 when a sensor error is detected on Input 1

If no Sensor Error is detected, their value will be as their name indicates (Input 1, Input 2, Average, Minimum or Maximum).
The backup function will only work if Sensor Error detection is enabled, i.e. *Sensor Error Action* is different from “None”.

14 Safe parameterization - user responsibility

It is the responsibility of the user to configure the transmitter so that it fits the required safety application.
The safe parametrization can be done with assist from any tool that can configure and verify the parameters described, and that supports the procedures described in this section.
The configuration tool must be specifically developed to support this, i.e. a generic HART tool cannot be used, but a device specific DD or DTM running in a generic framework is acceptable.

It is the overall responsibility of the user that the tool used for safe parametrization fulfills all requirements specified in this section.

14.1 Safety-related configuration parameters

14.1.1 Input 1 parameters

Parameter name in EDD	Parameter ID and name on the display	Description				
Input 1 Type	“01 InputType 1”	The range of other parameters can be depending on this parameter. NOTE: Only the Input Types listed are valid for Functional Safety mode.				
			Input Type	Min. Range	Max. Range	Units
		“Ohm”	Ohms	0	100000	Ω
		“kOhm”	kiloOhms	0	100	kΩ
		“Potm”	Potentiometer	0	100	%
		“PtxIEC”	RTD Pt x - IEC751, 10 ≤ x ≤ 10.000 NOTE 1	-200	850	°C
		“Pt50IEC”	RTD Pt 50 - IEC751	-200	850	°C
		“Pt100IEC”	RTD Pt 100 - IEC751	-200	850	°C
		“Pt200IEC”	RTD Pt 200 - IEC751	-200	850	°C
		“Pt500IEC”	RTD Pt 500 - IEC751	-200	850	°C
		“Pt1000IEC”	RTD Pt 1000 - IEC751	-200	850	°C
		“PtxJIS”	RTD Pt x - JIS C1604-81, 10 ≤ x ≤ 10.000 NOTE 1	-200	649	°C
		“Pt50JIS”	RTD Pt 50 – JIS C1604-81 (R100/R0 = 1.3916)	-200	649	°C
		“Pt100JIS”	RTD Pt 100 - JIS C1604-81 (R100/R0 = 1.3916)	-200	649	°C
		“Pt200JIS”	RTD Pt 200 - JIS C1604-81 (R100/R0 = 1.3916)	-200	649	°C
		“NixDIN”	RTD Ni x - DIN43760, 10 ≤ x ≤ 10.000 NOTE 1	-60	250	°C
		“Ni50DIN”	RTD Ni 50 - DIN 43760	-60	250	°C
		“Ni100DIN”	RTD Ni 100 - DIN 43760	-60	250	°C
		“Ni120DIN”	RTD Ni 120 - DIN 43760	-60	250	°C
		“Ni1000DIN”	RTD Ni 1000 - DIN 43760	-60	250	°C
		“CuxECW15”	RTD Cu x - ECW No. 15, 5 ≤ x ≤ 1.000 NOTE 1	-200	260	°C
		“Cu10ECW15”	RTD Cu 10 - ECW No. 15 (α = 0.00427)	-200	260	°C
		“Cu100ECW15”	RTD Cu 100 - ECW No. 15 (α = 0.00427)	-200	260	°C
		“Cu50GOST-94”	RTD Cu 50 - GOST 6651-1994 (α = 0.00426)	-50	200	°C
		“Cu50GOST-09”	RTD Cu 50 - GOST 6651-2009 (α = 0.00428)	-180	200	°C
		“Cu100GOST-09”	RTD Cu 100 - GOST 6651-2009 (α = 0.00428)	-180	200	°C
		“Pt50GOST-09”	RTD Pt 50 – GOST 6651-2009 (α = 0.00391)	-200	850	°C

Parameter name in EDD	Parameter ID and name on the display	Description				
		“Pt100GOST-09”	RTD Pt 100 – GOST 6651-2009 (α = 0.00391)	-200	850	°C
		“Cu100GOST-94”	RTD Cu 100 – GOST 6651-1994 (α = 0.00426)	-50	200	°C
		“CuxGOST-94”	RTD Cu x – GOST 6651-1994 (α = 0.00426) NOTE 1	-50	200	°C
		“NixGOST-09”	RTD Ni x – GOST 6651-2009 (α = 0.00617) NOTE 1	-60	180	°C
		“Ni50GOST-09”	RTD Ni 50 – GOST 6651-2009 (α = 0.00617)	-60	180	°C
		“Ni100GOST-09”	RTD Ni 100 – GOST 6651-2009 (α = 0.00617)	-60	180	°C
		“uV±”	Micro-Volts bipolar	-800000	800000	µV
		“mV±“	Milli-Volts bipolar	-800	800	mV
		“V±”	Volts bipolar	-0.8	0.8	V
		“TCB-IEC”	TC Type B - IEC 584	0	1820	°C
		“TCW5-ASTM”	TC Type W5 - ASTM E 988	0	2300	°C
		“TCW3-ASTM”	TC Type W3 - ASTM E 988	0	2300	°C
		“TCE-IEC584”	TC Type E - IEC 584	-200	1000	°C
		“TCJ-IEC584”	TC Type J - IEC 584	-100	1200	°C
		“TCK-IEC584”	TC Type K - IEC 584	-180	1372	°C
		“TCN-IEC584”	TC Type N - IEC 584	-180	1300	°C
		“TCR-IEC584”	TC Type R - IEC 584	-50	1760	°C
		“TCS-IEC584”	TC Type S - IEC 584	-50	1760	°C
		“TCT-IEC584”	TC Type T - IEC 584	-200	400	°C
		“TCL-DIN43710”	TC Type L - DIN 43710	-200	900	°C
		“TCU-DIN43710”	TC Type U - DIN 43710	-200	600	°C
		“TCLr-GOST”	TC Type Lr - GOST 3044-84	-200	800	°C
		“CuxGOST-09”	RTD Cu x – GOST 6651-2009 (α = 0.00428) NOTE 1	-180	200	°C
		“PtxGOST-09”	RTD Pt x – GOST 6691-2009 (α = 0.00391) NOTE 1	-200	850	°C
		“uV”	Micro-Volts unipolar	-100000	1700000	µV
		“mV”	Milli-Volts unipolar	-100	1700	mV
		“V”	Volts unipolar	-0.1	1.7	V
		Note 1: For these Input Types *Input 1 RTD Factor* applies				
Input 1 RTD Factor	“02 RTDFactor 1”	RTD Factor (R0) value in Ohms for Input 1. Only used if a PtX, NiX or CuX sensor type is selected for *Input 1 Input Type*. Range 10..10.000 Ohm for Ptx and Nix, 5..1000 for CuX.				
Input 1 Wiring configuration	“03 NumWires 1”	Wiring configuration is used for cable compensation of Input 1. Only used if an RTD, Linear Resistance or Potentiometer is selected for *Input 1 Input Type*. The range is dependent on the selected *Input 1 Input Type*. **If an RTD type or Linear resistance is selected, the range is 2 – 4:** 2 = The measurement is compensated with a fixed wire resistance value: *Input 1 Wire Resistance*. 3 = The measurement is compensated for wire resistance using 3-wires. (All sensor wires must be equal length and type). 4 = The measurement value is compensated for wire resistance using 4-wires. **If Potentiometer is selected, the range is 3 - 5:**				

Parameter name in EDD	Parameter ID and name on the display	Description
		3 = The measurement is compensated with a fixed wire resistance value: *Input 1 Wire Resistance*. 4 = The measurement is compensated for wire resistance using 4-wires. (All sensor wires must be equal length and type). 5 = The measurement value is compensated for wire resistance using 5-wires. **NOTE: 5-wire compensation is only possible for SITRANS TH/TR/TF or SITRANS TS500 with SITRANS TH (dual input types).** **NOTE: If 2 or 3 wires (3 or 4 for Potentiometer input) is selected in Functional Safety mode, the end user must ensure that the applied sensor wiring does not introduce failures exceeding the requirements for the safety application.**
Input 1 Wire resistance	"04 CableRes 1"	Total wire resistance in the 2 wires to an RTD or linear resistance sensor element. Only used if an RTD, Linear Resistance or Potentiometer input type is selected for *Input 1 Input Type* and if 2 (3 for potentiometer) is selected for *Input 1 Wiring Configuration*. Range 0...100 Ohm.
Input 1 Cold Junction Compensation (CJC) Type	"05 CJCType 1"	Cold Junction Compensation type for Input 1. Only used if a Thermocouple sensor type is selected for *Input 1 Input Type*. "Int" = Internal: The internal temperature sensor is used for CJC. "Ext" = External: An external connected temperature sensor is used for CJC, See *External CJC Type*. "Fix" = Fixed: A fixed temperature, given in *Input 1 Fixed CJC Value*, is used for CJC.
Input 1 Fixed Value	"06 CJCTemp 1"	Value for fixed CJC value for Input 1 Only used if a Thermocouple sensor type is selected for *Input 1 Input Type* and if Fixed is selected for *Input 1 CJC Type*. Range -50 to 135 degrees Celsius.
Input 1 Lower calibration point value	"07 LoTrimP1"	The process value on Input 1 where the last lower value was calibrated. See *Input 1 Trim Offset/Trim gain* for details on calibration. Note: If the Calibration is reset, the *Input 1 Lower Calibration Point* value will be forced to 0.0 by the device.
Input 1 Upper calibration point value	"08 UpTrimP 1"	The process value on Input 1 where the last upper value was calibrated. See *Input 1 Calibration Point Offset/Calibration Point* gain for details on calibration. Note: If the Calibration is reset, the *Input 1 Upper Calibration Point* value will be forced to 0.0 by the device.
	"09 TrimOffs 1"	Input 1 calibrated offset If the *Input 1 Trim Offset* is different from 0.0, a user calibration has been applied to Input 1. The required accuracy must be verified by user. End user must verify by test that the applied calibration does not introduce failures exceeding the requirements for the safety application.
	"10 TrimGain 1"	Input 1 calibrated gain If the *Input 1 Trim Gain* is different from 1.0, a user calibration has been applied to Input 1. End user must verify if the required accuracy is achieved. End user must verify by test that the applied calibration does not introduce failures exceeding the requirements for the safety application.

14.1.2 Input 2 parameters

NOTE: Only relevant for SITRANS TH/TR/TF or SITRANS TS500 with SITRANS TH (dual input types)

<table>
<tr><th>Parameter Name</th><th>Parameter ID and name on the display</th><th colspan="2">Description</th></tr>
<tr><td rowspan="8">Input 2 Type</td><td rowspan="8">“11 InputType 2”</td><td colspan="2">As Input 1 Input Type for Input 2.
In addition, the Input Type “None” can be selected to disable Input 2 measurement.
Only certain combinations are allowed dependent on the configuration of Input 1 Input Type:</td></tr>
<tr><td>Selected Input 1 Input Type</td><td>Allowed value for Input 2 Input Type</td></tr>
<tr><td>Ohms or kiloOhms or any RTD type</td><td>None, Ohms, kOhms or any RTD type</td></tr>
<tr><td>Potentiometer</td><td>None or Potentiometer</td></tr>
<tr><td>Micro-Volts unipolar, Milli-Volts unipolar or Volts unipolar</td><td>None, Micro-Volts unipolar, Milli-Volts unipolar or Volts unipolar</td></tr>
<tr><td>Micro-Volts bipolar, Milli-Volts bipolar or Volts bipolar</td><td>None, Micro-Volts bipolar, Milli-Volts bipolar or Volts bipolar</td></tr>
<tr><td>Any TC type</td><td>None, Any TC type, Ohms, kOhms or any RTD type</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td>Input 2 RTD Factor</td><td>“12 RTDFactor 2”</td><td colspan="2">As Input 1 RTD Factor for Input 2.
NOTE: This is only relevant if Input 2 Input Type is different from None.</td></tr>
<tr><td>Input 2 Wiring Configuration</td><td>“13 NumWires 2”</td><td colspan="2">As Input 1 Wiring Configuration for Input 2.
NOTE: This is only relevant if Input 2 Input Type is different from None.
NOTE: 5-wire compensation on potentiometer input is not possible for Input 2. 4-wire compensation on potentiometer input is not possible for Input 2 if 5-wire is selected for Input 1.</td></tr>
<tr><td>Input 2 Wire Resistance</td><td>“14 CableRes 2”</td><td colspan="2">As Input 1 Wire Resistance for Input 2.
NOTE: This is only relevant if Input 2 Input Type is different from None.</td></tr>
<tr><td>Input 2 Cold Junction Compensation Type</td><td>“15 CJCType 2”</td><td colspan="2">As Input 1 CJC Type for Input 2.
NOTE: This is only relevant if Input 2 Input Type is different from None.</td></tr>
<tr><td>Input 2 Fixed Value</td><td>“16 CJCTemp 2”</td><td colspan="2">As Input 1 Fixed CJC Value for Input 2.
NOTE: This is only relevant if Input 2 Input Type is different from None.</td></tr>
<tr><td>Input 2 Lower calibration point value</td><td>“17 LoTrimP 2”</td><td colspan="2">As Input 1 Lower Calibration Point for Input 2.
NOTE: This is only relevant if Input 2 Input Type is different from None.</td></tr>
<tr><td>Input 2 Upper calibration point value</td><td>“18 UpTrimP 2”</td><td colspan="2">As Input 1 Upper Calibration Point for Input 2.
NOTE: This is only relevant if Input 2 Input Type is different from None.</td></tr>
<tr><td></td><td>“19 TrimOffs 2”</td><td colspan="2">As Input 1 Trim Offset for Input 2.
NOTE: This is only relevant if Input 2 Input Type is different from None.</td></tr>
<tr><td></td><td>“20 TrimGain 2”</td><td colspan="2">As Input 1 Trim Gain for Input 2.
NOTE: This is only relevant if Input 2 Input Type is different from None.</td></tr>
</table>

14.1.3 External CJC parameters

Parameter Name	Parameter ID and name on the display	Description
External CJC Type	"21 ExtCJC"	External CJC sensor Code Only used if either: • a Thermocouple sensor type is selected for *Input 1 Input Type* and *External CJC* is selected for *Input 1 CJC type*. • a Thermocouple sensor type is selected for *Input 2 Input Type* and *External CJC* is selected for *Input 2 CJC type*. "Pt100" = Pt100 (IEC751) is used as External CJC sensor "Ni100" = Ni100 (DIN43760) is used as External CJC sensor
External CJC, Wiring Configuration	"22 CJCNumWires"	Wiring Configuration that is used for measuring external CJC sensor: Only used if *Input 1 Input Type* is a Thermocouple sensor type and *External* is selected for *Input 1 CJC Type*. "2" = 2-wire measurement compensated with the *External CJC Wire Resistance* "3" = 3-wire automatic wire resistance compensation "4" = 4-wire automatic wire resistance compensation **NOTE: If 2 or 3 is selected, the end user must ensure that the applied sensor wiring does not introduce failures exceeding the requirements for the safety application.** **NOTE: 4-wire is only possible for SITRANS TH/TR/TF or SITRANS TS500 with SITRANS TH (dual input types) and if *Input 2 Input Type* is not an RTD-type.**
Extern CJC Wire Resistance	"23 CJCCableRes"	Wire resistance for external CJC Temperature Sensor: Total wire resistance in the 2 wires to the RTD element measuring the External CJC temperature. Only used if either: • *Input 1 Input Type* is a Thermocouple sensor type, *External* is selected for *Input 1 CJC Type* and *2-wire* is selected for *External CJC Wiring Configuration*. • *Input 2 Input Type* is a Thermocouple sensor type, *External* is selected for *Input 2 CJC Type* and *2-wire* is selected for *External CJC Wiring Configuration*. Range 0..100 Ohm.

14.1.4 PV parameters

Parameter Name	Parameter ID and name on the display	Description		
PV selector	"24 PVMap"	Device variable assigned to Primary Variable. The DV performing the appropriate measurement function (applicable to the PV and thereby the analog output).		
		DV 0:	"Input1"	Input 1
		DV 1:	"Input2"	Input 2
		DV 2:	"Input1CJC"	Input 1 CJC temperature, only valid if Input 1 is a TC
		DV 3:	"Input2CJC"	Input 2 CJC temperature, only valid if Input 2 is a TC
		DV 4:	"AvgI1I2"	Average Input 1 and Input 2
		DV 5:	"DiffI1-I2"	Difference Input 1 - Input 2
		DV 6:	"DiffI2-I1"	Difference Input 2 - Input 1
		DV 7:	"AbsDiffI1-I2"	Absolute difference (Input 1 - Input 2)
		DV 8:	"MinIS1I2"	Minimum (Input 1, Input 2)
		DV 9:	"MaxI1I2"	Maximum (Input 1, Input 2)
		DV 10:	"I1WI2Backup"	Input 1 with Input 2 as backup
		DV 11:	"I2WI1Backup"	Input 2 with Input 1 as backup
		DV 12:	"AvgI1I2Back"	Average with Input 1 or 2 as backup
		DV 13:	"MinI1I2Back"	Minimum with Input 1 or 2 as backup

Parameter Name	Parameter ID and name on the display	Description
		DV 14: "MaxI1I2Back" Maximum with Input 1 or 2 as backup DV 15: "ElectrTemp" Electronics Temperature
PV Lower Range Value	"25 PVLowerRng"	PV lower range value (LRV) Lower input value for the linear measurement range, i.e. the input signal value corresponding the *Output Range 0%* (4.0 mA). The range is dependent on the selected Input Type for the DV selected as the *Primary Variable*. The value is shown in the units that supports the Input Type for the DV selected as the *Primary Variable* (e.g. "mV" for *mVolts bipolar*, "µV" for *micro-volts bipolar*, etc.).
PV Upper Range Value	"26 PVUpperRng"	PV upper range value (URV) Upper input value for the linear measurement range, i.e. the input signal value corresponding the *Output Range 100%* (20.0 mA). The range is dependent on the selected Input Type for the DV selected as the *Primary Variable*. The value is shown in the units that supports the Input Type for the DV selected as the *Primary Variable* (e.g. "mV" for *mVolts bipolar*, "µV" for *micro-volts bipolar*, etc.)
PV Damping	"27 PVDamp"	Damping for the DV selected as the *Primary Variable*. Damping is a first order digital filter applied to the DV value. The Damping value specifies the time constant, i.e. the time at which 63.2% of a full signal change on the input is reached on the output. Valid range is 0 to 60 seconds. **NOTE: Damping value ≈ 0.434 * Response Time** **(The response time, i.e. the time at which 90% of full signal change is reached, is approx. 2.3 times higher than the Damping).**

14.1.5 Analog Output parameters

Parameter Name	Parameter ID and name on the display	Description
Lower Range Current	"28 Out0%" **NOTE 2**	Analog output at *PV Lower Range*. Current in mA. **NOTE: For Functional Safety mode the value must be exactly 4.0 mA (Conforms to NAMUR NE43).**
Upper Range Current	"29 Out100%" **NOTE 2**	Analog output at *PV Upper Range*. Current in mA. **NOTE: For Functional Safety mode the value must be exactly 20.0 mA (Conforms to NAMUR NE43).**
Range Check	"30 LimitCheck" **See restrictions described in 2.4.6**	"None" = Range Check Mode disabled NOTE 2 "Input" = Range Check Mode enabled on Input Range "Output" = Range Check Mode enabled on Output Range NOTE 2 "Input+Output" = Range Check Mode enabled on Input Range and Output Range **NOTE: For Functional Safety mode the value must be Check enabled on Input Range or Check enabled on Input and Output Range.**
Fault Current Output Range Error	"31 OutLimErrVal" **NOTE 2**	Current output in mA indicating Output Range Error if the calculated output value is outside the limits configured in *Output Lower/Upper Range Error*. I.e. when Device Status bit "Loop Current Saturated" is set (only if enabled). Range 3.5...23.0 mA **NOTE: For Functional Safety mode the value must be ≤ 3.6 mA or ≥ 21.0 mA (conforms to NAMUR NE43) if Enabled.**
Lower Saturation Limit	"32 OutLowLim" **NOTE 2**	Current output saturation limit. The current level where the output current will saturate in lower direction. Current in mA. **NOTE: For Functional Safety mode the value must be exactly 3.8 mA (Conforms to NAMUR NE43).**

Parameter Name	Parameter ID and name on the display	Description
Upper Saturation Limit	“33 OutUpLim” **NOTE 2**	Current output saturation limit. The current level where the output current will saturate in upper direction. Current in mA. **NOTE: For Functional Safety mode the value must be exactly 20.5 mA (Conforms to NAMUR NE43).**
Error Detection Mode	“34 SensorError” **NOTE 2**	“None” = Sensor error detection disabled “Broken” = Sensor error detection of broken sensor enabled “Shorted” = Sensor error detection of shorted sensor enabled “Broken+Short” = Sensor error detection of both broken and shorted sensor enabled **NOTE: For Functional Safety mode the value must be Sensor error detection of Broken and Shorted enabled.**
Fault Current Broken Circuit	“35 BrkSensVal” **NOTE 2**	Broken sensor alarm analog output signal Current in mA indicating broken sensor alarm. Range: 3.5...23.0 mA **NOTE: For Functional Safety mode the value must be ≤ 3.6mA or ≥ 21.0 mA (Conforms to NAMUR NE43).**
Fault Current Short Circuit	“36 ShortSensVal” **NOTE 2**	Shorted sensor alarm analog output signal Current in mA indicating shorted sensor alarm. Range: 3.5...23.0 mA **NOTE: For Functional Safety mode the value must be ≤ 3.6 mA or ≥ 21.0 mA (Conforms to NAMUR NE43).**
Drift Detection Mode	“37 SensDrift”	“Disable” = No detection of sensor drift “Warning” = Only a warning on HART is issued if drift is detected “Error” = Analog output is set to Sensor Drift Current if drift is detected **Note: Only valid for dual input applications i.e. *Input 2 Input Type* < > “None”.** The process values measured by Input 1 and Input 2 are compared regularly and if the absolute value of the difference |Input 1 - Input 2| exceeds *Sensor Drift Limit* for longer than *Sensor Drift Timeout*, a sensor drift is detected. If the difference is lower than the limit, the detection is cleared and the timer is reset.
Drift Limit	“38 SensDriftLim”	Measurement limit for drift detection on difference between Input 1 and Input 2. See *Drift Detection Mode.* **NOTE: Only valid if *Sensor Drift* is not set to Disable.** **NOTE: No units are used, since the *Input 1 Input Type* and *Input 2 Input Type* are expected to have the same measuring unit**.
Drift Timeout	“39 SensDriftTim”	Timeout value for sensor drift detection in seconds. See *Sensor drift Configuration*. Range: 0...86400 seconds (~24 hours) **NOTE: Only valid if *Sensor Drift* is not set to Disable.**
Fault Current Drift Detection	“40 SDriftErrVal” **NOTE 2**	Current in mA indicating sensor drift alarm. Range: 3.5...23.0 mA **NOTE: Only valid if *Sensor Drift* is set to Error.** **NOTE: For Functional Safety mode the value must be ≤ 3.6 mA or ≥ 21.0 mA (conforms to NAMUR NE43).**
Fault Current Input Range Error	“41 InLimErrVal” **NOTE 2**	Current output in mA indicating Input Check Input Range Error if Input 1 or Input 2 is outside the limits configured in *Input 1 Lower/Upper Range Error* and *Input 2 Lower/Upper Range Error.* I.e. when the Device Status bit “Primary Value Out Of Limits” is also set. Range 3.5 -23.0 mA **NOTE: For Functional Safety mode the value must be ≤ 3.6 mA or ≥ 21.0 mA (conforms to NAMUR NE43).**
Input 1 Lower Limit	“42 LowLim 1”	Lower Measurement Limit for Input 1. Depending on the wanted measurement (PV assignment), this value should be set to support the configured PV Range. The range is dependent on the selected input type as shown for *Input 1 Input Type.* The value is shown in the units that supports the selected *Input 1 Input Type (*e.g. “mV” for *mVolts bipolar*, “µV” for *micro-volts bipolar*, etc.).

Parameter Name	Parameter ID and name on the display	Description
Input 1 Upper Limit	"43 UpLim 1"	Upper Measurement Limit for Input 1. Depending on the wanted measurement (PV assignment), this value should be set to support the configured PV Upper Range. The range is dependent on the selected input type as shown for *Input 1 Input Type*. The value is shown in the units that supports the selected *Input 1 Input Type* (e.g. "mV" for *mVolts bipolar*, "µV" for *micro-volts bipolar*, etc.). If *Input 1 Input Type* is set to *Potentiometer*, this value determines the selected potentiometer size.
Input 2 Lower Limit	"44 LowLim 2"	As Input 1 Lower Limit for Input 2. **NOTE: This is only relevant if Input 2 Input Type is different from None.**
Input 2 Upper Limit	"45 UpLim 2"	As Input 1 Upper Limit for Input 2. **NOTE: This is only relevant if Input 2 Input Type is different from None.**
Analog Output Calibration Gain	"46 OutCalGain" **NOTE 2**	Analog output calibration gain. Loop current can be calibrated using measured loop current values with HART commands 45 and 46. This parameter holds the calculated gain. **NOTE: This value must be 1.0 for Functional Safety mode**
Analog Output Calibration Offset	"47 OutCalOffset" **NOTE 2**	As above, this parameter holds the calculated offset. **NOTE: This value must be 0.0 for Functional Safety mode**

NOTE 2: These parameters are checked by the transmitter and will only be shown if they are not configured correctly for a Functional Safety application.

14.1.6 HART parameters

Parameter Name	Parameter ID and name on the display	Description
Polling Address	"48 PollAddr" **NOTE 2**	Polling address for HART communication: Range HART 5 mode: 0...15, any value > 0 will result in constant 4 mA output. Range HART 7 mode: 0...63 **NOTE: For HART 5 this MUST be set to 0 in Functional Safety mode.**
Loop Current Mode	"49 LoopCurrent" **NOTE 2**	Loop Current Mode: Disable = Constant 4 mA output Enable = Analog Output is proportional to measured Primary Value **NOTE: For HART 7 mode this must be set to Enable in Functional Safety mode.**
Write Protection	"50 WriteProtect" **NOTE 2**	Indicates if Write Protection is enabled "HW" = The configuration is protected by HW jumper "Yes" = The configuration is protected by PIN "No" = The configuration is not protected **NOTE: The configuration must be write protected with user PIN in Functional Safety mode.**
Functional Safety Available	"51 SILMode"	Indicates if Functional Safety Mode is active "No" = Normal operation mode (no FUNCTIONAL SAFETY restrictions applies) "Yes" = Functional Safety operation mode. All restrictions described in the Functional Safety Manual applies Must be "Yes" for a Functional Safety configuration to be valid.
Functional Safety Status	"52 SILStatus" The value is not shown until the Functional Safety is entered!	Indicates the result of configuration check by Functional Safety rated SW: "FAIL": No valid configuration has been received "OPEN": Actual configuration is NOT locked (non-Functional Safety) "LOCK": Actual configuration is locked (Functional Safety validated) "INIT": Initial status when load/check is in progress **NOTE: Only the value "LOCK" indicates a successful Functional Safety parametrization.**

NOTE 2: These parameters are checked by the transmitter and will only be shown if they are not configured correctly for a Functional Safety application.

14.1.7 Option Parameters

Parameter Name	Parameter ID and name on the display	Description
Noise Damping	“53 MainsFilter”	Noise damping supply damping filter: “50 Hz” = 50 Hz mains supply noise will be suppressed. “60 Hz” = 60 Hz mains supply noise will be suppressed.

14.2 Enabling Functional Safety

14.2.1 Enabling Functional Safety over configuration tool

When all relevant parameters have been configured correctly according to the required safety application, the user shall request the Functional Safety mode.
Functional Safety mode is requested by pressing the “Change Functional Safety mode” and ”Enter Functional Safety mode” from the configuration tool and entering the requested user PIN (default 2457). Optionally the user PIN can be changed.

Validating all safety related Parameters

The user’s validation of correct parametrization is mandatory and will be requested automatically by the configuration tool after Functional Safety mode is requested. The tool will reset the device to make sure that the verified configuration parameters are stored non-volatile in the transmitter. The tool will then request the transmitter to validate the currently stored safety relevant configuration parameters. If the stored configuration parameters are valid for Functional Safety mode, a report showing every relevant parameter listed in section “14.1 Safety-related configuration parameters” is requested by the configuration tool and then shown in the “human readable format” (as generated by the transmitter) to the user. The parameters may be shown one or more at a time, or as a whole, dependent on the tool.

The reported parameters must be carefully verified by the user to be in accordance with the safety application!

If the stored configuration parameters are not valid for Functional Safety mode, an error report showing the invalid parameter is generated by the transmitter, and shown to the user by the configuration tool, instead of the normal report.

If any of the parameters listed in 14.1 are not shown correctly or have an incorrect value, the procedure must be aborted by pressing “Parameters NOT OK” and the device may not be considered as being in correct Functional Safety mode!

If all parameters are correct, the user validates them by pressing “Parameters OK”.
The tool will confirm the configuration by sending a CRC calculated over the whole parameter report, and then ask for the resulting Functional Safety mode.
Finally, this will be polled by the tool and shown to the user.

Only the value “LOCK” shall be accepted by the user. If the result is not shown or if anything else is shown (“OPEN”, “FAIL” or “INIT”), the device shall not be considered as being in correct Functional Safety **mode!**

It may take some seconds before the correct value is shown.
Press “Status OK” to confirm the status ”LOCK” and end the procedure, or press ”Status Wrong” to reject if the value ”LOCK” is not shown.

14.2.2 Enabling Functional Safety over device with display

Requirement

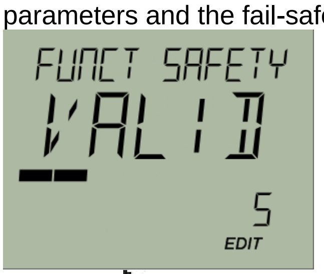
- You know how to operate the device. Refer to the Operating Instructions, see section 1.1 Links to Operating Instructions.
- You have checked the settings of the safety-related parameters.

Procedure

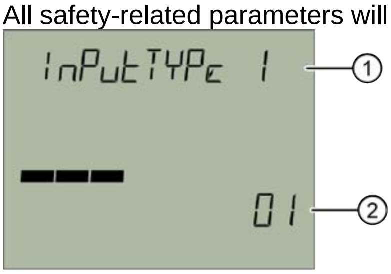
1. Navigate into the parameter view.
2. Select the parameter "Functional Safety" [12].

3. Press the ▶ button.
4. Enter the user PIN.
5. Use the ▶ button to confirm.
   The display test runs automatically.
6. Check that all segments displayed correctly, numbers from 0 to 9 run correctly along the screen and on the info field and all symbols and logos displays correctly.

7. Once the display test is complete, start the validation of the safety-related parameters and the fail-safe behavior.



8. Press the ▶ button.
9. Navigate to the safety-related parameters with the ▶ button.
   All safety-related parameters will be displayed.



① Name of parameter and value (alternating)

② Parameter ID

You find a parameter description in section 14.1 Safety-related configuration parameters.

10. Use the ▶ button to confirm every safety-related parameter.
11. To complete validation of the safety-related parameters, confirm with YES.

Result

The device is in the "Functional Safety enabled" device mode.

The "SIL" symbol is displayed.
The "DSABL" command appears (Disable Functional Safety).
All parameters are protected against changes.
When a safety-related error is detected on the device, the device changes to "Safety critical error" device mode.

14.3 Disabling Functional Safety over configuration tool

To exit Functional Safety mode, press "Disable" in the functional safety menu in the configuration tool, and enter the correct user PIN when prompted.
The configuration tool will then request normal operation mode and show the resulting Functional Safety mode to the user.
The value “OPEN” will indicate that the device is not in Functional Safety mode, and it will then be possible to change the parameters.

14.4 Disabling Functional Safety over device with display

Requirement

The device is in the "Functional Safety enabled" device mode.

Procedure

1. Navigate into the parameter view.
2. Select the parameter "Functional Safety" [12].
3. Enter the user PIN.
4. Select YES immediately and confirm with the button.

Result

The device switches to "Functional Safety disabled" device mode.

Note
If Functional Safety remains enabled, repeat the procedure described above without any interruptions.

14.5 Functional test

After entering Functional Safety mode, the user is responsible for making a functional test after verification of the safety parameters. The procedure described in section 10 Periodic proof test procedure shall be used.

In addition, if a process calibration is taken into Functional Safety-mode operation (refer to section 13.2 Process calibration (input calibration). It is mandatory that the accuracy of the device (and sensor, if applicable) are tested.

15 Fault reaction and restart condition

When the SITRANS TH/TR/TF or SITRANS TS500 with SITRANS TH detects a fault, the output will go to Safe State.
Via remote operation you will furthermore be able to see the diagnostic message describing the detected error. You will find the diagnostic messages in for example SIMATIC PDM or in the Operating Instructions of the device in the section “Diagnose and Troubleshooting”.

15.1 Application specific faults

If the fault is caused by a sensor error or sensor wiring, the LED on the SITRANS TH/TR will flash red and the correct output current will automatically be reestablished when the fault has been corrected.

15.2 Device faults

If the fault is in the device itself (detected by internal diagnostic measures), the LED on the SITRANS TH/TR will light constantly RED.
There are 2 ways of bringing the device out of Safe State:

1. Power-cycle the device.
2. Reset the device by using a configuration tool that supports a reset of the device. If the error is persistent, the device will enter the Safe State again.

16 Installation

The device must be installed as required for the Functional Safety application according to the Operating Instructions. All assumption and restrictions as described in Section “2 Assumptions and restrictions for use of the product” must be observed.