ACT20X-HUI-SAO
Universal signal converter

Safety Manual

Weidmüller

1.1 Revision history

Version	Date	Change
00	04/2014	First Edition
01	05/2016	Page 12, chapter 6
02	11/2017	Product added
03	11/2020	1) C 16.5.2 / P 36: Note 2: "Action on Error" changed to "Error actions" for relays functions 2) C 16.5.3 / P 36: Input condition "Voltage" in table entry "Controlled by setpoints → Error actions" removed 3) C 16.5.3 / P 37: Note 2: "Action on Error = NONE" changed to "Action on Error ≠ No action"

1.2 Validity

This manual is valid for the following products:

Device version	Type	Order number
2	ACT20X-HUI-SAO-S	8965490000
2	ACT20X-HUI-SAO-P	2456200000

1.3 Contact address

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2. Observed standards

Standard	Description
IEC 61508	Functional safety of electrical / electronic / programmable electronic safety-related systems
IEC 61508-2:2000	Part 2: Requirements for electrical / electronic / programmable electronic safety-related systems
IEC 61508-3:1998	Part 3: Software requirements
IEC 61326-3-1:2008	Immunity requirements for safety-related systems

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.

4. Purpose of the product

The ACT20X-HUI-SAO is an one channel universal signal converter for conversion and scaling of temperature (Pt, Ni and TC), voltage, potentiometer, linear resistance and current signals from hazardous areas.

The device can be mounted in the safe area and in Zone 2 / Division 2 and receive signals from Zone 0, 1, 2, 20, 21, 22 and mines or Class I/II/III, Division 1, Group A-G. Error events, including cable breakage, are monitored and signaled via the individual status relay. The ACT20X-HUI-SAO has been designed, developed and certified for use in SIL 2 applications according to the requirements of IEC 61508.

5. Assumptions and restrictions for use of the product

5.1 Basic safety specifications

Operational temperature range:	-20...+60 °C
Storage temperature range:	-20...+85 °C
Power supply type:	Double or reinforced
Supply voltage:	19.2...31.2 V DC
Relay output pulse length, min.:	70 ms
Loop supply:	>16.5 V @ 20 mA
External loop supply voltage	5...26 V DC + external drop (passive output)
Mounting area:	Zone 2 & Class I, Division 2 or safe area
Mounting environment:	Pollution degree 2 or better, Overvoltage category II

5.2 Safety accuracy

The analogue output corresponds to the applied input within the safety accuracy.

Safety accuracy: ±2 %

5.2.1 Minimum span

For temperature measurements, the selected range (high limit – low limit) shall be larger or equal to the values below:

Input type	Minimum span for safety accuracy
Pt100, Pt200, Pt1000	28 °C
Pt500, Ni100, Ni120, Ni1000	43 °C
Pt50, Pt400, Ni50	57 °C
Pt250, Pt300	85 °C
Pt20	142 °C
Pt10	283 °C
TC: E, J, K, L, N, T, U	91 °C
TC: B, R, S, W3, W5, LR	153 °C
Resistance high limit ≤ 800 Ω	53 Ω
Resistance high limit > 800 Ω	667 Ω

5.2.2 Range limitations

TC type B shall not be used below +400 °C.

5.3 Associated equipment

5.3.1 RTD or linear resistance sensor wiring

If a 2-wire or a 3-wire connection for RTD or linear resistance is selected, the end user must ensure that the applied sensor wiring does not introduce failures exceeding the requirements for the safety application.

5.3.2 Sensor errors

If the loop supply is used to supply a current input signal, the sensor error indication shall be enabled on the safety output(s).

If sensor error detection is disabled, or if any of the configurations below are used, the user must ensure that the applied sensor, including wiring, has a failure rate that qualifies it for the safety application without sensor error detection enabled:

- Input is current, 0...20 mA
- Input is voltage
- Input is resistance and low limit < 18 Ω (no short circuit detection)
- Input is Pt10, Pt20 or Pt50 (no short circuit detection)
- Input is potentiometer (no short circuit detection on arm)

5.3.3 Process calibration

If a process calibration is taken into SIL-mode operation, it is mandatory that the accuracy of the device (and sensor, if applicable) is tested by the end user after SIL-mode is entered, in addition to the normal functional test (refer to chapter 16.5 "Safety-related configuration user responsibility" on page 33).

5.3.4 Analogue output

The connected safety PLC shall be able to detect and handle the fault indications on the analogue output of the ACT20X-HUI-SAO converter by having a NAMUR NE43-compliant current input.

5.3.5 Relay output

The relay output shall only be connected to equipment which has a current limiting function of 2 A.

5.4 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 also not included.

5.5 Safe parameterization

The user is responsible for verifying the correctness of the configuration parameters (refer to chapter 16.5 "Safety-related configuration user responsibility" on page 33). Manual override may not be used for safety applications.

5.6 Installation in hazardous areas

The IECEx installation drawing, ATEX installation drawing and FM installation drawing shall be followed, if the products are installed in or connected to hazardous areas.

6. Functional specification of the safety functions

Conversion of current signals (0...20 mA or 4...20 mA), voltage signals, potentiometer, linear resistance, RTD sensor signals or thermocouple sensor signals from hazardous areas to a 4...20 mA current output signal, and/or an output relay, within specified accuracy. For RTD and linear resistance input sensors, cable resistances of up to 50 Ω per wire can be compensated if 3- or 4-wire connection is configured. For thermocouple sensors, cold junction temperature errors can be compensated, either by an internally mounted temperature sensor, or by an accessory connector with a built-in temperature sensor. The selection of CJC measurement must be done and verified by the end user (refer to chapter 18 "Connection diagram" on page 39).

7. Functional specification of the non-safety functions

The status relay (terminal 53 and 54) and LED outputs are not suitable for use in any Safety Instrumented Function.

8. Safety parameters

Configuration overview of the ACT20X-HUI-SAO

ID	Name	Description
C1	3W Pt100 Aout	Resistance / RTD temperature / TC temperature inputs, current output
C2	3W Pt100 Relay	Resistance / RTD temperature / TC temperature inputs, relay output
C3	Current Aout	Current input, current output
C4	Current Relay	Current input, relay output
C5	Voltage Aout	Voltage input, current output
C6	Voltage Relay	Voltage input, relay output

Safety basic parameters	Ex input SIL2
Demand response time, opto output	Signal input: < 0.5 s Potentiometer and linear resistance input: < 0.65 s Temperature input: < 1.1 s
Demand mode	High
Demand rate	3000 s
Diagnostic test interval	30 s
Mean Time To Repair (MTTR)	24 h
Hardware Fault Tolerance (HFT)	0
Component type	B
SIL capability	SIL 2
Description of the "safe state", analogue output	Output ≤ 3.6 mA or output ≥ 21 mA
Description of the "safe state", relay output	de-energized (open contact)
Relay lifetime (see note1)	100000 times

Note 1: The user must calculate the product lifetime with regard to the relay lifetime.

ID	PFD$_{AVG}$			PFH (see note 1)	T_{proof}	SFF
	T_{proof} = 1 year	T_{proof} = 2 years	T_{proof} = 5 years			
C1	2.82×10^{-4}	4.63×10^{-4}	1.00×10^{-3}	4.33×10^{-8} h^{-1}	4 years	93 %
C2	4.03×10^{-4}	6.63×10^{-4}	1.44×10^{-3}	6.24×10^{-8} h^{-1}	3 years	90 %
C3	2.77×10^{-4}	4.52×10^{-4}	9.76×10^{-4}	4.20×10^{-8} h^{-1}	5 years	95 %
C4	4.00×10^{-4}	6.56×10^{-4}	1.42×10^{-3}	6.16×10^{-8} h^{-1}	3 years	93 %
C5	3.66×10^{-4}	5.99×10^{-4}	1.30×10^{-3}	5.60×10^{-8} h^{-1}	3 years	93 %
C6	4.89×10^{-4}	8.04×10^{-4}	1.75×10^{-3}	7.57×10^{-8} h^{-1}	2 years	91 %

PFD$_{AVG}$ = Average Probability of Failure on Demand

PFH = Probability of dangerous Failure per Hour

T_{proof} = Proof-test interval, (10 % of loop PFD)

SFF = Safe Failure Fraction

Note 1: The ACT20X-HUI-SAO contains no lifetime limiting components, therefore the PFH figures are valid for up to 12 years, according to IEC 61508.

9. Failure category SIL 2

Failure rates according to IEC 61508	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**
Total failure rate for dangerous detected failures (λ_{DD})	352 FIT	230 FIT	554 FIT	320 FIT	479 FIT	353 FIT
Total failure rate for dangerous undetected failures (λ_{DU})	43 FIT	62 FIT	42 FIT	62 FIT	56 FIT	76 FIT
Total failure rate for all safe failures (λ_{Safe})	278 FIT	359 FIT	444 FIT	636 FIT	395 FIT	480 FIT

FIT = 10^{-9} h^{-1} (Failure in time)

10. 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.

11. Periodic proof test procedure

Step	Action
1	Bypass the safety PLC or take other appropriate action to avoid a false trip.
2	Connect a simulator identical to the input setup.
3	Apply input value corresponding to 0/100 % output range to each channel.
4	Observe whether the output channel acts as expected.
5	Restore the input terminals to full operation.
6	Remove the bypass from the safety PLC or otherwise restore normal operation.

This test will detect approximately 95 % of possible "DU" (dangerous undetected) failures in the pulse isolator. The proof test is equivalent to the functional test.

12. 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 Weidmüller Interface GmbH & Co. KG.

Repair of the device and replacement of circuit breakers must be done by Weidmüller Interface GmbH & Co. KG only.

13. Maintenance

No maintenance required.

14. Configuration with FDT/DTM

The universal signal converter ACT20X-HUI-SAO will be configured via PC according to the FDT/DTM standard.

14.1 Concept

The FDT technology standardizes the configuration and communication interfaces between different devices and connected systems, IEC 62453. Therefore the FDT provides a common environment for accessing and connecting the devices features. Any device can be configured, operated and maintained through the standardized graphical user interfaces. These functions are regardless of supplier and type of communication protocol. The FDT interface is the specification describing the standard data exchange between field devices and PC.

A device driver with full fit the FDT mandatory interfaces are called device type manager (DTM). The DTMs are classified for the ACT20X product family into two categories:

- Device DTMs which represent the ACT20X product family with its configuration components
- Communication DTMs which create the connection to the ACT20X over the CBX 200 hardware

The FDT Frame Application is the software program that implements all DTMs. The FDT Frame Application, also called FDT container, provides the DTM management, navigation, user management and common environment. The Weidmüller FDT container is called "WI-Manager".

14.2 Hardware / Firmware

The hardware of the ACT20X product family has a jack plug for the CBX 200 hardware. The CBX 200 hardware is used for the configuration via serial port and PC. The result is a point to point connection (PC to hardware).

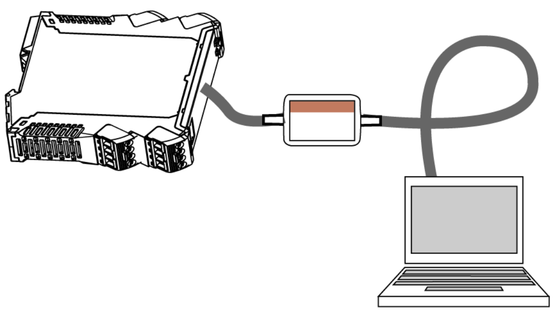


Figure 1 Point to point connection with the CBX 200 and an ACT20X device for the configuration

15. Parameterization by user interface

Configuration of the parameter via the General User interface "GUI" via the FDT / DTM software.

The parameterization according to the safety requirements is oriented towards the general using the product related DTM (Figure 2 "GUI DTM configuration (1) (example)" and Figure 3 "GUI DTM configuration (2) (example)" shows an example of a DTM).

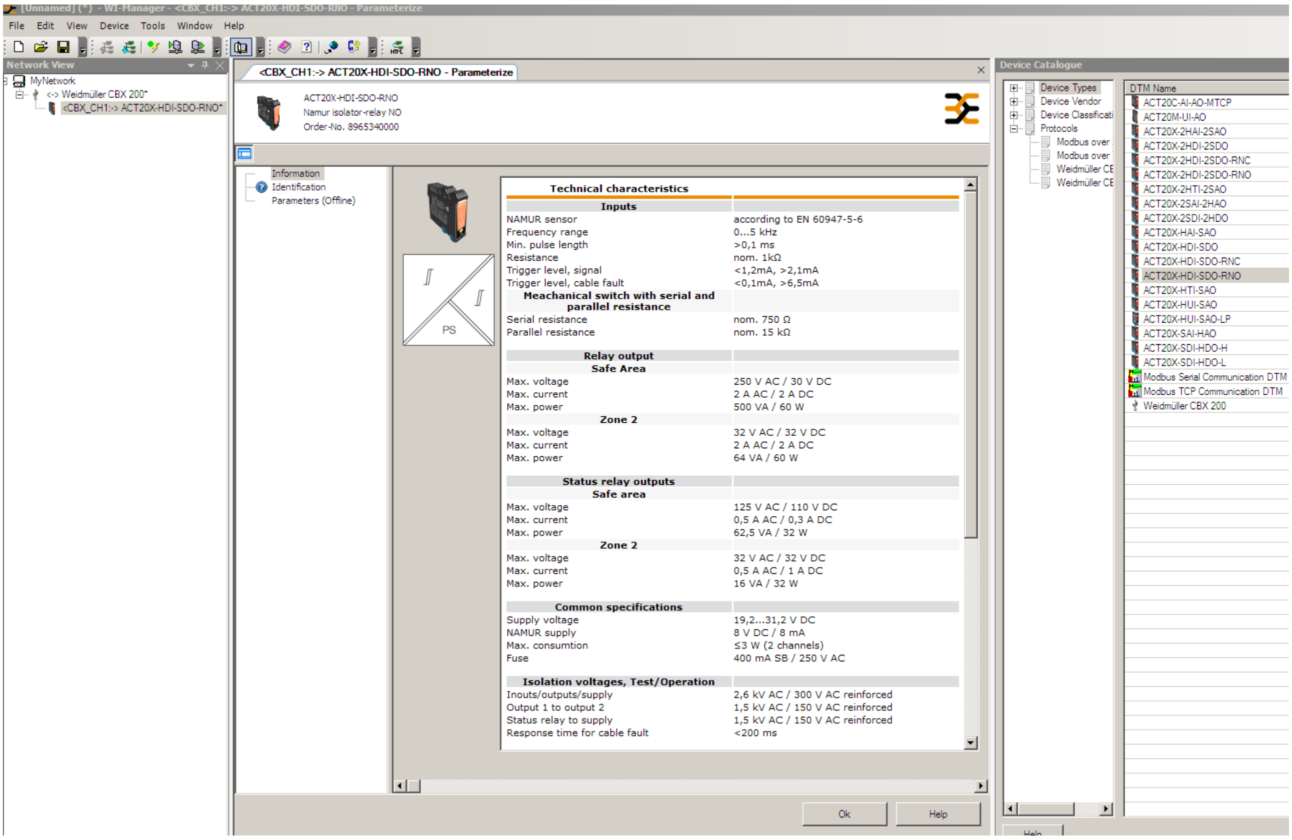


Figure 2: GUI DTM configuration (1) (example)

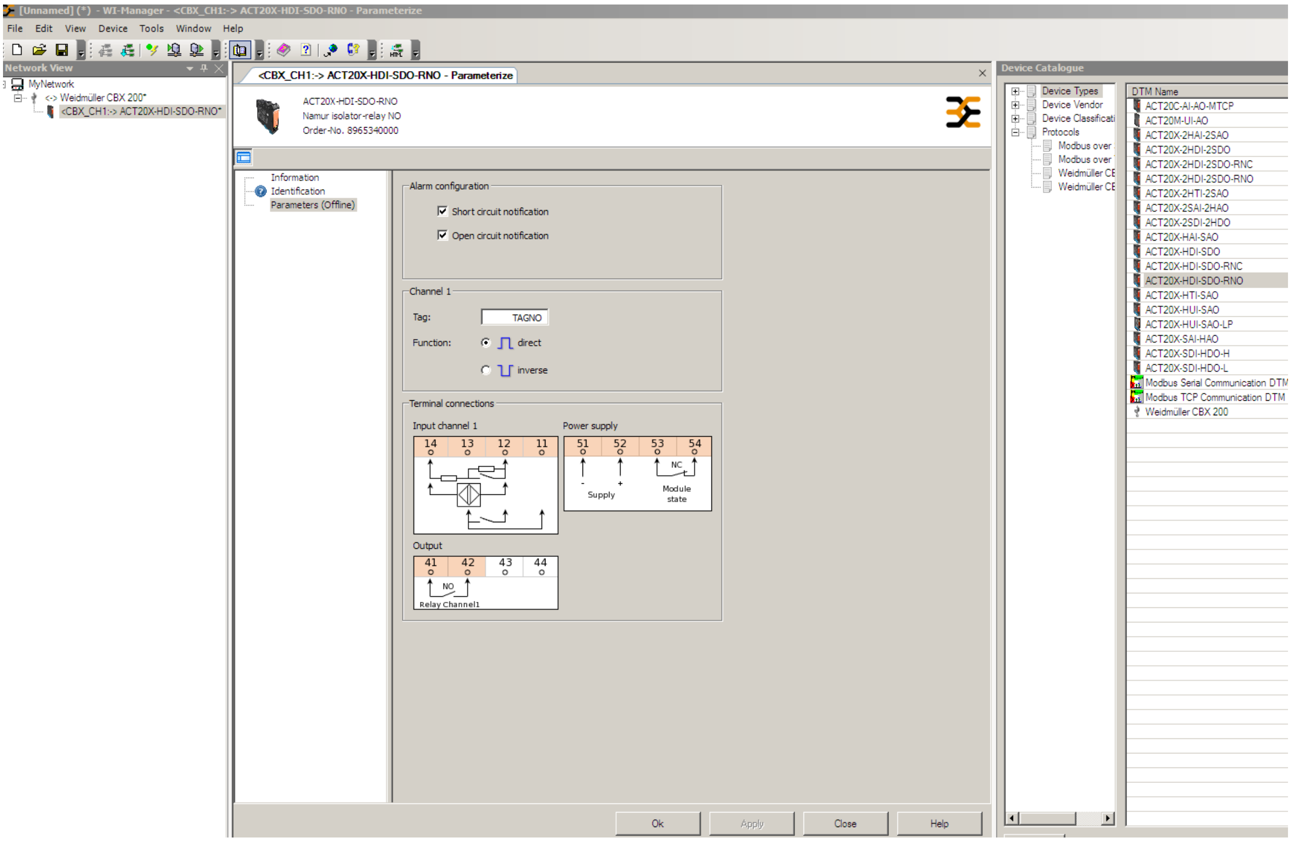


Figure 3: GUI DTM configuration (2) (example)

16. SIL concept for DTMs

16.1 Activate/deactivate safe parameterization

In online mode of the DTM the user can directly configure the device and / or the offline parameterization at the PC. For the SIL configuration the user shall shown "Change SIL state" in the additional functions of each DTM. The function is only available in online state and the hardware is verified, according Figure 4 "SIL configuration (example)".

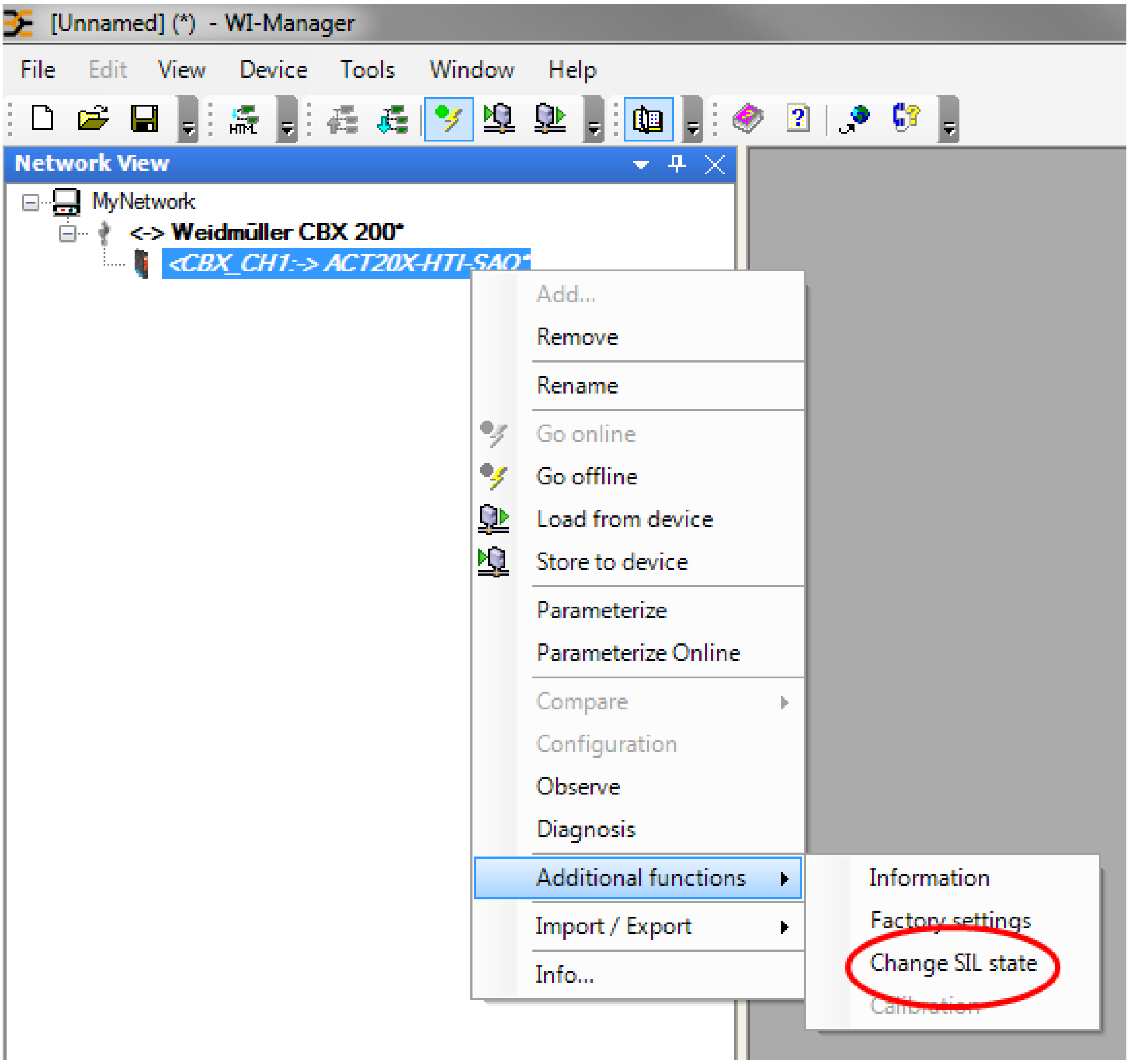


Figure 4 SIL configuration (example)

By activate the SIL configuration all other parameter views and functions are disabled (and closed) and vice versa, according to Table 1 "Function against SIL".

Functions against SIL		
Parameter	**SIL state: LOCK**	**SIL state: OPEN / FAIL**
Parameter Offline	Disabled	Enabled
Parameter Online	Disabled	Enabled
Upload	Enabled, execution follows an error message with reject the upload request	Enabled
Download	Enabled, execution follows an error message with reject the upload request	Enabled
Restore Factory Defaults	Disabled	Enabled
Additional Function – Text	Change SIL state	Change SIL state

Table 1 Function against SIL

By executing the SIL function the DTM request the SIL-state and the user has to enter the password. The SIL-state and the password (enable and password) are defined in open and lock, see Figure 5 "GUI SIL configuration (OPEN) (example)" and Figure 9 "GUI SIL configuration (LOCK) (example)".

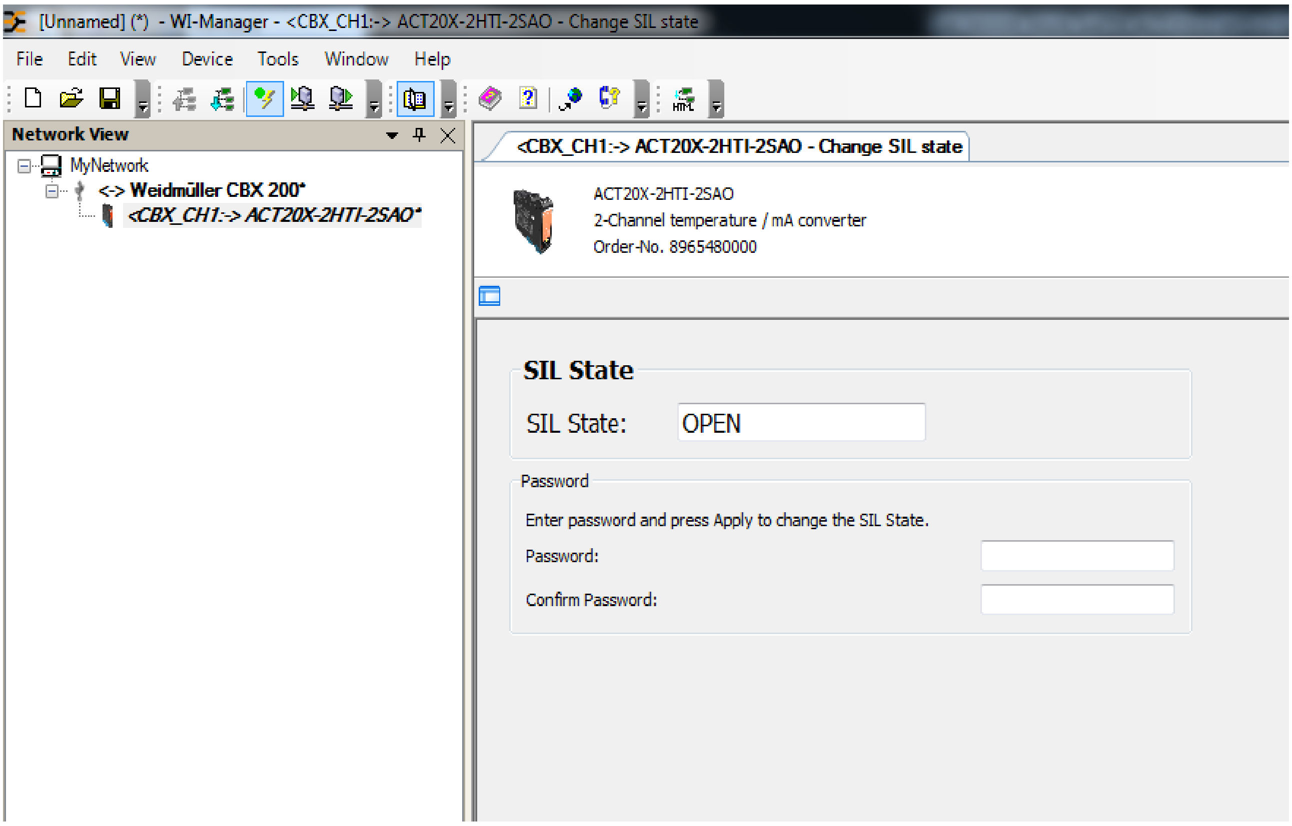


Figure 5: GUI SIL configuration (OPEN) (example)

To deactivate the SIL state the user has to enter the same password and confirm it to change the SIL state from locked to open.

If any configuration parameter is not valid for the SIL configuration (refer to chapter 16.5.1 "Safety-related configuration parameters" on page 33) the user will receive the message below. It is not possible to activate the SIL state (refer to chapter 16.1 "Activate/deactivate safe parameterization" on page 24). The parameters which are mentioned must be corrected according to chapter 16.5 "Safety-related configuration user responsibility" on page 33.

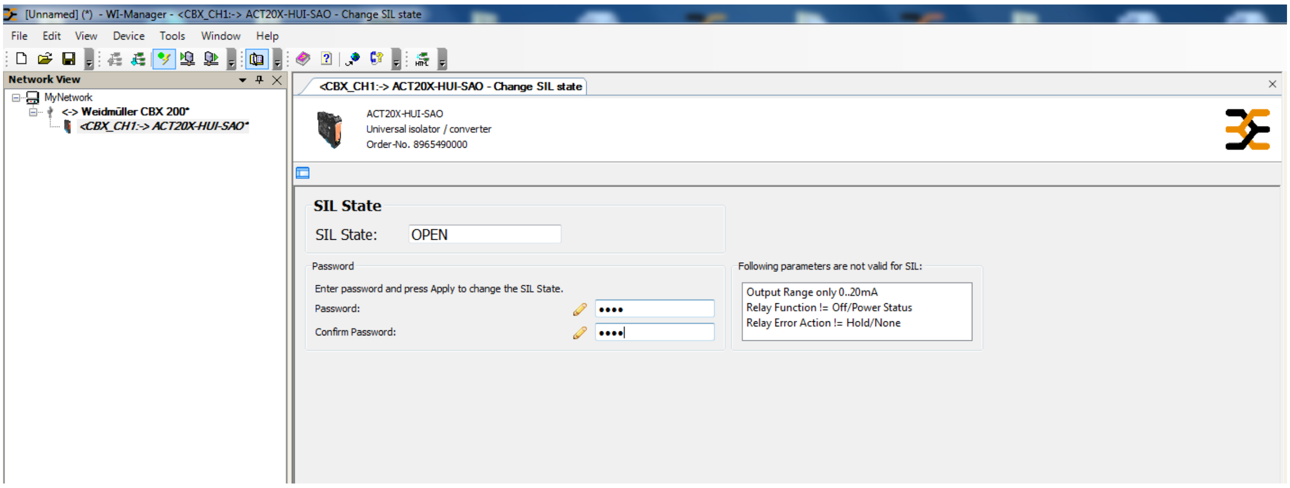


Figure 6: Valid configuration check (example)

16.2 Verification procedure

The configuration is re-load from the device and shown in a DTM GUI (Graphical User Interface). The user interface loaded the image (as image) with the loaded configuration in the same window. The user now sees a GUI with the configuration loaded from the device, the entered configuration (device parameters) and the stored image (written parameters) as a configuration and will be prompted to check the configuration.

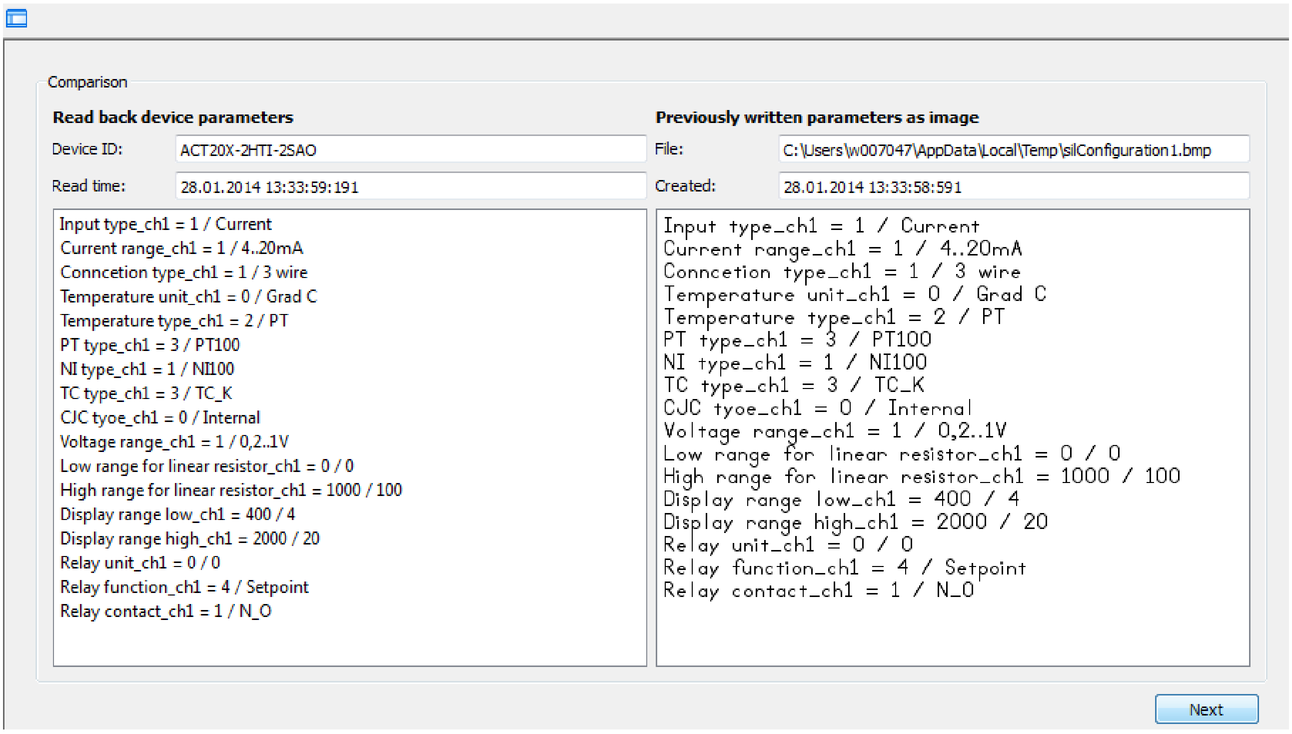


Figure 7: GUI SIL configuration – compare parameters (1)

The user must compare each parameter from the "read back device parameters" side with the "Previously written paramers as image". To accept the parameters the user must press the "Next" button. After that the next window with a parameter set will show and must accept by the user. If all parameters are compared by the user, the configuration software shows the screen below.

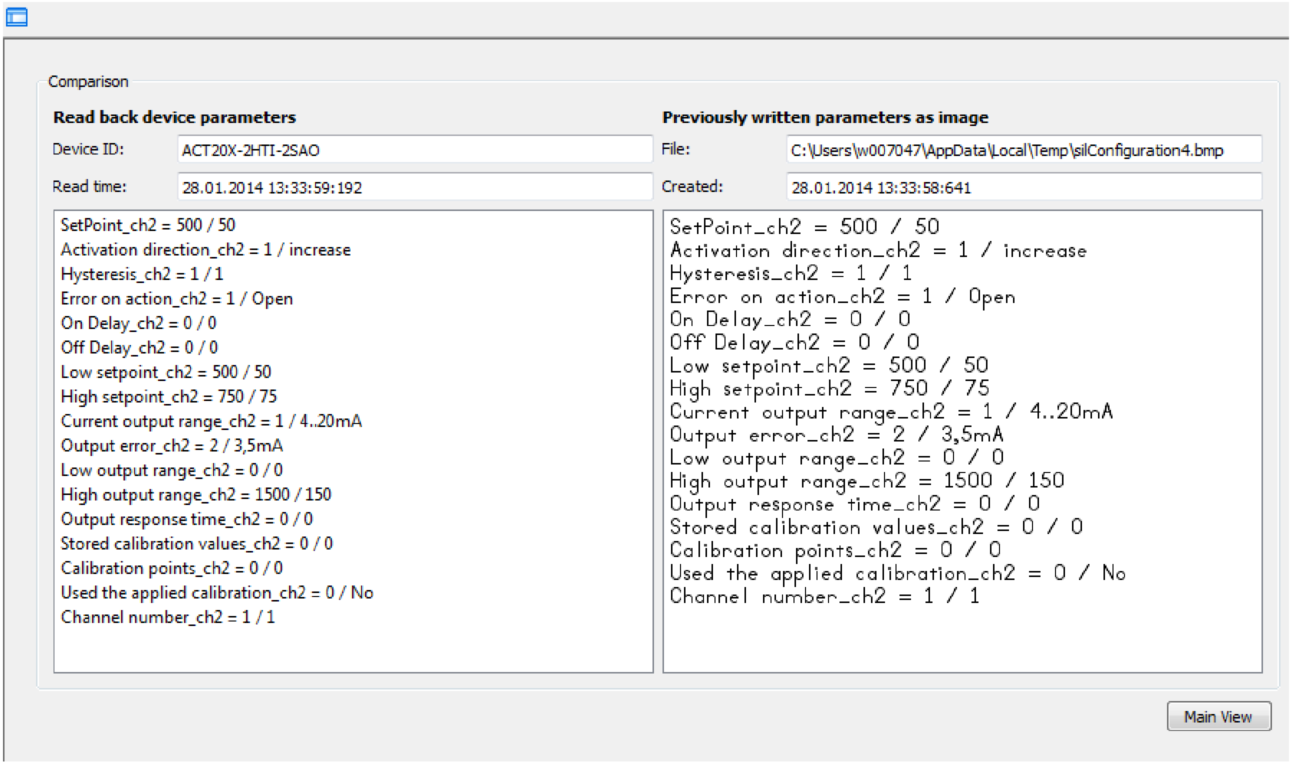


Figure 8: GUI SIL configuration – compare parameters (2)

After pressing the "Main View" Button the user can close the SIL configuration windows.

The GUI for SIL configuration is continues read the SIL state and shall shown the change from "OPEN" to "LOCK", see Figure 9 "GUI SIL configuration (LOCK) (example)". If the configuration is corrupted, then the devices rejected the configuration and change the state to "FAIL". After successful locking the configuration the user get a list of all parameter from the DTM and from the stored image file.

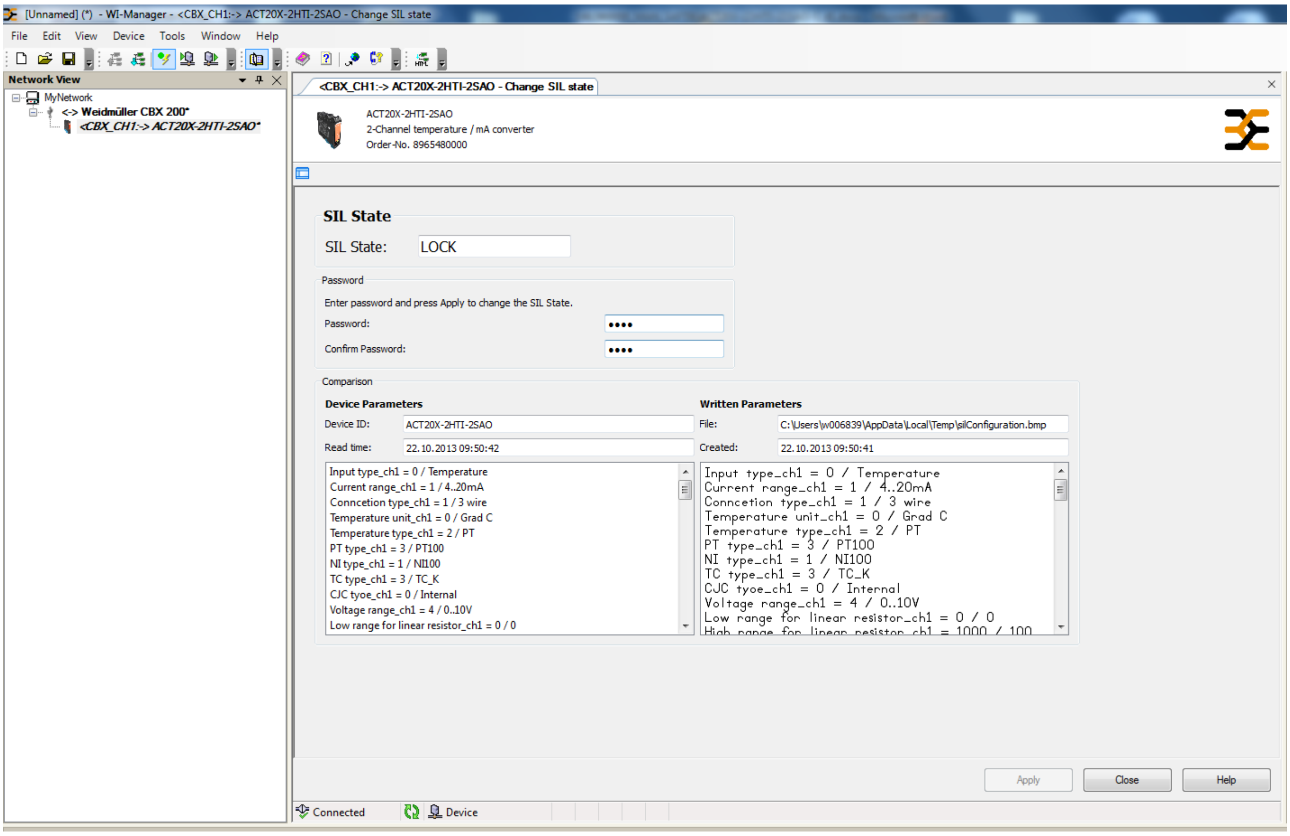


Figure 9: GUI SIL configuration (LOCK) (example)

If any parameter is found to be incorrect during verification deactivate the SIL state and go through the configuration menu and correct the parameter(s). After the correction, activate the SIL state by entering the password and confirm the password.

16.3 Configuration of a SIL active product

If the user would like to reconfigure a SIL activated product the software will show the message below.

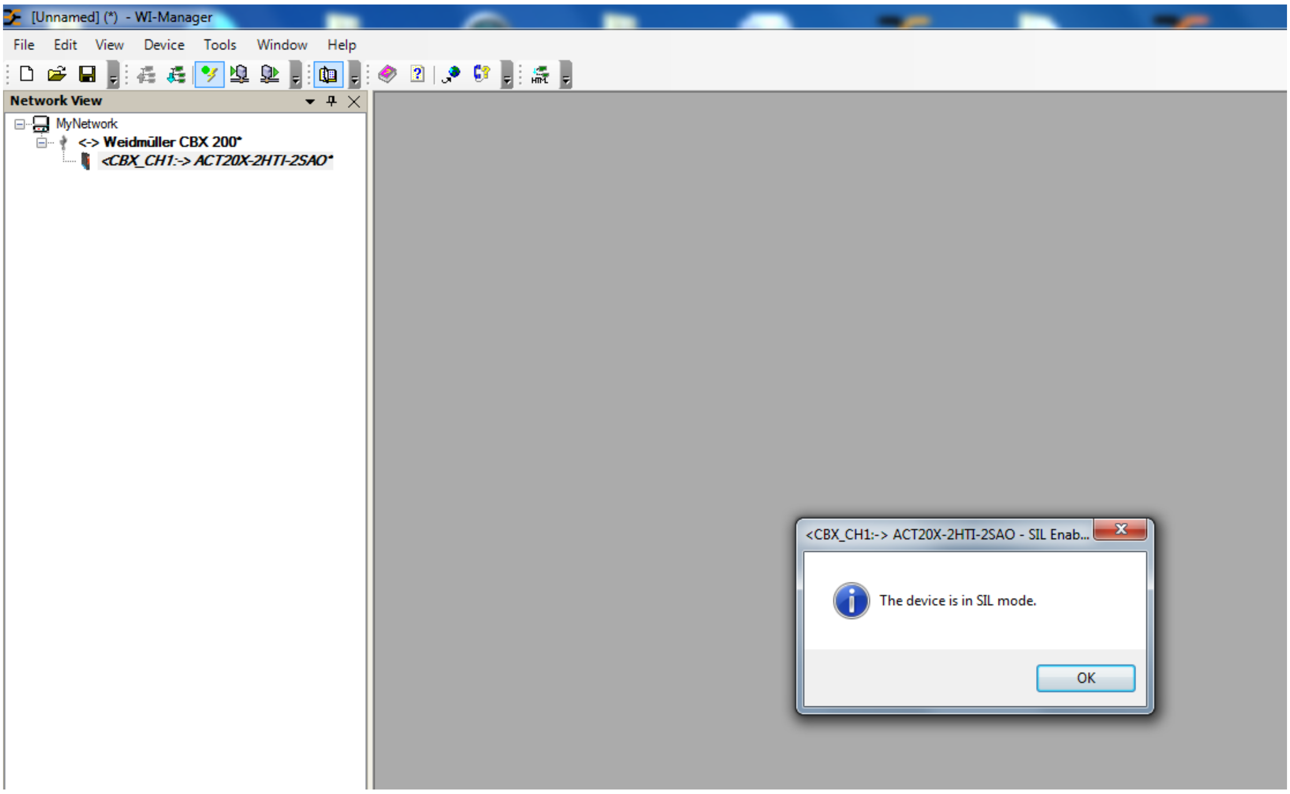


Figure 10: SIL active

To do a reconfiguration, the user needs to deactivate the SIL mode as described in chapter 16.1 "Activate/deactivate safe parameterization" on page 24. Then all parameters are available and can configure.

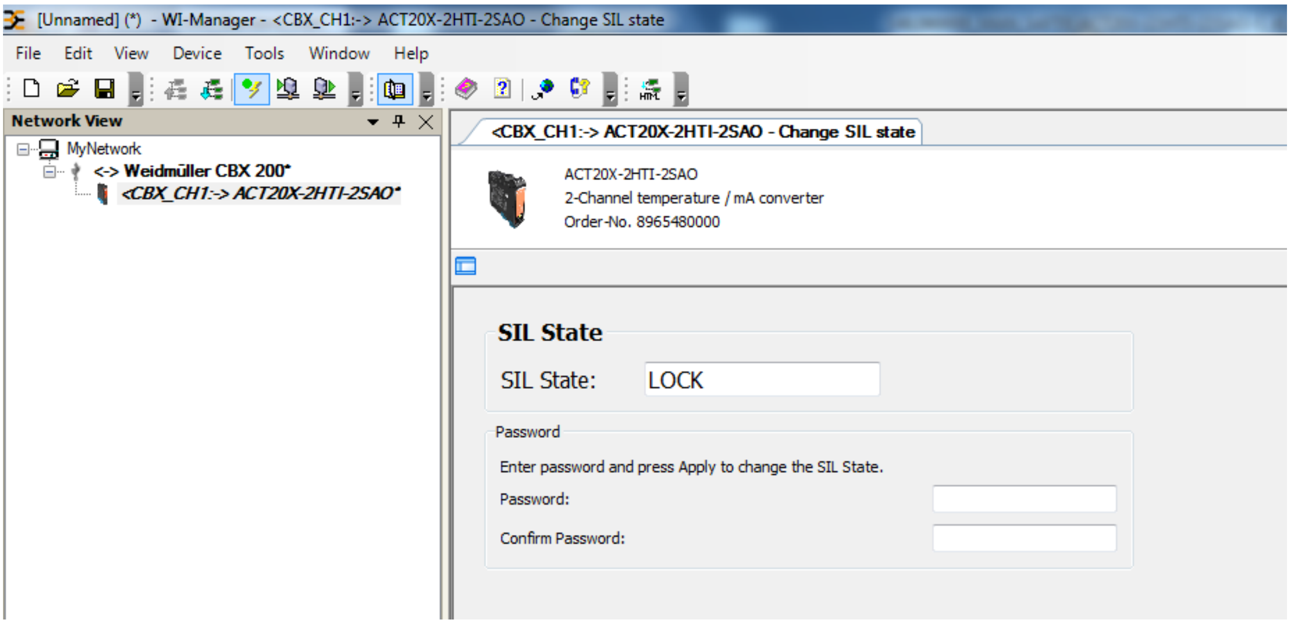


Figure 11: Locked SIL state after configuration

16.4 Changing SIL password

The user can change the SIL password in the SIL "OPEN" state, when the user type a new password and confirm it. The user can choose a password between 0000 and 9999 in order to protect the device against unauthorized modifications to the configuration. The device is delivered without password.

16.5 Safety-related configuration user responsibility

16.5.1 Safety-related configuration parameters (analogue input)

Input Tab	
Name	**Function**
Channel tag and type	**Selected input type:** Temperature Current Potentiometer Resistance Voltage
Input current	
Current range	**Selected fixed input range for current measurements (for channel tag and type = current):** 0...20 mA (no sensor error detection!) 4...20 mA
Input TC	
Temperatur sensor type	**Selected temperature sensor type (for channel tag and type = current):** TC = Thermocouple Ni = Ni RTD sensor Pt = Pt RTD sensor **Selectable PT sensor types (for channel tag and type = Pt):** Pt10 (no short circuit detection!) Pt20 (no short circuit detection!) Pt50 (no short circuit detection!) Pt100 Pt200 Pt250 Pt300 Pt400 Pt500 Pt1000 **Selectable Ni sensor types (for channel tag and type = Ni):** Ni50 Ni100 Ni120 Ni1000 **Selected sensor connection type for RTD measurements (for channel tag and type = Ni or Pt):** 2-wire 3-wire

	4-wire If 2-wire or 3-wire is selected, the end user must ensure that the applied sensor wiring does not introduce failures exceeding the requirements for the safety application. **Selectable TC sensor types (for channel tag and type = TC):** type B type E type J type K type L type N type R type S type T type U type W3 type W5 type Lr **CJC type for (for channel tag and type = TC):** Internal CJC = internal CJC sensor measurement External CJC = connector measurement (accessory)
Temperature unit	**Selected temperature unit (for channel tag and type = current):** Celsius Fahrenheit
Temperature limits	**Selected temperature unit (for channel tag and type = temperature)** Low = selected temperature value for 0 % output (for channel tag and type = temperature) for selected temperature unit (°C or °F). Range is defined by the selected temperature sensor (TC-, Ni- or Pt-type), but value must be less than high - minimum span. High = Selected temperature value for 100 % output (for channel tag and type = temperature) for selected temperature unit (°C or °F). Range is defined by the selected temperature sensor (TC-, Ni- or Pt-type), but must be larger than low + minimum span.
Input potentiometer	
Potentiometer	No configurable input value
Input resistance	
Resistance wire	**Selected sensor connection type for RTD measurements (for channel tag and type = resistance):** 2-wire 3-wire 4-wire If 2-wire or 3-wire is selected, the end user must ensure that the applied sensor wiring does not introduce failures exceeding the requirements for the safety application.

Resistance limits	**Selected resistance unit (for channel tag and type = resistance):** Low = selected resistance value for 0% output (for channel tag and type = resistance). Value must be less than high - minimum span. High = Selected resistance value for 100% output (for channel tag and type = resistance). Value must be larger than low + minimum span.
Input voltage	
Voltage range	**Selected fixed input range for voltage measurements (for channel tag and type = voltage):** 2...10V 0...10V 1...5V 0...5V 0.2...1V 0...1V

16.5.2 Safety-related configuration parameters (analogue output)

Output tab	
Name	**Function**
Range	**Fixed output range for current output:** Not valid when SIL is active (safety applications) 0...20 mA 20...0 mA Valid when SIL is active (safety applications) 4...20 mA 20...4 mA
Action on Error	**Fixed output value on detected sensor error:** No action (see note 1) = sensor error detection NOT enabled (see note 2), output at sensor error is undefined. The end user must ensure that the applied sensor including wiring has a failure rate qualifying it for the safety application without the detection enabled. Downscale (0 mA) = output is 0 mA at sensor error Downscale (3.5 mA) = output is 3.5 mA at sensor error (NE43 downscale) Upscale (23 mA) = output is 23 mA at sensor error (NE43 upscale)
Response time	**Analogue output response time in seconds:** Range is 0.0 to 60.0 s

Note 1: Value not allowed if analogue output is used in a safety application and "Channel tag and type" = current and loop supply is used to supply a current input signal.

Note 2: Error detection is enabled if "Error actions" for relays functions ≠ NONE, but analogue output value is undefined.

16.5.3 Safety-related configuration parameters (digital output)

Output tab	
Name	**Function**
Relay function	**Selected Relay function:** Permanently off (see note 1) = Relay is always OFF Power status (see note 1)= Relay is always ON if power is applied Sensor Error = Relay is activated when sensor error is present Controlled by window = Relay is activated when input signal is between "Relay set point low" and between "Relay set point high" value Controlled by set point = Relay is activated when input signal reaches "Relay set point" value
Relay delay	**Selected relay delay (for relay function = controlled by window or controlled by set point:** ON = Relay ON delay from "Relay setpoint" (Relay function = Controlled by setpoint) or "Relay setpoint low" or "Relay setpoint high" (Relay function = Controlled by window"). OFF = Relay OFF delay from "Relay setpoint" (Relay function = Controlled by setpoint) ± "Hysteresis" or "Relay setpoint low" or "Relay setpoint high" (Relay function = Controlled by window") ± "Hysteresis".
Controlled by setpoints ⟶ Hysteresis	**Selected set points (for channel tag and type = all selectable):** Hysteresis value for "Relay function" = "Controlled by window" or "Controlled by setpoint"
Controlled by setpoints ⟶ Error actions	**Selected "Error actions" for relays functions = "Sensor Error", "Controlled by set point" or "Controlled by window") for input "Channel tag and type" = Temperature, Current (Current range = 4...20mA), Potentiometer, Resistance (Resistance limits low ≥ 18 %):** None (see note 1) = Sensor error detection NOT enabled (see note 2) Open = Relay contact is open at sensor error Close = Relay contact is closed at sensor error Hold (see note 1) = Relay contact holds the state as before sensor error

	occurred. (NOT for "Relay function" = Sensor Error)
Controlled by setpoint	**Selected set point (for Channel tag and type = all selectable):** "Relay setpoint" value for "Relay function" = "Controlled by setpoint" Signal increase = Relay activates when signal ≤ "Relay setpoint" value Signal decrease = Relay activates when signal ≥ "Relay setpoint" value
Controlled by window	**Selected set point (for Channel tag and type = all selectable):** "Relay setpoint" value for "Relay function" = "Controlled by window" Relay setpoint low = Relay setpoint low" value for "Relay function" = "Controlled by window" Relay setpoint high = Relay setpoint high" value for "Relay function" = "Controlled by window"
Relay contact	**Selected Relay contact function (for Channel tag and type = all selectable):** For "Relay function" = "Controlled by setpoint" Relay contact NC = Normally close contact Relay contact NO = Normally open contact For "Relay function" = "Controlled by window" Relay contact NC = Relay contact closed inside Window Relay contact NO = Relay contact open inside Window

Note 1: Value is not allowed if the relay is used in a safety application and "Channel tag and type" = Current and loop supply is used to supply a current input signal.

Note 2: Error detection is enabled if "Action on Error" ≠ No action, but relay state at sensor error is undefined.

16.6 Functional test

The user is responsible to make a functional test after verification of the safety parameters. The procedure for periodic proof test, described in chapter 11 "Periodic proof test procedure" on page 18, shall be used.

17. Fault reaction and restart

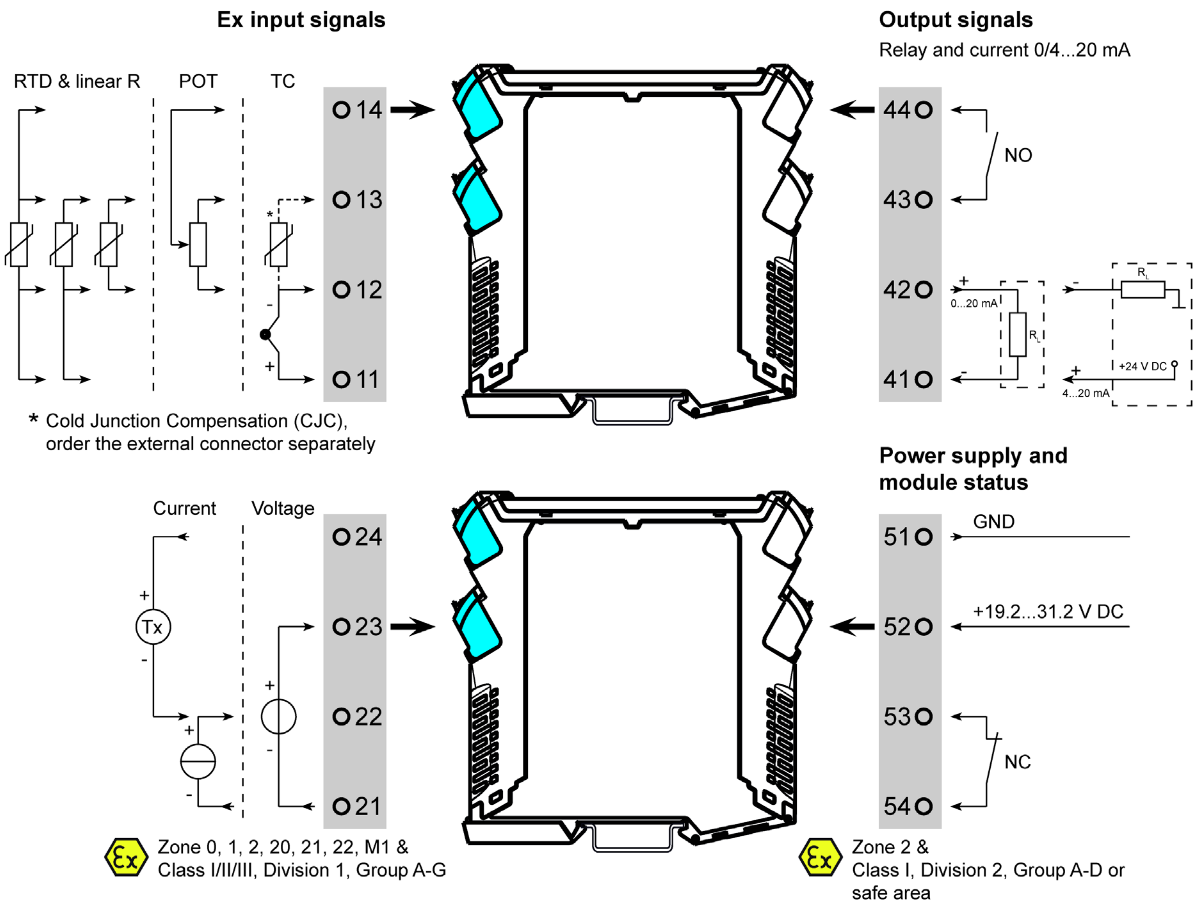
When the ACT20X-HUI-SAO detects a fault the output will go to Safe State, in which the output will go to "de-energised". If the fault is application-specific (cable error detection) the device will restart when the fault has been corrected.

For device faults there are 2 ways of bringing the module out of Safe State.

1. Power cycle the module.
2. Bring the module out of SIL mode (refer to chapter 16.1 "Activate/deactivate safe parameterization" on page 24).
3. Set it back to SIL mode again (refer to chapter 16.1 "Activate/deactivate safe parameterization" on page 24).

18. Connection diagram

18.1 Application



18.2 Electrical connections

Terminal	Function						Connector
	TC	RTD	POT	V	mA	mA Loop	
11	+	3W / 4W			+		Ex input channel 1
12	– / CJC	2W / 3W / 4W	M3		–		
13	CJC	2W / 3W / 4W	M1				
14		4W	M2				
21				–	–		Ex input channel 2
22					+	–	
23				+			
24						+	
41	Out –						output
42	Out +						
43	COM						output relay
44	NO						
51	GND						power supply
52	+24 V DC						
53	NC						status relay
54	COM						

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Order Number:
1482870000/03/11-2020