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USER GUIDE

# CoreSense

## Hydrogen and moisture sensor



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## CHAPTER 1

# Safety

To ensure personal safety and optimal performance, make sure you thoroughly read and understand the contents of this manual before installing or using the instrument.

This equipment intended for field installation by qualified service personnel according to manufacturer's installation instructions and local/national wiring requirements.

Users must comply with all safety indications (danger, warning, caution and notices) given in this manual.

## Symbol definitions

This document uses the following symbols to bring attention to key technical and safety-related information.



### **DANGER—SERIOUS DAMAGE TO HEALTH/RISK TO LIFE**

Indicates a hazardous situation that, if not avoided **will** result in death or serious injury.



### **WARNING—DAMAGE TO HEALTH/RISK TO LIFE**

Indicates a hazardous situation that, if not avoided **could** result in death or serious injury.



### **CAUTION—DAMAGE TO HEALTH**

Indicates a hazardous situation that, if not avoided, could result in **minor or moderate injury**.



### **NOTICE**

Indicates information considered important, but not hazard related, that could impact things *other than personal injury*, like property damage.



### **WARNING—HIGH VOLTAGE**

Indicates the presence of electrical energy at voltages high enough **to inflict harm on living organisms**.



### **LASER RADIATION**

Indicates the presence of a laser related hazard. It also indicates the type of laser in use, its wavelength and its safety class.



### SHARP EDGES

Indicates the presence of sharp edges that could cause personal injury if touched.



### HOT SURFACES

Indicates the presence of heat sufficient enough to cause burns.



### ELECTROSTATIC DISCHARGES

Indicates a device or part of a device that is susceptible to electrostatic discharges.



Identifies any terminal intended for connection to an external conductor for protection against electrical shock in case of a fault, or the terminal of a protective earth (ground) electrode.



Identifies protective earth conductor terminals.



Indicates the presence of direct current.

# General



## DANGER

Failing to comply with any of the instructions, precautions or warnings contained in this manual is in direct violation of the standards of design, manufacture, and intended use of the equipment.

ABB assumes no liability for the user's failure to comply with any of these safety requirements which may result in personal injuries and/or equipment damages.



## WARNING

Do not, under any circumstances, remove the warning and caution labels. Information must be available at all times for the security of the user.

Read this manual thoroughly before using this equipment. If you do not fully understand the information contained in this manual or if the equipment shows any sign of damage, please contact ABB. Refer to the back cover of this manual for contact information.

If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

# Electrical

The CoreSense is an overvoltage category II instrument.

Use only fuse(s) specified as appropriate for this equipment (see "Technical specifications" on page A57.)

In accordance with international safety standards, the sensor uses a three-wire power cord typically connected to an electrical panel that provides grounding for the sensor chassis.



## DANGER

Disconnect power at the distribution panel circuit breaker before opening the sensor.

Ensure that the equipment and all devices or power cords connected to the sensor are properly grounded. Make sure that the sensor ground is at the same potential as the transformer ground.

Protective earthing connection (grounding) must be active at all times.

The absence of grounding can lead to a potential shock hazard that could result in serious personnel injury. If an interruption of the protective earthing is suspected, cut the power to the sensor at the plant's distribution panel and have the electrical circuit tested.



## DANGER

An external circuit breaker with a maximum rating of 15 amps must be installed on the AC source and labeled accordingly, in compliance with your country's national electrical code.

In accordance with IEC61010-1 edition 3.0, to prevent contamination of the electronics by outside elements, the sensor cover shall be removed only under controlled environmental conditions defined as:

- Temperature shall be between 5 °C and 40 °C
- Maximum relative humidity shall be 80% for temperatures up to 31 °C, decreasing linearly to 50% relative humidity at 40 °C.

Do not expose the interior of the sensor to rain or snow.

For configuration purposes, the sensor can be powered when empty, **but the thermal pump must be turned off** (this can be done in the web interface in Settings/administration settings). To prevent accidents, the CoreSense is delivered with the thermal pump turned off.

When the installation is complete and the sensor is in contact with oil, make sure the thermal pump is enabled in the web interface.



#### NOTICE

Operating the heater in air will result in failure of the thermal pump.

## Handling

The CoreSense hydrogen and moisture sensor weighs approximately 8 kg. To avoid personal injuries, make sure to use proper body mechanics (bend your knees) when lifting the sensor.



#### WARNING

Do not grab the sensor by the threaded NPT interface. The threaded edges are sharp and there is a risk of personal injury.



#### WARNING

- During operation, the NPT port interface becomes **hot**. Avoid touching the surface of the adapter.
- The sensor contains an internal heater. Thus, some parts of the sensor may be hot when powered, i.e. all parts that contain hot oil. **Always manipulate the sensor with caution.**



CHAPTER 1

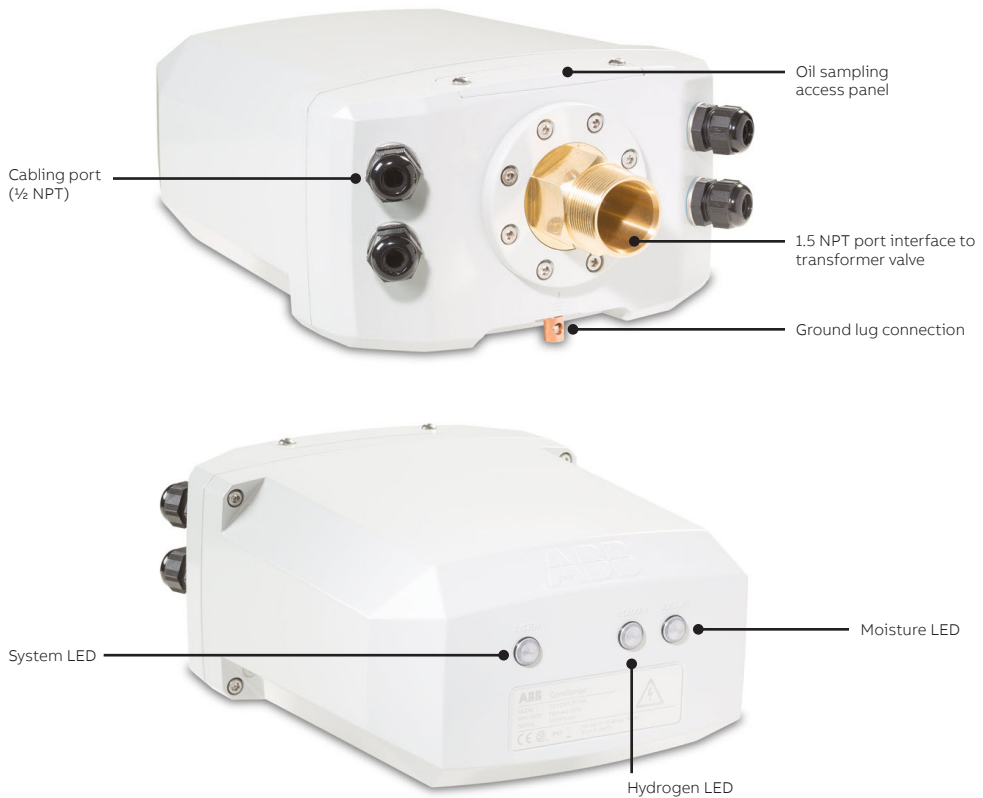
# Introducing the CoreSense

The CoreSense continuously monitors hydrogen and moisture levels in oil and alerts the user when either one starts increasing beyond a predefined threshold. Real-time monitoring complements periodic off-line dissolved gas analysis (DGA) by alerting the user much sooner to evolving conditions.

The CoreSense can be mounted at multiple locations on the transformer including on the drain valve because it uses a heating element to induce forced convection and ensure that fresh representative oil is always reaching the solid state sensing elements.

The CoreSense user interface is designed as a series of simple web pages that can be accessed through most web browsers. The web interface allows viewing of the current CoreSense status and settings.

**Figure 1** CoreSense sensor head



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## CHAPTER 2

# Preparing for installation

This chapter provides information relevant to the steps that should be performed prior to installing the CoreSense sensor.

## Tools for installation

Here are the various tools necessary to install the CoreSense system.

### Tools supplied by ABB

4 mm Allen key



5 mm Allen key



### Spare Parts

O-ring no 1 (sensor enclosure)	Buna-N O-ring no: AS568A DASH NUMBER 269, A50 durometer
O-ring no 2 (sensor brass fitting) already installed on sensor	Metric Buna-N O-ring 3 mm width, 50 mm inside diameter
Plugs	To cover unused cable gland ports
Bleeding hose (ID 1/8 in.)	For sampling

### Additional tools (not supplied by ABB)

Laptop with Internet Explorer 9 or above (for sensor commissioning)



Straight Ethernet cable (for sensor commissioning)



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2 in wrench or adjustable wrench (50.8 mm)



8 mm wrench or adjustable wrench (0.31 in)

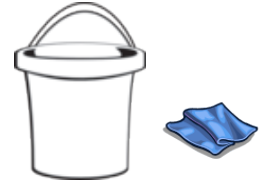


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Roll of PTFE tape

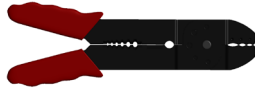


Bucket and rags



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Wire stripper



Wire cutter

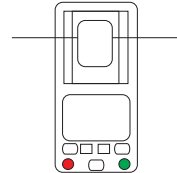


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Flat head screwdriver



Optical termination equipment if installing the optional optical Ethernet port



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Torque wrench



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Transformer valve adapter (when applicable).

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## Necessary protection equipment

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Safety shoes



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Gloves



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Protective glasses



# Unpacking

The sensor is supplied in a cardboard box with internal shock absorbing packaging. Always transport the sensor in the packaging supplied to minimize the risk of damage.

# Handling

The product is designed to withstand many industrial environmental conditions. However, a few handling precautions will ensure reliable operation of the unit for years to come:

- DO NOT DROP the sensor.
- It is not recommended to open the CoreSense if it is raining or snowing.
- Always turn off power at the electrical panel before doing any installation or adjustment.
- Do not expose the sensor internal electronics to any liquids or dirt.
- Ensure that the cable glands are tight after connection and that all 4 cable glands contain a cable.
- Make sure the cover is well secured with the supplied O-ring once connections inside the sensor have been completed (see "Removing the cover" on page 22).



## NOTICE

While the initial (cold start) accuracy of the sensor is likely to be within specifications, a settling period of approximately 12 hours is strongly recommended to allow the electronic components to fully warm up and the internal temperature to stabilize.

# Siting on the transformer

On the transformer, several mounting locations may be available for installing the sensor. Care should be taken to select a mounting location where the sensor will be exposed to maximal oil flow and minimal oil temperature. The following table and Figure 2 can be used to help select the best location.

**Table 1** Typical instrument locations

Location	Benefits	Issues
(A) Radiator return	<ul style="list-style-type: none"> <li>• Good oil flow</li> <li>• Low operating temperature</li> <li>• Easy access</li> <li>• Installation without outage</li> </ul>	<ul style="list-style-type: none"> <li>• Good connection flange not always present</li> <li>• Physical constraints may require complex curved tubing</li> </ul>
(B) Drain valve	<ul style="list-style-type: none"> <li>• Low operating temperature</li> <li>• Easy access</li> <li>• Always present</li> <li>• Installation without outage</li> </ul>	<ul style="list-style-type: none"> <li>• Often connected to a baffle or downward pointing tube inside the tank (in which case it cannot be used)</li> <li>• Sometimes connected to a globe valve (in which case it cannot be used)</li> <li>• Low oil flow could increase reaction time</li> <li>• Sludge can accumulate at this location</li> </ul>
(C) Top tank fill valve	<ul style="list-style-type: none"> <li>• Good oil flow (from thermal convection)</li> <li>• Often present</li> <li>• Never connected to a baffle or downward pointing tube</li> </ul>	<ul style="list-style-type: none"> <li>• Temperature may exceed 100 °C (212 °F)</li> <li>• Difficult access; installation requires working at heights</li> <li>• Installation may require outage</li> </ul>
(D) Radiator inlet	<ul style="list-style-type: none"> <li>• Good oil flow</li> </ul>	<ul style="list-style-type: none"> <li>• Temperature may exceed 100 °C (212 °F)</li> <li>• Difficult access; installation requires working at heights</li> <li>• Good connection flange rarely present</li> <li>• Installation may require outage</li> </ul>

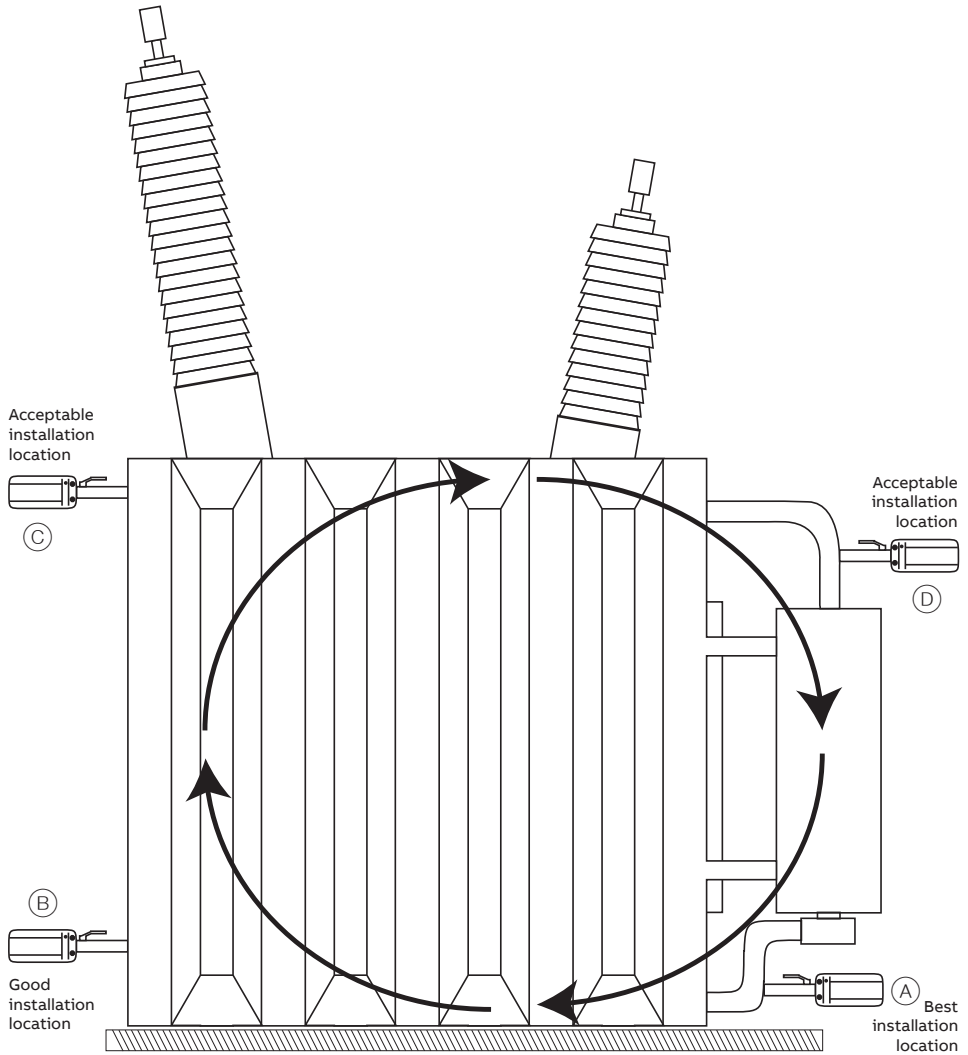


## NOTICE

Valves not providing linear flow are to be avoided (e.g., globe valves). Valves providing linear flow are preferred (e.g., gate, ball and butterfly valves).

When in doubt for any other type of valve, contact Transformer support.

**Figure 2** Recommended installation locations



# Planning your cabling

Select cabling according to your communication needs. Refer to the table below for recommended cable gauge or cable type.

Always comply with national codes and electrical standards.

**Table 2** Recommended cable gauge and type

Cable	Gauge/Type	Maximum length
Power	12 AWG	15 m (50 ft)
	14 AWG	10 m (33 ft)
Ground	10 or 6 AWG	15 m (50 ft)
RS-485	24 AWG	1220 m (4003 ft)
Alarm relays	16 or 14 AWG	N/A
4–20 mA	18 AWG	N/A
Ethernet (SCADA)	Category 5 cable	100 m (328 ft)
Ethernet (SERVICE)	Category 5 cable	3 m (10 ft)
Ethernet (optical)	ST-ST Plenum Duplex 62.5/125 Multi-mode fiber	2000 m (6562 ft)
USB (service port)	USB key only	N/A



## WARNING

To maintain the sensor IP67 rating, all cables must have a diameter of 10 to 14 mm when used with the supplied cable glands. All four cable glands must contain a cable. If necessary, tape can be used to adjust for the minimum required diameter. Failure to comply may result in water infiltration and the presence of electrical shock hazards.

# Planning your communications

The digital protocols supported by the sensor are Modbus, DNP3, and IEC 61850. Modbus and DNP3 are available on the RS-485 serial interface, the Ethernet SCADA port or the optical Ethernet port. IEC 61850 is available on the Ethernet SCADA port or the optical Ethernet port.

Table 3 below shows the default RS-485 serial configuration. These default values can be modified at any time using the built-in web interface.

**Table 3** Default RS-485 configuration

Baud rate	9600
Data bit	8
Stop bits	1
Parity	None
Flow control	None

When using Modbus, the default slave ID is 1, and when using the DNP3, the default outstation ID is 4.



**Table 4** Summary of communication parameters

Port	Default communication setup		Setting options from web page (see x-ref)		Protocol
RS-485	Baud rate	9600	Baud rate	110; 300; 600; 1200; 2400; 4800; 9600; 19200; 38400; 57600; 115200; 230400; 576000; 921600; 11520000	Modbus (point to point only): default slave ID = 1 Default DNP3 outstation ID = 4
	Data bit	8	Data bit	7; 8	
	Stop bit	1	Stop bit	1; 2	
	Parity	None	Parity	None; Even; Odd	
	Flow control	None	Flow control	None	
Ethernet (SCADA)			Static IP; DHCP client Administrator settings on SCADA port can be enabled or disabled using the web interface.	<b>Web http port</b> 80/tcp <b>Modbus TCP port</b> 502/tcp <b>DNP3 port</b> 20000/tcp <b>IEC61850 MMS port</b> 102/tcp	
Ethernet (optical)	DHCP client		When the fiber optic port is in use, the Ethernet SCADA port must not be used.		
Ethernet (SERVICE)	DHCP server Default IP address range 172.16.100.x for PC Default IP address for CoreSense 172.16.100.1		Static IP; DHCP server. ABB remote access can be enabled or disabled using the web interface.		



**NOTICE**

For best results it is recommended to configure the Modbus or DNP3 master with a timeout of 10000 ms and 5 retries.

Minimum delay between polls shall be at least 100 ms.

The DNP3 cold restart function is not supported for cybersecurity reasons.



**NOTICE**

**Do not** connect your internal network to the SERVICE port.



## NOTICE – CYBERSECURITY

This product is designed to be connected to and to communicate information and data via a network interface. It is the user's sole responsibility to provide and continuously ensure a secure connection between the product and the user network or any other network (as the case may be). Users shall establish and maintain any and all appropriate measures (such as, but not limited to, the installation of firewalls, application of authentication measures, encryption of data, installation of anti-virus programs, etc.) to protect the product, the network, its system, and the interface against any kind of security breaches, unauthorized access, interference, intrusion, leakage and/or theft of data or information. ABB Inc. and its affiliates are not liable for damages and/or losses related to such security breaches, any unauthorized access, interference, intrusion, leakage and/or theft of data or information.

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<http://new.abb.com/about/technology/cyber-security>

Information about your product is also available on the product page:

<http://new.abb.com/products/transformers/service/advanced-services/coresense>

If you are planning on connecting to the Ethernet port or the optional optical Ethernet port, contact your network administrator to confirm the network settings and check that the service ports described in the table below are accessible. The SCADA Ethernet port and the optional optical Ethernet port are configured at the factory as DHCP clients. Ethernet ports may also be configured with static IP settings.

The **service** Ethernet port is configured as a DHCP server and will automatically assign an IP address to your laptop/PC in the 172.16.100.x range. The default server address on the **service** port is 172.16.100.1.

**Table 5** Application TCP ports

Application	Port
Web interface	80/tcp
IEC61850 MMS	102/tcp
Modbus TCP	502/tcp
DNP3	20000/tcp
ABB diagnostic port	22/tcp
DHCP	67/udp & 68/udp



## NOTICE

The ABB TCP diagnostic port can be enabled and disabled using the web interface.



## NOTICE

**Do not** connect your internal network to the SERVICE port.

# Password protection

The sensor is secured by a password for the operator role and a password for the administrator role. For cybersecurity reasons, it is absolutely **mandatory** to change the default password. Not doing so could expose your entire network to cyberattacks.

Passwords should comply with your company's policies and meet minimal complexity requirements to avoid security breaches.

**Table 6** Default passwords

User role	Default password
Acknowledge	Ack
Administrator	Admin

Default passwords can be modified using the web interface.



# Installing the sensor head

This chapter explains the various steps necessary to physically install the CoreSense on the transformer.



## NOTICE

In accordance with IEC61010-1 edition 3.0, to prevent contamination of the electronics by outside elements the sensor cover shall be removed only under controlled environmental conditions defined as:

**Temperature shall be** 5 °C to 40 °C.

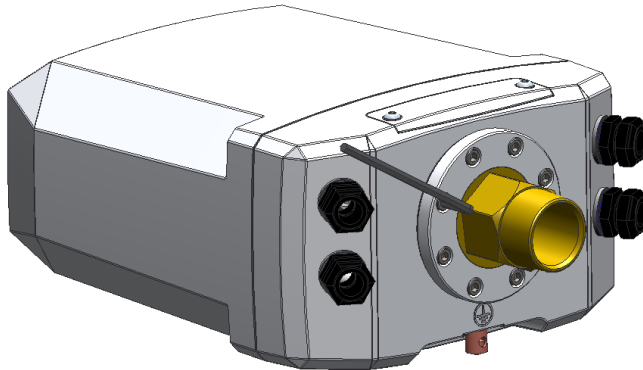
**Maximum relative humidity** 80% for temperatures up to 31 °C, decreasing linearly to 50% relative humidity at 40 °C.

Do not expose the interior of the sensor to rain or snow.

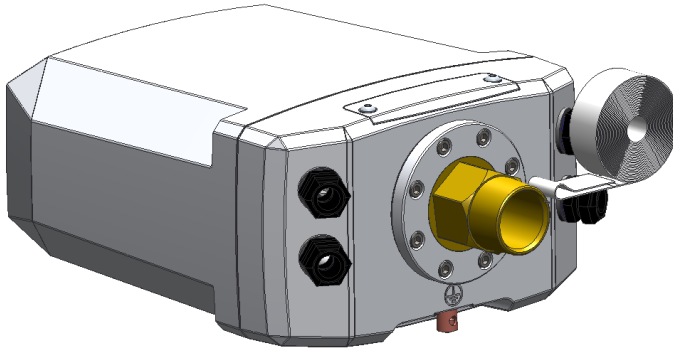
## Installation on transformer valve

The sensor is designed to be installed on a 1.5 NPT transformer valve, as explained below:

- 1 Loosen the eight rotating flange screws with the 5 mm Allen key.



- 2 Wrap the sensor male fitting thread with PTFE tape.

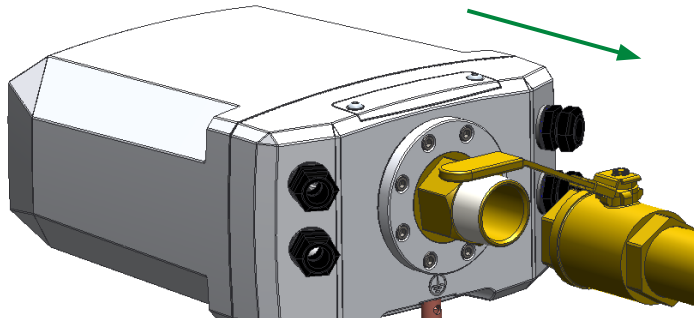


- 3 Install the sensor on the transformer valve. An optional adapter can be used if the valve fitting is not 1.5 in. (e.g., most North American fittings are 2 in.).

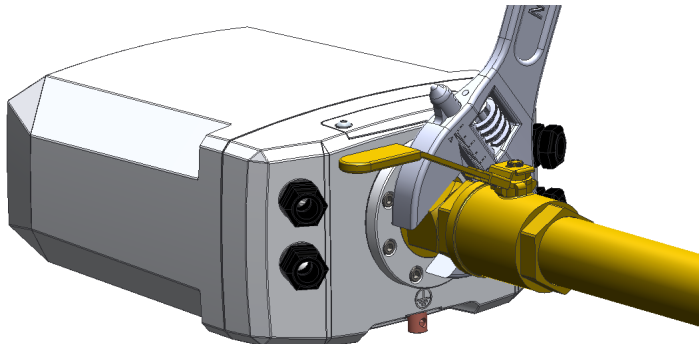


**WARNING**

During operation, the NPT port interface becomes hot. **Avoid touching the surface of the adapter.**



- 4 Tighten with a 2 in. (50.8 mm) wrench or use an adjustable wrench.

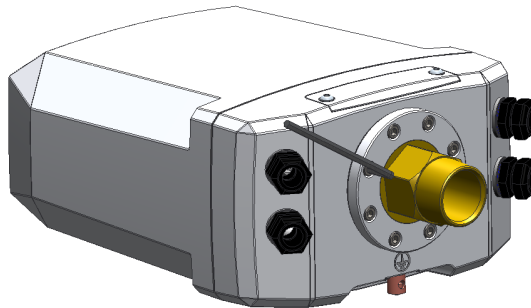
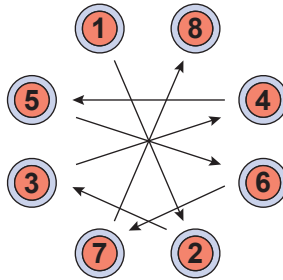


- Once fully tightened, make sure that the sensor is in horizontal position with the sampling access panel pointing upwards. Rotate the sensor as required to achieve this.

**NOTICE**

Failure to position the CoreSense horizontally, with the access panel pointing upwards, will cause the thermal pump to malfunction and may result in erroneous readings.

- With the 5 mm Allen key, tighten the rotating flange nuts to a torque of 8.1 N-m (6.0 lb-ft) according to the following tightening pattern.



Start running in all the bolts or nuts a few threads and then run them hand-tight. Tighten by hand, then according to the torque specification.

**NOTICE**

**Do not over tighten.**

# Bleeding the sensor





## NOTICE

The instrument is delivered with the bleeding valve open, as indicated by the sticker located near the sampling port cover. Should no oil come out of the bleeding port during step 3 on page 19, use the provided Allen key to open the valve.

**ABB**

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 **SAFETY WARNING** 

**Sensor's bleeding valve is OPEN upon delivery**

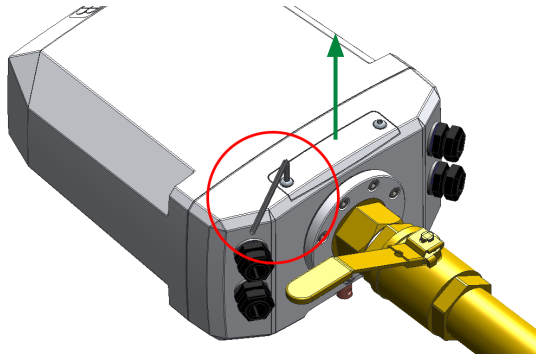
Air bubbles in the tank of an energized transformer pose a serious safety risk. In order to prevent air bubbles entering the transformer during installation:

- 1 Ensure the bleeding port is open **BEFORE** opening the transformer valve. Close the bleeding port only after all air in the transformer valve has been properly purged.
- 2 Ensure the transformer has a positive gauge pressure before opening the transformer valve. Never open the valve of a transformer with negative gauge pressure while the transformer is energized.

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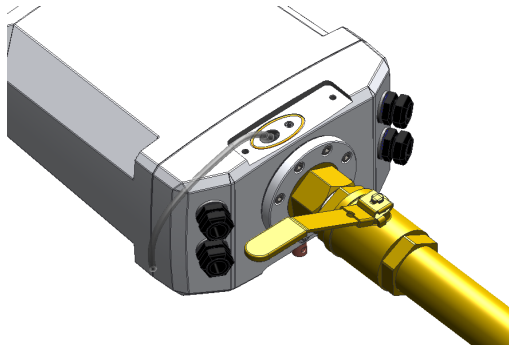
You must bleed the sensor to make sure that no air is present in the system:

- 1 With the 4 mm Allen key, remove the external sampling port cover located on top of the sensor.

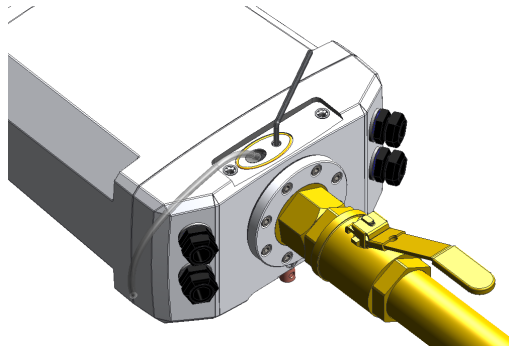




- 2 Connect the sampling adapter to your bucket (for oil collection) with a bleeding hose (ID 1/8 in.).



- 3 Slowly open the transformer valve and wait until oil comes out of the sensor.

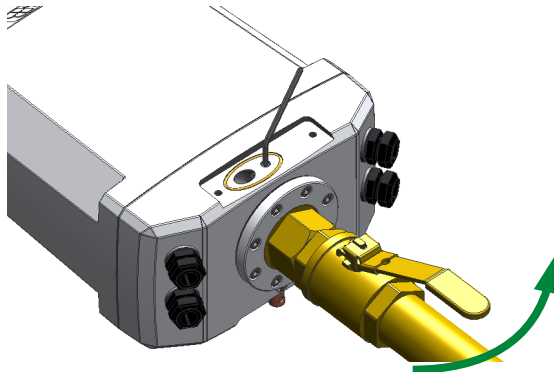


- 4 Tighten the bleed screw to a maximum torque of 2.26 N·m (20 lbf.in).



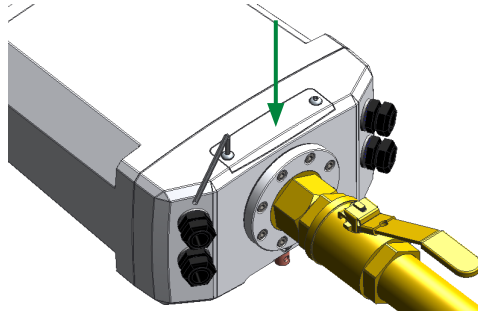
**NOTICE**

Do not exceed the recommended torque as this may permanently damage the instrument.



- 5 Wipe excess oil with a clean cloth.

- 6 Re-install the external sampling port cover and secure with the 4 mm Allen key.



For configuration purposes, the sensor can be powered when empty, **but the thermal pump must be turned off** (this can be done in the web interface in Settings/administration settings). To prevent accidents, the CoreSense is delivered with the thermal pump turned off.

When the installation is complete and the sensor is in contact with oil, make sure the thermal pump is enabled in the web interface.



#### NOTICE

Operating the heater in air will result in failure of the thermal pump.

## Removing the cover



#### WARNING

Disconnect power from the distribution panel prior to removing the cover.

- 1 Unscrew the retaining screws from the enclosure cover with the 5 mm Allen key.



- 2 Remove the enclosure cover.
- 3 Discard the used O-ring, if necessary.

# Establishing the connections



## WARNING

Make sure to comply with the national electrical standards.

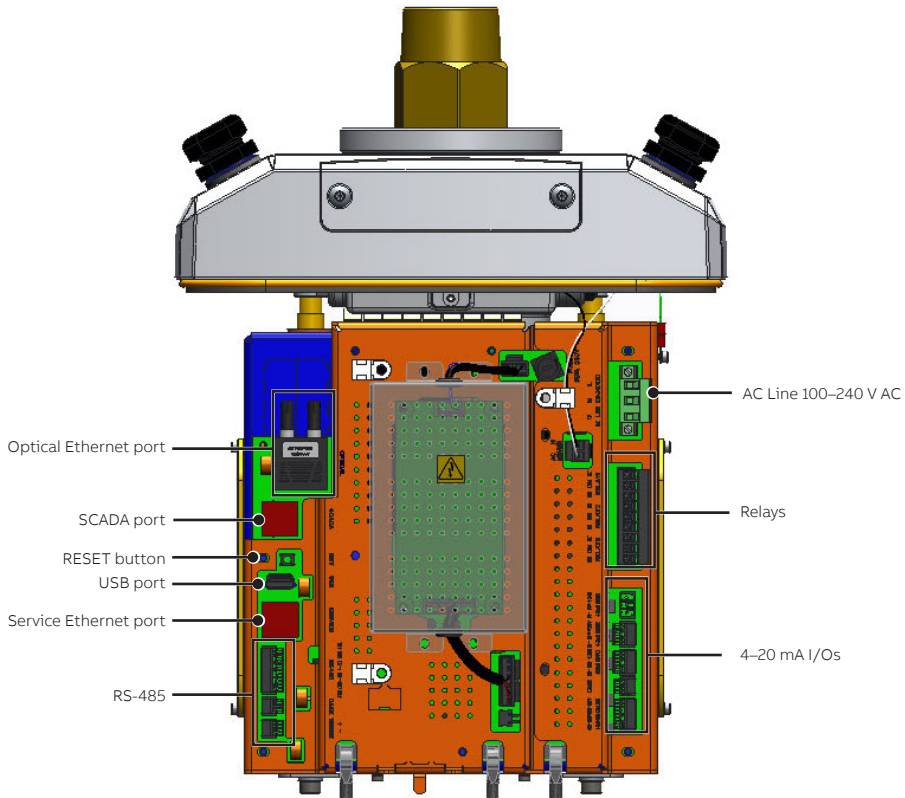
Disconnect power at the electrical distribution panel prior to performing any adjustment (connections) on the sensor.

The sensor is equipped with four ports for cabling. Make sure the power cables (line voltage) and all other cables are routed separately in a dedicated cable port through a proper cable gland (i.e., there must never be more than one multi-strand cable through any of the cable glands). Putting two cables through a cable gland invalidates the IP67 protection, allows water ingress and creates an electrical hazard.

Prior to establishing connections inside the CoreSense sensor:

- 1 Make sure to ground the CoreSense, either by means of the three-wire cable on the internal ground wire of the power cable or with a separate cable to the external ground lug.
- 2 Install on the sensor the required watertight cabling.

**Figure 3** CoreSense port and relay connections



## AC power line terminal block

The CoreSense is an overvoltage category II instrument.

The AC voltage must be between 100 V and 240 V (single phase) and have a minimum capacity of 1 A.

The frequency must be between 50 Hz and 60 Hz.

The AC power must be supplied through a 12 AWG cable of at most 15 m (50 ft.) or a 14 AWG cable of at most 10 m (33 ft.) with an overcurrent protection (see “Planning your cabling” on page 12).



### WARNING

An external circuit breaker with a rating of 15 amps must be installed on the AC source and labeled accordingly, in accordance with your country’s national electrical code.



### NOTICE

For configuration purposes, the sensor can be powered when it does not contain any oil. However, **the thermal pump must be turned off** (this can be done in the web interface [in Settings/administration settings]).

The CoreSense is delivered with the thermal pump turned off to avoid accidents.

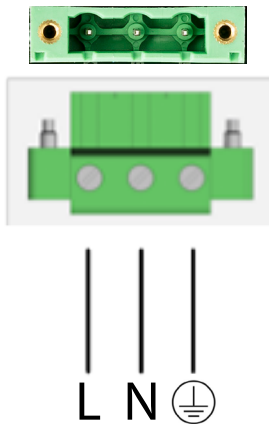
**Operating the heater in air will result in failure of the thermal pump.**

The cable glands must be torqued to 3.6 N·m to ensure safe installation.

Make sure the power cord is properly secured.

When the installation is complete and the sensor is in contact with oil, make sure that the thermal pump is enabled in the web interface.

**Figure 4** AC power line terminal block



## RS-485 to SCADA

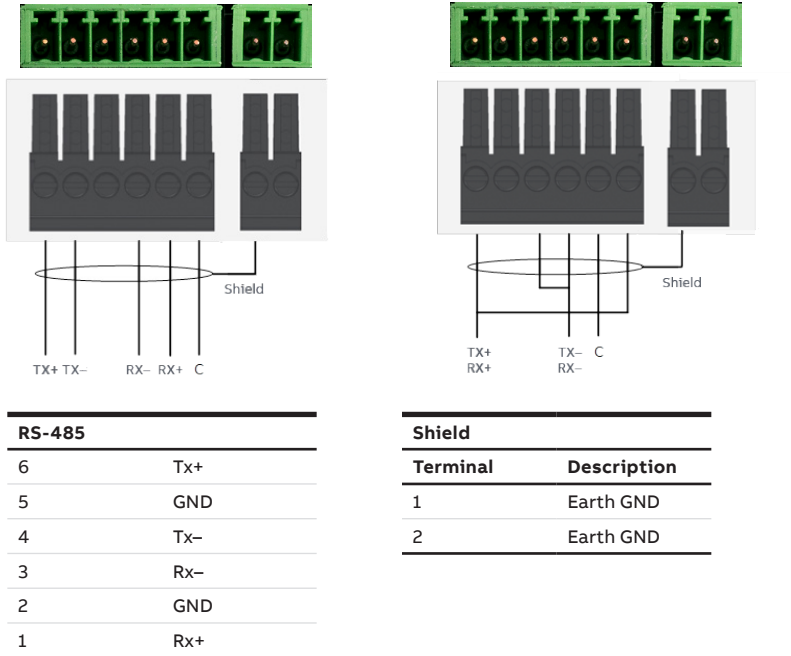
The RS-485 can be used in full- or half-duplex mode (see Figure 5 and Figure 6 on page 27). All signals on RS-485 (J18) are isolated.



### NOTICE

Use only shielded cable for wiring the RS-485 interface.

**Figure 5** RS-485 wiring details (left: full duplex mode, right: half-duplex mode)



The RS-485 interface is intended to be used in point-to-point mode. There is no need to add a 120  $\Omega$  termination on the receiver (Rx); the resistor is present on board. The transmitter (Tx) must be terminated at the other end.

Other RS-485 topologies are not supported.

## Ethernet to SCADA

ABB recommends a **Cat5** Ethernet cable. Its maximum length must not exceed 100 m.

## Optical Ethernet to SCADA

Use 62.5/125  $\mu\text{m}$  or 50/125  $\mu\text{m}$  multimode optical fibers to connect to the 100Base-FX optical Ethernet interface on the sensor. Before connecting the optical transceiver, see Appendix A of this manual for more information on the optical characteristics. Make sure optical power levels and wavelength are within the specified range.



### NOTICE

Since ST connectors do not fit through the cable glands, the optical fiber must be terminated once it has been pulled through the cable gland.

When using the optical Ethernet port, the copper-based SCADA Ethernet port **must not be used**.

## Wiring the alarm relays (dry-contact)

Relay contacts can be used in normally closed or normally open mode by using the appropriate pins on the connector. Use NC and C for normally closed operation and use NO and O for normally open operation.



### WARNING

All relays shall be connected to the same power source.



### NOTICE

The current on the relay should not exceed 3 A.

Inductive loads must be protected with voltage suppressors. A derating on current must be applied to protect the contacts.

## Analog 4–20 mA outputs

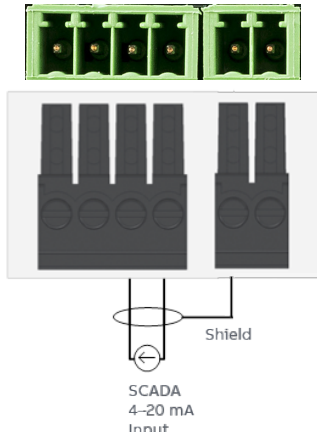
The 4–20 mA output range can be configured using the web interface. A value higher than 21 mA is used to indicate a detector error.



### WARNING

Use only shielded cables for wiring the 4–20 mA outputs interface.

**Figure 6** Wiring analog 4–20 mA outputs



4–20 mA Output	
Terminal (J2)	Description
1	Hydrogen +
2	Hydrogen –
3	Moisture +
4	Moisture –

Shield	
Terminal (J3)	Description
1	Earth GND
2	Earth GND

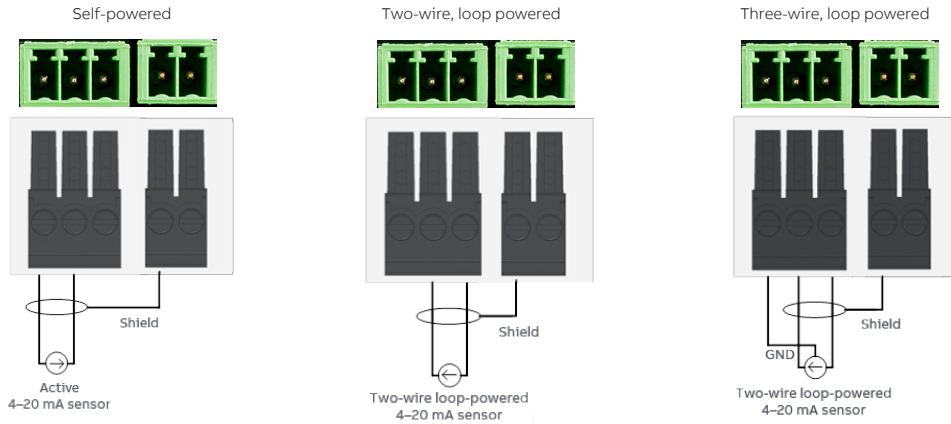
## Analog 4–20 mA inputs



### WARNING

Shielded cable must be used for connecting to the 4–20 mA outputs.

**Figure 7** Analog inputs



Terminal (J4, 5, 6)	Description
1	Analog 1
2	Analog 2
3	Analog 3

Shield	Description
Terminal (J3)	
1	Earth GND
2	Earth GND

Once all connections are made, re-install the enclosure cover and secure it with the 5 mm Allen key.



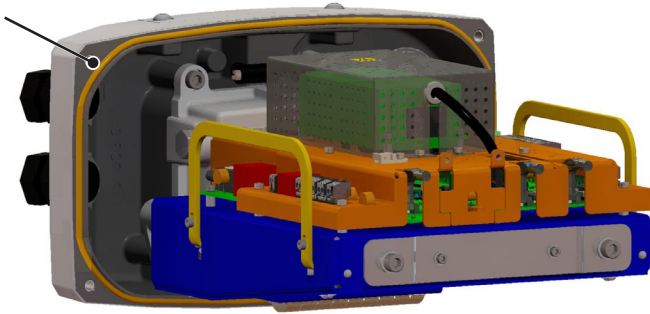
# Reinstalling the cover

To reinstall the cover:

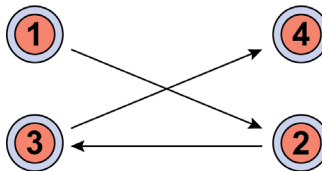
- 1 Install the supplied sensor cover O-ring (see “Spare Parts” on page 7). Make sure that it is well-fitted in the groove of the front cover.

The sensor cover O-ring can be compressed only once. Each time the cover is removed, the O-ring must be replaced.

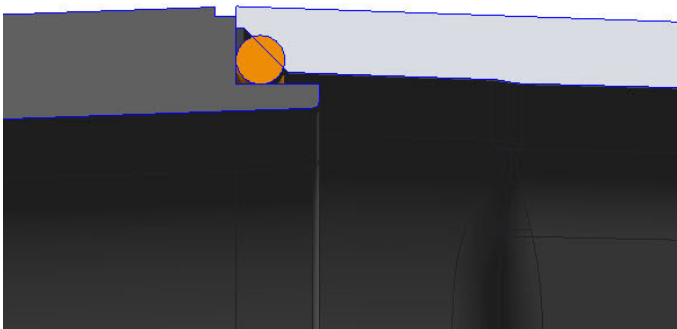
**Figure 8** O-ring fitted on the front of the enclosure



- 2 Once the O-ring properly fitted, close the cover and make sure pressure is evenly applied on the O-ring (to maintain the IP67 rating).
- 3 Secure the fasteners in an alternate pattern (see below). Start all bolts by a few threads, and run them hand-tight. Tighten mildly by hand, then to a torque of 8.1 N-m (6.0 lbf.ft).



**Figure 9** Close-up showing the O-ring and the closed cover



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# Configuring the sensor head

You can configure the sensor head once it has been properly installed in the transformer. The following pages explain the proper method to do so.

## Connecting a laptop for the first time

The first time you connect a laptop to your system:

- 1 Power up your laptop.
- 2 Connect the laptop to the **service** Ethernet port using a straight Ethernet cable. For the location of the Ethernet port, see “Figure 3 CoreSense port and relay connections” on page 23.

The sensor service Ethernet port is configured as a DHCP server and will assign a valid IP address automatically to your laptop.



### NOTICE

**Do not** connect your internal network to the SERVICE port.

- 3 Start up your web browser (recommended: Internet Explorer 9 or above).
- 4 Direct your web browser to <http://172.16.100.1> to connect to the web interface.

Figure 10 CoreSense dashboard



- 5 Click on the **Settings** tab to configure communication settings (see "Administration settings" on page 38).
- 6 Set the system ID to label each specific CoreSense.
- 7 Set the system date.
- 8 Modify your password.
- 9 Configure communication settings, i.e. RS-485 configuration, TCP configuration, 4–20 mA output configuration (see "Communication settings" on page 39).
- 10 Enable the thermal pump.



### NOTICE

When enabling the thermal pump, the CoreSense must be properly connected and it must contain oil. Make sure there are no oil leaks.

# Tabs of the CoreSense web interface

The web interface allows easy visualization of hydrogen and moisture levels. Clicking of the various tabs gives access to more options.

- **Dashboard:** Use the dashboard to quickly assess the state of the system and the hydrogen and moisture measurements (see “CoreSense dashboard” on page 32).
- **Hydrogen:** Use the Hydrogen tab to gain access to charts with historical data, or you export the historical data in .csv format. To export data, simply select a time range and click **Export**. A dialog box prompts you to select a destination for the .csv file. For more details on the Hydrogen tab, see “Hydrogen.csv” on page H93.

Figure 11 Hydrogen tab



## NOTICE

CoreSense records only the last 120 days of operation.

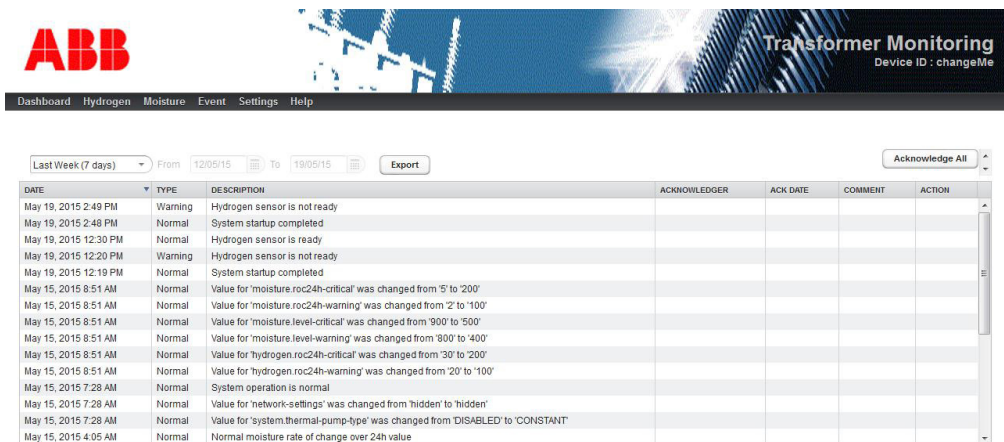
**Moisture:** Use the **Moisture** tab to gain access to charts with historical data, or to export historical data in .csv format. To export data, select a time range and click **Export**. A dialog box prompts you to select a destination for the .csv file. For more detail on the **Moisture** tab, "Moisture.csv" on page H93.

Figure 12 Moisture tab



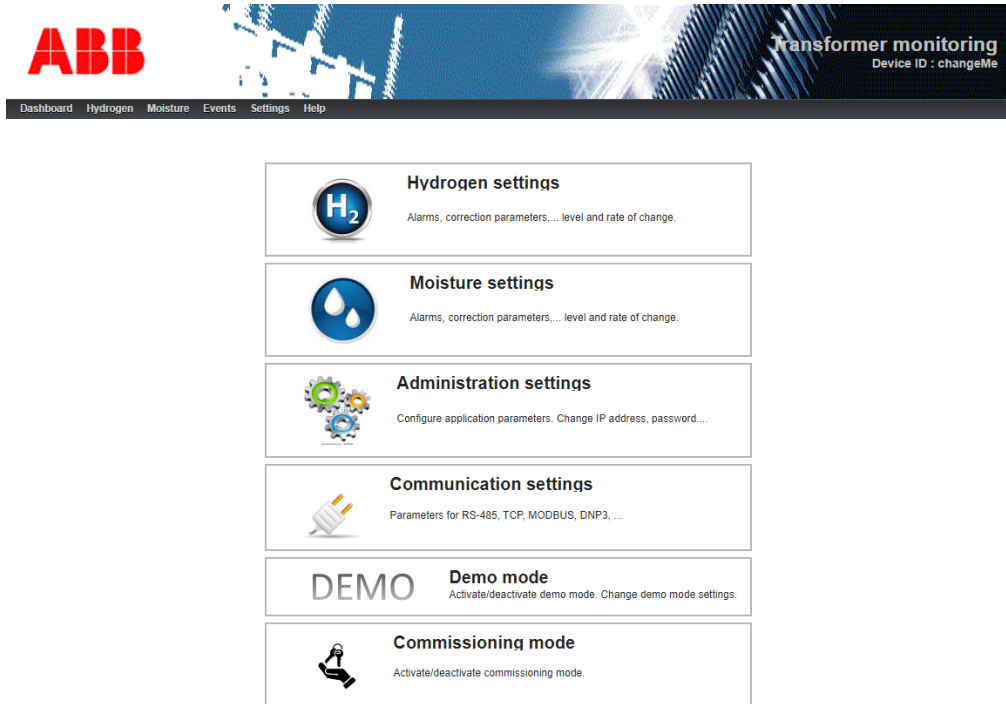
- **Event:** Use the **Event** tab to access the system log. To export data, simply select a time range and click **Export**. A dialog box prompts you to select a destination for the .csv file. For more details on the **Event** tab, see "System events" on page G91.

Figure 13 Event tab



- **Settings:** Use the **Settings** tab to access sub-menus to configure application settings (Hydrogen and Moisture), administration settings or communication settings.

Figure 14 Settings tab



- **Help:** Provides access to system information.

# Hydrogen settings

Accessing the **Hydrogen settings** dialog box requires the administrator password.

**Figure 15** Hydrogen settings dialog box

The screenshot shows a dialog box titled "Hydrogen settings". It contains three main sections:

- Level:** Two input fields. "Warning (ppm)" is set to 100. "Alarm (ppm)" is set to 250.
- Rate Of change over 24 hours:** Three input fields. "Minimum level for rate of change alarms (ppm)" is set to 80. "Warning (ppm/day)" is set to 10. "Alarm(ppm/day)" is set to 25.
- Application configuration:** Two input fields. "Slope" is set to 1. "Offset" is set to 0.

At the bottom right of the dialog are two buttons: "Apply" and "Cancel".

## Level

The sensor is delivered with preset default values for warning and alarm levels. However, it is possible to modify these default values. The default alarm and warning values are described in detail in "Configuring alarm levels" on page 45.

## Rate Of Change over 24h

The rate of change (RoC) is evaluated over a period of 24 hours to determine whether a warning is issued or not. Default values are preconfigured but can be modified to suit specific applications (see "Rate-of-Change (RoC) trigger level" on page 45 for more information).

## Application configuration

The **Application configuration** section allows you to apply a correction to the sensor's basic values.

The **Slope** applies a multiplier to the basic value (i.e., changing the default slope value from 1.0 to 1.1 multiplies a basic measurement of 100 ppm to 110 ppm).

The **Offset** adds to or subtracts from the basic value (i.e., changing the default bias value from 0.0 to -5.0 modifies the basic measurement from 100 ppm to 95 ppm).

Using the bias is a convenient way to reconcile minor differences between the sensor reading and the off-line DGA lab results.



### NOTICE

The slope and offset should be changed with care; it is not recommended to change these values on a regular basis as it will distort results.

The alarm value setting can be modified to determine whether an alarm is issued or not.



# Moisture settings

Accessing the **Moisture settings** dialog box requires the administrator password.

**Figure 16** Moisture settings dialog box

If your CoreSense unit is connected to a transformer containing synthetic esters of the Midel 7131 type, you must enter the following values:

**Oil A: 670.53**  
**Oil B: 5.59**

## Level

The sensor is delivered with preset default values for warning and alarm levels. However, it is possible to modify these default values. The default alarm and warning values are described in detail in “Configuring alarm levels” on page 45.

## Rate Of Change over 24h

The rate of change is evaluated over a period of 24 hours to determine whether an alarm or warning is issued or not. Default values are preconfigured, but can be modified to suit specific applications (see “Rate-of-Change (RoC) trigger level” on page 45 for more information).

## Post-processing (opt)

This section allows you to apply corrections to the sensor’s basic values. The **Slope** value applies a multiplicative factor to the basic value while the **Offset** value applies an additive factor to the basic value.

For example, for a sensor value of 100, if you enter 5 in the **Slope** field, you obtain a post-processing value of 500. For the same sensor value of 100, if you enter 5 in the **Offset** field, you obtain a post-processing value of 105.



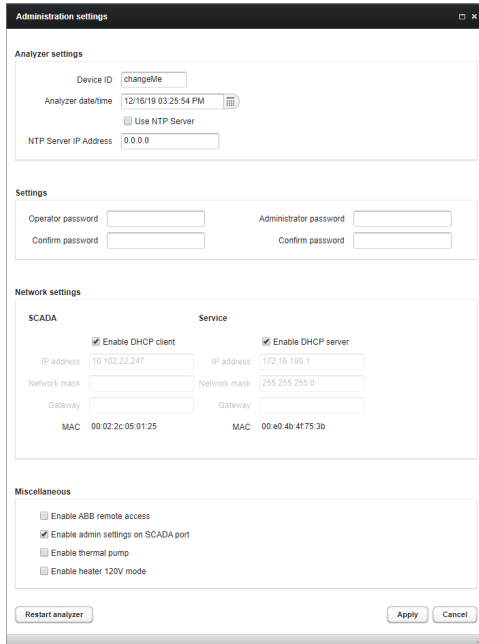
### NOTICE

In situations where both values are used, the slope value is calculated first. To continue with the example above, in a situation where you enter 5 for both **Slope** and **Offset**, the post-processing value would be 505 ( $100 \times 5 + 5$ ) and not 125 ( $100 + 5 \times 5$ ).

# Administration settings

The **Administration settings** tab allows to modify and/or set several analyzer or administrative settings. Accessing the **Administration settings** dialog box requires the administrator password.

**Figure 17** Administration settings dialog box



## Analyzer settings

- **Device ID:** configurable field to label a sensor.
- **Analyzer date/time:** enter local time.
- **Use NTP server:** click to activate and enter address of NTP server.

## Settings

The **Settings** section allows you to set or modify the active passwords.

## Network Settings

The **Network Settings** section allows your to configure the SCADA and service Ethernet ports. Both ports can be DHCP enabled. See “Figure 3 CoreSense port and relay connections” on page 23 for the location of the SCADA and service Ethernet port.

## Miscellaneous

- **Enable ABB remote access:** when checked, allows an ABB user to access special diagnostics.
- **Enable admin settings on SCADA Port:** when unchecked, the settings section of the web interface will not be accessible using the SCADA port.
- **Enable thermal pump:** when checked, allows the oil to be circulated to the sensor. When the thermal pump is not enabled, the system LED is yellow.

# Communication settings

The **Communication settings** tab allows you to set the RS-485 configuration, to define the TCP configuration and to define 4–20 mA outputs. Accessing the **Communication settings** dialog box requires the administrator password.

**Figure 18** Communication settings dialog box



## RS-485 Configuration

The **RS-485 Configuration** section allows you to change the protocol used (Modbus or DNP3). For corresponding configuration parameters, see “Modbus table” on page B61 and “DNP3” on page C65. The Modbus identification slave ID can be changed in this dialog box.

## TCP Configuration

For the corresponding TCP configuration parameters, see “Modbus table” on page B61 and “DNP3” on page C65.

## 4–20 mA Outputs Configuration

Use the **4–20 mA Outputs Configuration** section to configure the minimum and maximum settings for hydrogen and moisture. For more details on connecting the 4–20 mA output, see “Analog 4–20 mA outputs” on page 27.

## IEC 61850 Configuration

Displayed when **Enable strict mode** is checked. Only data objects in strict compliance to IEC 61850 edition 1 are available on the CoreSense IEC 61850 MMS Server.

**When Enable strict mode is NOT** checked, additional data objects are available.

## Demo mode

Check **Enable demo mode** to enter a simulation mode for the CoreSense.

Figure 19 Demo mode dialog box

The dialog box is titled "Demo mode" and contains a checked checkbox for "Enable demo mode". It features two sections for parameter configuration: "Hydrogen" and "Moisture". Each section includes four input fields: "Refresh rate (s)" (60), "Slope" (1), "Minimum value" (1), and "Maximum value" (100). "Apply" and "Cancel" buttons are located at the bottom.



### NOTICE

In demo mode, the simulator overwrites real data.

## Commissioning mode

The commissioning mode is used to test operating values before actually implementing or committing to those values. In commissioning mode, the system database in use is left untouched at all times. While the system is in commissioning mode, it is not taking measurements.



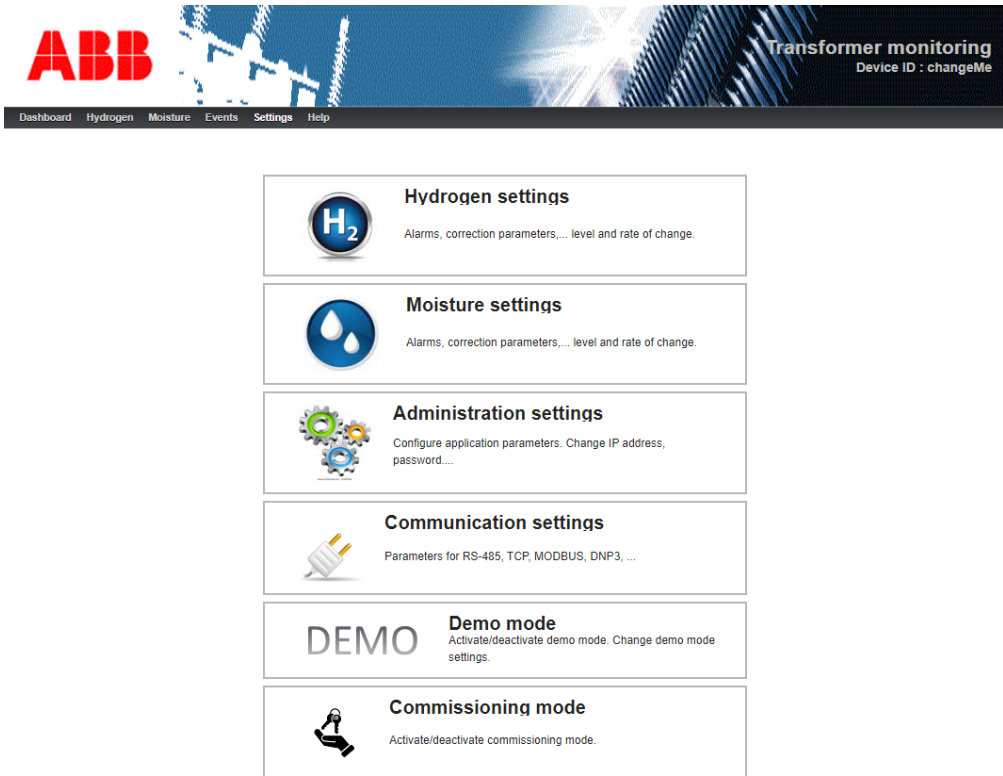
### NOTICE

Activating or deactivating the commissioning mode requires a system reboot.

To use the commissioning mode:

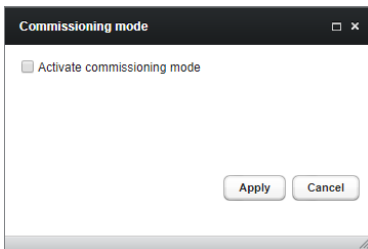
- 1 From the CoreSense dashboard, click the **Settings** tab.
- 2 On the **Settings** tab, click **Commissioning mode**.

Figure 20 Clicking Commissioning mode



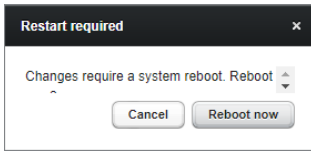
A **Commissioning mode** dialog box is displayed (you may have to enter your password the first time that you try to access the commissioning mode).

Figure 21 Activating the commissioning mode



- 3 In that dialog box, check the **Activate commissioning mode** box and click **Apply**. The system asks you to reboot the system.

Figure 22 Rebooting the system



- 4 Click **Reboot now** to activate the commissioning mode. The system reboots (there is a slight delay between the time the mode change is applied and the system has actually completed its reboot; you might have to refresh your computer screen). Once the system has rebooted, a **Commissioning** tab is displayed between the **Settings** and **Help** tabs.
- 5 Click the **Commissioning** tab. The Commissioning page is displayed.  
From this page, you can set various sensor, input and output values, and also toggle the specific relays.



### NOTICE

In commissioning mode, the system database in use is left untouched at all times.

Basic hydrogen, moisture and oil temperature values can be modified directly, and set by clicking **Set sensor values**.

Figure 23 The Commissioning page



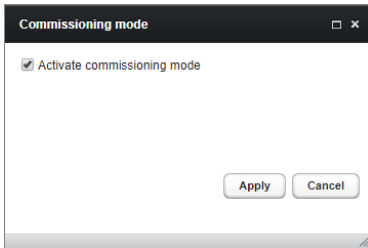
- 6 To activate the remaining values (that are otherwise grayed out), check the **Override [value name] values** box. Once checked, the value fields underneath become active and you can modify those values as needed.
- 7 To set these modified values, click **Set [value name] values**.  
The effect of these changes is reflected in the dashboard. Click the **Dashboard** tab to view the effects of the changes that you just made.

Once you are done using the commissioning mode, you need to deactivate it to return the system to its standard operating mode.

To do so:

- 1 From the CoreSense dashboard, click the **Settings** tab.
- 2 On the **Settings** tab, click **Commissioning mode**. A **Commissioning mode** dialog box is displayed (you may have to enter your password).
- 3 In that dialog box, uncheck the **Activate commissioning mode** box and click **Apply**. The system asks you to reboot the system.

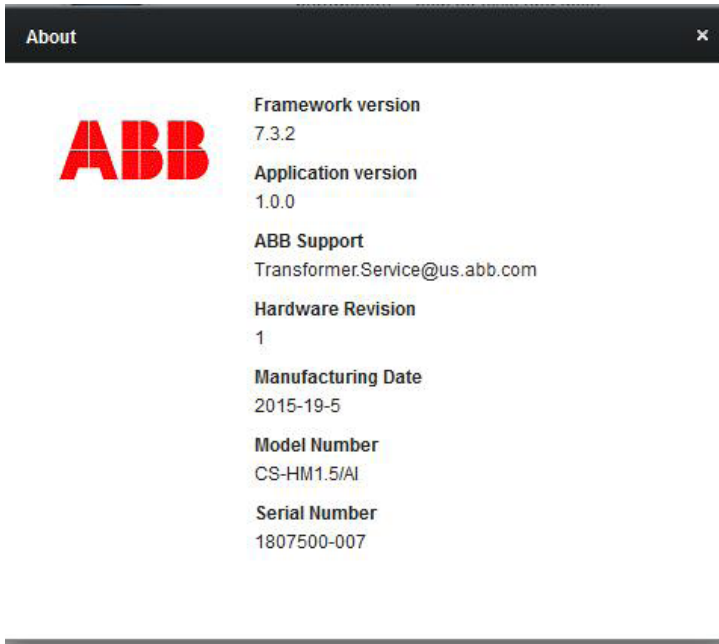
**Figure 24** Deactivating the commissioning mode



- 4 Click **Reboot now** to deactivate the commissioning mode. The system reboots (there is a slight delay between the time the mode change is applied and the system has actually completed its reboot; you might have to refresh your computer screen). Once the system has rebooted, the **Commissioning** tab is no longer available.

# About dialog box

Figure 25 About dialog box





# Configuring alarm levels

For hydrogen and moisture, the sensor supports two user-configurable alarm thresholds for level and two more for rate-of-change (RoC). See Table 7 for default factory settings.

**Table 7** Default warning and alarm threshold settings

Alarm thresholds	Warning value	Alarm value
Hydrogen level	100 ppm	250 ppm
Hydrogen 24h rate-of-charge (RoC)	+10 ppm	+25 ppm
Hydrogen RoC trigger level	80 ppm	
Moisture level	20 ppm	30 ppm
Moisture 24h rate-of-charge (RoC)	+5 ppm	+10 ppm
Moisture RoC trigger level	15 ppm	

It is your responsibility to define warning and alarm thresholds suited to the condition and application of your transformer. ABB Transformer Service will be glad to help.



## NOTICE

Default warning and alarm level values can be modified using the web interface.

## Rate-of-Change (RoC) trigger level

To avoid false alarms, a minimum level is configured for the rate-of-change alarm to be considered. Only when the hydrogen level is above the hydrogen RoC trigger level will a rate-of-change warning or alarm condition be raised.

Similarly, only when the moisture level is above the moisture RoC trigger level can a rate-of-change warning or alarm condition be raised.

## Latched alarms





Warnings and alarms raised by the CoreSense are “latching”, meaning that even if the level goes back under the warning or alarm threshold, the warning or alarm will stay on until it is acknowledged in the event log using the web interface.

# Visual indications and alarms

The sensor is equipped with LED indicators that allow you to evaluate at a glance the current state of the sensor and to determine if hydrogen or moisture levels are in spec. These indicators are also available remotely through the web interface.

## Meanings of the visual indicators

**Table 8** Meanings of visual indicators

	System	Hydrogen	Moisture
SOLID GREEN 	The sensor is powered up and operating normally.	Both the hydrogen level AND the hydrogen 24-hour rate-of-change are below the user-configured WARNING threshold.	Both the moisture level AND the moisture 24-hour rate-of-change are below the user-configured WARNING threshold.
BLINKING YELLOW (WARNING) 	This indicator will remain on while the CoreSense is booting up. If the sensor remains in warning mode for more than three minutes, the sensor requires user attention, the thermal pump is disabled or it is being operated outside its nominal specifications *	The hydrogen level OR the hydrogen 24-hour rate-of-change is above the user-configured WARNING threshold.	The moisture level OR the moisture 24hour rate-of-change is above the user-configured WARNING threshold.
BLINKING RED (ALARM) 	This indicates a sensor fault. Please refer to the event log and contact ABB.	The hydrogen level OR the hydrogen 24-hour rate-of-change is above the user-configured ALARM threshold.	The moisture level OR the moisture 24 hour rate-of-change is above the user-configured ALARM threshold.
OFF 	Sensor is not powered.		This sensor is not equipped with a moisture sensor.



\* This indicates that the sensor is booting up, requires attention or is operating outside its nominal specifications. This condition can be triggered by an unacknowledged ALARM, oil temperature beyond 100 °C, etc. The event log should be used to determine the root cause of the WARNING.

## In case of WARNING or ALARM

Your company may already have a standard policy in place for dealing with hydrogen or moisture alarms. In addition to this, for a WARNING, ABB recommends scheduling an off-line DGA to confirm the readings and obtain the levels of other dissolved gases.

For an ALARM, ABB recommends performing an off-line DGA as soon as possible. Based on the result of the off-line DGA, a diagnosis and maintenance recommendation can be formulated.

**Table 9** Reaction to warnings and alarms

CoreSense	Recommended action
Hydrogen or moisture level or rate-of-change reached the WARNING threshold 	Plan to perform an off-line lab DGA to confirm hydrogen and moisture values and obtain other important gases. <b>This should be done in a short time frame.</b>
Hydrogen or moisture level or rate-of-change reached the ALARM threshold 	Plan to perform an off-line lab DGA to confirm hydrogen and moisture values and obtain other important gases. <b>This should be done as soon as possible.</b>



---

## CHAPTER 5

# Post-installation check list

- Make sure that the system date was set properly using the CoreSense web interface.
- Make sure that the thermal pump is enabled (see “Administration settings” on page 38). While the thermal pump is disabled, the SYSTEM LED is yellow.
- Make sure that the hydrogen and moisture WARNING and ALARM limits have been configured properly for your application.
- Perform a visual inspection of the installation. Check for oil leaks.
- Verify that cable glands are properly tightened and secured.
- Make sure that the CoreSense is appropriately grounded.
- Was PTFE applied on the 1.5 NPT fitting, as per “Installation on transformer valve” on page 17?
- Make sure that the eight bolts for the CoreSense rotating flange are secured with the proper torque, as described in “Installing the sensor head” on page 17.
- Make sure that the two bolts for the CoreSense external sampling cover are properly secured.
- Did you install/replace the O-ring that seals the CoreSense enclosure?
- Verify that the 4 retaining screws of the CoreSense enclosure are properly secured.
- Verify that the system, hydrogen and moisture LEDs are green.
- Dispose of any collected oil according to your company regulations and local laws.

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## CHAPTER 6

# Maintenance

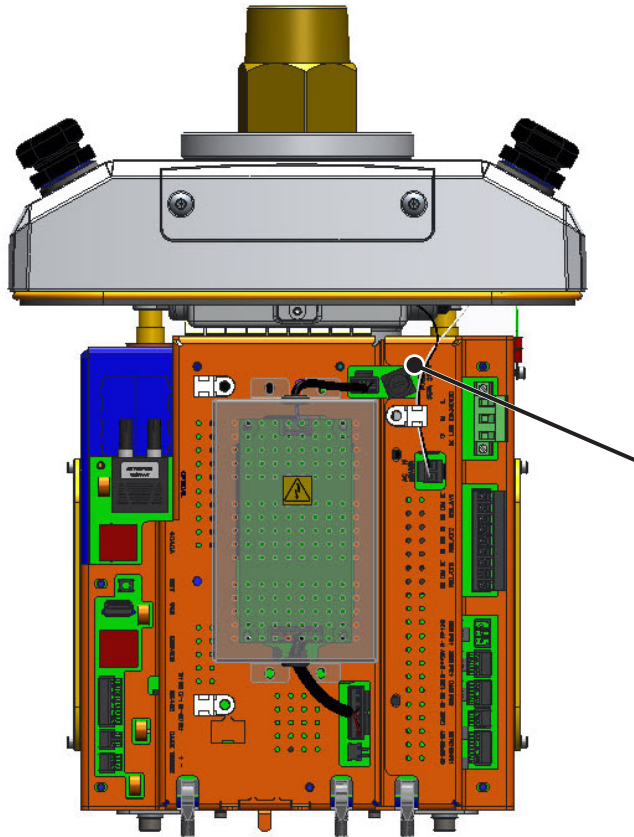
The CoreSense is maintenance-free, i.e., no regular maintenance is required. The fuse may require replacement after an unusual voltage event.

## Replacing the fuse

Use only the specified fuses: 1A/250V slow-blow (5×20 mm).

Simply replace the fuse in the fuse holder. See picture below for fuse holder location. To access the fuse holder, remove the cover (see “Removing the cover” on page 22).

**Figure 26** Location of the fuse holder



## Taking an oil sample

Oil samples are taken on a regular basis depending on company policies in order to perform a complete analysis of the oil. Such a laboratory analysis allows to complement the hydrogen measurement done with the CoreSense with the other gases that may be present in the oil.

To take an oil sample, simply perform steps 1–7 from “Installation on transformer valve” on page 17 , but using a syringe instead of a bucket.

## Cleaning

On a regular basis and in accordance with your company’s procedure:

- Perform a visual inspection of the sensor, check for oil leaks, water or snow accumulation.
- Make sure that the enclosure is properly secured.
- Keep the sensor clean to make reading the LEDs easier. Wipe excess oil or water using a clean cloth.

## Before sending a CoreSense to ABB

Before sending a CoreSense to ABB, you must first:

- Make sure that the CoreSense has been completely emptied. Wipe excess oil with a clean cloth.
- Cover the NPT access port to prevent any contaminants from entering the sensor.
- Obtain a Contamination Data Sheet from ABB’s after sales service.
- Fill out and sign the Contamination Data Sheet. Do not forget to check the check boxes of the Non-contaminated Material Declaration section.
- Return the fully completed Declaration to ABB.
- Obtain the authorization from ABB personnel. You must receive a Return Merchandise Authorization (RMA) prior to sending the analyzer back to ABB, otherwise receipt of analyzer will be refused.



## FAQ and troubleshooting

This section answers frequently asked questions about installing and operating the CoreSense.

**Q. On which transformer valve should I install the CoreSense?**

**A.** When selecting an installation location for the CoreSense, you should consider availability, serviceability and oil flow. Figure 2 on page 11 of this manual summarizes the typical installation options.

**Q. Will the CoreSense work on the drain valve?**

**A.** Yes, the CoreSense can be installed on the drain valve thanks to its forced convection thermal pump that will create an oil flow to the sensor. It is designed to work at most locations on a transformer.

**Q. The power is connected to the CoreSense, but none of the LEDs are lit?**

**A.** Verify that the proper voltage is applied to the AC line terminal. The power supply will accept 100–240 V AC (50–60 Hz). Also, check for a blown fuse. If necessary, replace the sensor fuse (see “Replacing the fuse” on page 51).

## Q. Cannot connect to the web interface on the service port

A. Make sure that you are connected to the **service port** and not the SCADA port. On your laptop or PC, verify in your Ethernet settings that your IP address is set to Automatic. The CoreSense **service** port is configured by default as a DHCP server and it will assign an IP address in the 172.16.100.10 to 172.16.100.20 range. This could take a few minutes.

```
Administrator: C:\Windows\system32\cmd.exe
C:\Users\CAALOU>ipconfig
Windows IP Configuration

Wireless LAN adapter Wireless Network Connection 2:
    Media State . . . . . : Media disconnected
    Connection-specific DNS Suffix . . :

Wireless LAN adapter Wireless Network Connection:
    Media State . . . . . : Media disconnected
    Connection-specific DNS Suffix . . : ca.abb.com

Ethernet adapter Local Area Connection:
    Connection-specific DNS Suffix . . : internal.abb.com
    Link-local IPv6 Address . . . . . : fe80::6c5d:345:194e:189%11
    IPv4 Address. . . . . : 172.16.100.11
    Subnet Mask . . . . . : 255.255.255.0
    Default Gateway . . . . . :

Tunnel adapter 6T04 Adapter:
    Media State . . . . . : Media disconnected
    Connection-specific DNS Suffix . . :

Tunnel adapter Local Area Connection* 11:
    Media State . . . . . : Media disconnected
    Connection-specific DNS Suffix . . :

Tunnel adapter isatap.ca.abb.com:
    Media State . . . . . : Media disconnected
    Connection-specific DNS Suffix . . :

Tunnel adapter isatap.internal.abb.com:
    Media State . . . . . : Media disconnected
    Connection-specific DNS Suffix . . : internal.abb.com

Tunnel adapter isatap.{4COA93EF-6BCE-4A14-833B-EE0ED74A88C3}:
    Media State . . . . . : Media disconnected
    Connection-specific DNS Suffix . . :

C:\Users\CAALOU>
```

Verify that the CoreSense responds to a ping at 172.16.100.1

```
Administrator: C:\Windows\system32\cmd.exe
C:\Users\CAALOU>ping 172.16.100.1
Pinging 172.16.100.1 with 32 bytes of data:
Reply from 172.16.100.1: bytes=32 time<1ms TTL=64
Reply from 172.16.100.1: bytes=32 time<1ms TTL=64
Reply from 172.16.100.1: bytes=32 time<1ms TTL=64

Ping statistics for 172.16.100.1:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\Users\CAALOU>
```

**Q. The CoreSense system LED is blinking yellow or blinking red.**

**A.** Connect to the web interface on the service port and navigate to the **Event** tab. The event log should clarify the nature of the issue. Make sure that the thermal pump is on.

**Q. The CoreSense hydrogen LED is yellow or red.**

**A.** Verify your WARNING and ALARM settings. If they are as expected, verify the current reading. Perform a lab DGA to confirm the CoreSense levels.

**Q. The CoreSense moisture LED is yellow or red.**

**A.** Verify your WARNING and ALARM settings. If they are as expected, verify the current reading. Perform a lab DGA to confirm the CoreSense levels.

**Q. The hydrogen or moisture reading is normal (below the user-configured threshold) but still a WARNING or ALARM is reported**

**A.** The CoreSense has latching alarms, which means that once a threshold is crossed, the WARNING or ALARM needs to be acknowledged in the **Event** tab of the web interface. This is required even if the level falls below the user-configured threshold.

**Q. In the web interface, not all measurements are shown on the charts in the Hydrogen or Moisture tab.**

**A.** To see all measurements, use the Export feature and open the .csv file.



**NOTICE**

CoreSense records only the last 120 days of operation.

**Q. Why does CoreSense-reported hydrogen or moisture levels differ slightly from lab DGA results?**

**A.** The CoreSense is calibrated in a reference oil that may have chemical and physical properties that differ slightly from the transformer oil in your application. This may cause small variations in absolute accuracy. The lab DGA method is still the reference method for dissolved gas analysis. However it may suffer from handling issues from sample extraction, to transport and at the lab. A concern specific to hydrogen is its volatility. Samples should be sent to the lab in a timely manner. ABB recommends always using the same lab to ensure consistent results over time. The CoreSense allows for small differences to be reconciled using its software settings.

**Q. Do we need to de-energize the transformer prior to installing the CoreSense?**

**A.** While it is possible to install the CoreSense without de-energizing the transformer, ABB recommends that the transformer be de-energized to perform the installation. You shall comply with your company policies and recommendations regarding equipment installation.

**Q. How long does it take to install the CoreSense on a transformer?**

**A.** Typical installations should take less than 2 hours.

**Q. Are any special precautions required when the transformer is put under vacuum?**

**A.** No there are no special precautions required. The CoreSense is inherently tolerant to vacuum.

**Q. Does the CoreSense require planned maintenance?**

**A.** There is no planned maintenance required during the operational life of the product.

**Q. What is the expected operating lifetime of the CoreSense?**

**A.** The CoreSense is expected to operate for up to 15 years with no maintenance. This is enabled by the solid-state design of the CoreSense with no moving parts. Also, the CoreSense does not have a gas/oil separation stage based on a membrane or headspace; it senses hydrogen and moisture directly in the oil.

**Q. Can the CoreSense be used with transformers that use ester oils as an insulating fluid?**

**A.** The CoreSense is calibrated in transformer mineral oil. It also works in ester oils. The hydrogen will be reported accurately. The moisture measurement in percentage (%) will also be reported accurately, but the moisture value in ppm may need to be adjusted with some calibration factors. Once the calibration factors are known, this can easily be done using the CoreSense web interface.

**Q. How does data storage work on the CoreSense?**

**A.** The CoreSense stores 120 days of data on a First-In-First-Out (FIFO) basis.

# Technical specifications

## Description

Dissolved gas analysis (DGA) of transformer oil is a recognized detection method for incipient transformer faults. The CoreSense complements off-line lab DGA by providing real-time continuous monitoring of hydrogen and moisture levels in transformer oil.

The CoreSense can also monitor additional parameters provided by external sensors connected to optional analog inputs. The CoreSense provides a simple local indicator based on three LEDs that allow the condition of transformers to be determined at a glance, e.g., if the three LEDs are green everything is normal. All of the readings made by the CoreSense are also available on the built-in web interface and published through analog outputs and through digital protocols such as Modbus, DNP3 and IEC61850.

## Measurement specifications

<b>Hydrogen</b>	
Technology	Solid state electrochemical palladium-based sensor
Hydrogen measurement range	0 to 5000 with a detection limit of 25 µl/l (ppm)
Hydrogen measurement accuracy	±25 ppm or ±20%, whichever is higher
Hydrogen measurement repeatability H <sub>2</sub>	±15 ppm or ±10%, whichever is higher
Hydrogen response time	T90 (typical): 30 minutes T90 (max): 60 minutes
<b>Moisture (optional)</b>	
Technology	Thin-film capacitive type sensor immersed in mineral insulating oil
Moisture measurement range	0 to 1 aw (displayed in aw and ppm)
Moisture measurement accuracy	±0.02 aw
Temperature measurement accuracy	±0.2 °C

## Mechanical specifications

Dimensions	392 × 264 × 158 mm (14.43 × 10.39 × 6.2 in)
Weight	8 kg (18 lbs)
Interface to transformer	1.5 NPT, male thread
Enclosure	IP67/NEMA 4X enclosure

## Electrical specifications

Voltage input	100–240 V AC single phase (50 to 60 Hz) (mains supply voltage fluctuations not to exceed 10% of nominal supply voltage)
Power consumption	150 VA
Maximum current	0.8 A
Fuse type	1 × 1.0 A/250 V (5 × 20 mm), slow-blow

## Communication specifications

LED	Indicate system, hydrogen and moisture status
Digital interfaces	<p>IEC61850 MMS available over Ethernet or optical Ethernet</p> <p>Modbus and DNP3 are available over the following interfaces:</p> <ul style="list-style-type: none"><li>• RS-485</li><li>• Ethernet</li><li>• Optical Ethernet (100BASE-FX) when equipped<ul style="list-style-type: none"><li>– Wavelength = 1300 nm</li><li>– Tx max power = –14 dBm</li><li>– Tx min power = –23.5 dBm</li><li>– Rx max power = –14 dBm</li><li>– Rx min power = –31 dBm</li></ul></li></ul>
Analogue interfaces	<p><b>Dry-contact relays for alarms</b></p> <ul style="list-style-type: none"><li>• Maximum voltage: 250 V AC</li><li>• Resistive load: 3 A @ 250 V AC, 3 A up to 20 V DC, 50 W up to 250 V DC</li></ul> <p><b>4–20 mA inputs when equipped</b></p> <ul style="list-style-type: none"><li>• Input load: 250 Ω</li><li>• Compliant with NAMUR NE 43</li></ul> <p><b>4–20 mA outputs</b></p> <ul style="list-style-type: none"><li>• Maximum load: 500 Ω</li><li>• Compliant with NAMUR NE 43</li></ul>

## Environmental specifications

Operating ambient temperature	–50 to +55 °C (–58 to 131 °F)
Operating ambient humidity	5 to 95% relative humidity, non-condensing
Operating altitude	–610 to 3000 m (–2001 to 9843 ft.)
Shipping/storage temperature	–40 to 70 °C (–40 to 158 °F)
Shipping/storage relative humidity	10 to 100% relative humidity
Shipping/storage atmospheric pressure	500 to 1060 hPa
Pollution degree	2 (internal)
Oil temperature at valve	–20 to +100 °C (–4 to 212 °F)
Oil pressure at valve	0 to 10 bar

## Default RS-485 configuration

Baud rate	9600
Data Bits	8
Stop bits	1
Parity	None
Flow control	None (only none is supported)

## Application TCP ports table

Web interface	80/tcp
IEC61850 MMS	102/tcp
Modbus TCP	502/tcp
DNP3	20000/tcp
ABB diagnostic port	22/tcp
DHCP	67/udp & 68/udp

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## APPENDIX B

# Modbus table

The RS-485 and Modbus default settings can be modified using the web interface.



### NOTICE

For best results it is recommended to configure the Modbus master with a timeout of 10000 ms and 5 retries.

Minimum delay between polls shall be at least 100 ms.

**The default slave ID is 1.**

## Default RS-485 configuration

Baud rate	9600
Data Bits	8
Stop bits	1
Parity	None
Flow control	None (only none is supported)

## Default TCP configuration port

Modbus TCP	502/tcp
------------	---------

# Modbus parameters

Register	Modbus address	Parameter	Function	Data type	Access
<b>Status/Alarms</b>					
0		Not supported			
1-10		Reserved for future use			
<b>Info</b>					
11-20	40011	Model number		ASCII string	R
21-30	40021	Serial number		ASCII string	R
31-40	40031	Software version		ASCII string	R
41-50	40041	System ID		ASCII string	R
51	40051	Manufacturing date	high byte = month low byte = day	32 bit binary value	R
52	40052	Manufacturing date	Year	32 bit binary value	R
<b>Measurement</b>					
53	40053	Hydrogen (ppm)		signed 16-bit binary number	R
54	40054	Hydrogen RoC (ppm/day)	may need scaling	signed 16-bit binary number	R
55	40055	RESERVED - Hydrogen RoC (ppm/week)	return 0	signed 16-bit binary number	R
56	40056	RESERVED - Hydrogen RoC (ppm/month)	return 0	signed 16-bit binary number	R
57	40057	Oil temperature (moisture) (°C)		signed 16-bit binary number	R
58	40058	Moisture (aw)	scaled by 100	signed 16-bit binary number	R
59	40059	Moisture (ppm)		signed 16-bit binary number	R
60	40060	Moisture (ppm/day)	may need scaling	signed 16-bit binary number	R
61	40061	RESERVED - Moisture (ppm/week)	return 0	signed 16-bit binary number	R
62	40062	RESERVED - Moisture (ppm/week)	return 0	signed 16-bit binary number	R
63	40063	4-20 mA input 1	scaled by 100	signed 16-bit binary number	R
64	40064	4-20 mA input 2	scaled by 100	signed 16-bit binary number	R
65	40065	4-20 mA input 3	scaled by 100	signed 16-bit binary number	R
<b>Status/Alarms</b>					
66	40066	Status and alarms	See <status> table	16 bit binary map	R
<b>Configuration</b>					
67-100		Reserved for future use			

---

---

**<status>**

---

<b>Bit</b>	<b>Description</b>
15	Reserved
14	Reserved
13	Reserved
12	Reserved
11	Moisture RoC CRITICAL
10	Moisture RoC WARNING
9	Moisture level CRITICAL
8	Moisture level WARNING
7	Hydrogen RoC CRITICAL
6	Hydrogen RoC WARNING
5	Hydrogen level CRITICAL
4	Hydrogen level WARNING
3	System CRITICAL
2	System WARNING
1	System ready

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# DNP3

The CoreSense DNP3 outstation implementation is compliant to level 1 and level 2. The CoreSense DNP3 device profile can be downloaded from [www.abb.com](http://www.abb.com). Out of the box, you can communicate with the sensor using a default data link address = 4. DNP3 is available on the RS-485 serial interface or on the Ethernet interfaces.



## NOTICE

For best results, it is recommended to configure the DNP3 master with a time out of 10000 ms and 5 retries.

Minimum delay between polls shall be at least 100 ms.

The DNP3 cold restart function is not supported for cybersecurity reasons.

**The default outstation ID is 4.**

## Default RS-485 configuration

Baud rate	9600
Data Bits	8
Stop bits	1
Parity	None
Flow control	None (only none is supported)

## Default TCP configuration port

DNP3	20.000
------	--------

**Binary input point list**

<b>Point Index</b>	<b>Name</b>	<b>Event class assigned (1, 2, 3 or none)</b>	<b>Name for state when value is 0</b>	<b>Name for state when value is 1</b>	<b>Description</b>
0	Sys-Ready	none	OFF	ON	System ready
1	Sys-Warn	none	OFF	ON	System warning
2	Sys-Crit	none	OFF	ON	System critical
3	Hyd-Lev-Warn	none	OFF	ON	Hydrogen level warning
4	Hyd-Lev-Crit	none	OFF	ON	Hydrogen level critical
5	Hyd-Roc-Warn	none	OFF	ON	Hydrogen RoC warning
6	Hyd-Roc-Warn	none	OFF	ON	Hydrogen RoC critical
7	Moi-Lev-Warn	none	OFF	ON	Moisture level warning
8	Moi-Lev-Crit	none	OFF	ON	Moisture level critical
9	Moi-Roc-Warn	none	OFF	ON	Moisture RoC warning
10	Moi-Roc-Crit	none	OFF	ON	Moisture RoC critical

**Transmitted value          Scaling**

<b>Point Index</b>	<b>Name</b>	<b>Event Class Assigned (1, 2, 3, or none)</b>	<b>Min int/ft</b>	<b>Max int/ft</b>	<b>Multiplier</b>	<b>Offset</b>	<b>Units</b>	<b>Description</b>
0	Hydrogen	none	/	/	1	0	ppm	
1	Hyd_Roc_Day	none	/	/	1	0	ppm/day	Hydrogen RoC
2	Hyd_Roc_Week	none	/	/	1	0	ppm/week	RESERVED - Hydrogen RoC
3	Hyd_Roc_Month	none	/	/	1	0	ppm/month	RESERVED - Hydrogen RoC
4	Oil_Temp	none	/	/	1	0	Celsius	Oil temperature (moisture)
5	Moi_Aw	none	/	/	0.01	0	aw	Moisture
6	Moisture	none	/	/	1	0	ppm	Moisture
7	Moi_Day	none	/	/	1	0	ppm/day	Moisture
8	Moi_Week	none	/	/	1	0	ppm/week	RESERVED - Moisture
9	Moi_Month	none	/	/	1	0	ppm/month	RESERVED - Moisture
10	Input_1	none	/	/	0.01	0	mA	4–20 mA Input 1
11	Input_2	none	/	/	0.01	0	mA	4–20 mA Input 2
12	Input_3	none	/	/	0.01	0	mA	4–20 mA Input 3

## APPENDIX D

# IEC 61850

The CoreSense implements an IEC 61850 MMS server over TCP/IP Ethernet that is compliant with edition 1 of the IEC 61850 standard. The following supporting documents can be downloaded from [www.abb.com](http://www.abb.com).

PIXIT	Protocol Implementation eXtra Information for Testing
MICS	Model Implementation Conformance Statement
PICS	Protocol Implementation Conformance Statement
TICS	Technical Issues Implementation Conformance Statement
CoreSenseStrict.icd	ICD file which does not contain extended data attributes
CoreSenseExtended.icd	ICD file which contains extended data attributes

For your convenience, selected information is available in this appendix.

## PIXIT

### PIXIT for Association Model

ID	ED	Description	Value/Clarification	
As1	1	Maximum number of clients that can set-up an association simultaneously	2	
As2	1,2	TCP_KEEPLIVE value. The recommended range is 1..20 s	5 seconds	
As3	1,2	Lost connection detection time	5 sec (idle) + (5 sec * 5 retry) = 30 seconds	
As4	-	Authentication is not supported yet	NA	
As5	1,2	What association parameters are necessary for successful association	Transport selector	Y
			Session selector	Y
			Presentation selector	Y
			AP Title	N
			AE Qualifier	N
As6	1,2	If association parameters are necessary for association, describe the correct values e.g.	Transport selector	00 01
			Session selector	00 01
			Presentation selector	00 00 00 01
			AP Title	NA
			AE Qualifier	NA

ID	ED	Description	Value/Clarification	
As7	1,2	What is the maximum and minimum MMS PDU size	Max MMS PDU size	120000 bytes
			Min MMS PDU size	1200 bytes
As8	1,2	What is the maximum start up time after a power supply interrupt	5 minutes	
As9	1,2	Does this device function only as test equipment? (test equipment need not have a non-volatile configuration; but it cannot be part of the substation automation system)	No	

## PIXIT for Server Model

ID	ED	Description	Value/Clarification	
Sr1	1,2	Which analogue value (MX) quality bits are supported (can be set by server)	Validity:	
			Good	Y
			Invalid	Y
			Reserved	N
			Questionable	Y
			Overflow	N
			OutOfRange	N
			BadReference	N
			Oscillatory	N
			Failure	Y
			OldData	N
			Inconsistent	N
			Inaccurate	N
			Source:	
			Process	Y
Substituted	Y			
Test	N			
OperatorBlocked	N			



ID	ED	Description	Value/Clarification	
Sr2	1,2	Which status value (ST) quality bits are supported (can be set by server)	<b>Validity:</b>	
			Good	Y
			Invalid	Y
			Reserved	N
			Questionable	Y
			Overflow	N
			BadReference	N
			Oscillatory	N
			Failure	Y
			OldData	N
			Inconsistent	N
			Inaccurate	N
			<b>Source:</b>	
			Process	Y
Substituted	Y			
Test	N			
OperatorBlocked	N			
Sr3	-	What is the maximum number of data object references in one GetDataValues request	Deprecated	
Sr4	-	What is the maximum number of data object references in one SetDataValues request	Deprecated	
Sr5	1	Which Mode values are supported	On	Y
			[On-]Blocked	N
			Test	N
			Test/Blocked	N
			Off	N

## PIXIT for Data Set Model

ID	ED	Description	Value/Clarification
Ds1	1	What is the maximum number of data elements in one data set (compare ICD setting)	Only one non-configurable dataset containing all DO.
Ds2	1	How many persistent data sets can be created by one or more clients (this number includes predefined datasets)	Only one non-configurable dataset containing all DO. Data set creation is not supported.
Ds3	1	How many non-persistent data sets can be created by one or more clients	Data set creation is not supported.

## PIXIT for Substitution Model

ID	ED	Description	Value/Clarification
Sb1	1	Are substituted values stored in volatile memory	Substitution is not supported.

## PIXIT for Setting Group Control Model

ID	ED	Description	Value/Clarification
Sg1	1	What is the number of supported setting groups for each logical device	SG is not supported.
Sg2	1,2	What is the effect of when and how the non-volatile storage is updated (compare IEC 61850-8-1 §16.2.4)	SG is not supported.
Sg3	1	Can multiple clients edit the same setting group	SG is not supported.
Sg4	1	What happens if the association is lost while editing a setting group	SG is not supported.
Sg5	1	Is EditSG value 0 allowed	SG is not supported.
Sg6	2	When ResvTms is not present how long is an edit setting group locked	SG is not supported.

## PIXIT for Reporting Model

ID	ED	Description	Value/Clarification	
Rp1	1	The supported trigger conditions are (compare PICS)	Integrity	Y
			Data change	Y
			Quality change	Y
			Data update	Y
			General interrogation	Y
Rp2	1	The supported optional fields are	Sequence-number	Y
			Report-time-stamp	Y
			Reason-for-inclusion	Y
			Data-set-name	Y
			Data-reference	Y
			Buffer-overflow	N
			EntryID	N
			Conf-rev	Y
Segmentation	N			
Rp3	1,2	Can the server send segmented reports	No	
Rp4	1,2	Mechanism on second internal data change notification of the same analogue data value within buffer period (Compare IEC 61850-7-2 §14.2.2.9)	Send report immediately	
Rp5	1	Multi-client URCB approach (compare IEC 61850-7-2:2003 §14.2.1)	Each URCB is visible to all clients	
Rp6	-	What is the format of EntryID	Deprecated	
Rp7	1,2	What is the buffer size for each BRCB or how many reports can be buffered	BRCB are not supported.	
Rp8	-	Pre-configured RCB attributes that are dynamic, compare SCL report settings	Deprecated	
Rp9	1	May the reported data set contain:	-structured data objects?	Y
			-data attributes?	Y
R10	1,2	What is the scan cycle for binary events Is this fixed, configurable	100 ms	
			Fixed	

ID	ED	Description	Value/Clarification
RP11	1	Does the device support to preassign a RCB to a specific client in the SCL	SCL is not used as a configurable item in this device.
RP12	2	After restart of the server is the value of ConfRev restored from the original configuration or retained prior to restart	Restored from original configuration

## PIXIT for Logging Model

ID	ED	Description	Value/Clarification
Lg1	1,2	What is the default value of LogEna (Compare IEC 61850-8-1 §17.3.3.2.1, the default value should be FALSE)	Logging not supported.
Lg2	-	What is the format of EntryID	Deprecated
Lg3	1,2	Are there are multiple Log Control Blocks that specify the Journaling of the same MMS NamedVariable and TrgOps and the Event Condition (Compare IEC 61850-8-1 §17.3.3.3.2)	Logging not supported.
Lg4	1	Preconfigured LCB attributes that cannot be changed online	Logging not supported.

## PIXIT for GOOSE Publish Model

ID	ED	Description	Value/Clarification
Gp1	1,2	Can the test (Ed1) / simulation (Ed2) flag in the published GOOSE be set	GOOSE not supported.
Gp2	1	What is the behavior when the GOOSE publish configuration is incorrect	GOOSE not supported.
Gp3	1,2	Published FCD supported common data classes are	GOOSE not supported.
Gp4	1,2	What is the slow retransmission time Is it fixed or configurable	GOOSE not supported.
Gp5	1,2	What is the fastest retransmission time Is it fixed or configurable	GOOSE not supported.
Gp6	-	Can the GOOSE publish be turned on / off by using SetGoCBValues(GoEna)	Deprecated
Gp7	1,2	What is the initial GOOSE sqNum after restart	GOOSE not supported.
Gp8	1	May the GOOSE data set contain: <ul style="list-style-type: none"> <li>• structured data objects (FCD)</li> <li>• timestamp data attributes</li> </ul>	GOOSE not supported.

## PIXIT for GOOSE Subscribe Model

ID	ED	Description	Value/Clarification
Gs1	1,2	<p>What elements of a subscribed GOOSE header are checked to decide the message is valid and the allData values are accepted? If yes, describe the conditions.</p> <p>Notes:</p> <ul style="list-style-type: none"> <li>the VLAN tag may be removed by a Ethernet switch and shall not be checked</li> <li>the simulation flag shall always be checked (Ed2)</li> <li>the ndsCom shall always be checked (Ed2)</li> </ul>	<p>destination MAC address NA</p> <p>APPID NA</p> <p>gocbRef NA</p> <p>timeAllowedtoLive NA</p> <p>datSet NA</p> <p>goID NA</p> <p>t NA</p> <p>stNum NA</p> <p>sqNum NA</p> <p>simulation / test NA</p> <p>confRev NA</p> <p>ndsCom NA</p> <p>numDatSetEntries NA</p>
Gs2	1,2	When is a subscribed GOOSE marked as lost (TAL = time allowed to live value from the last received GOOSE message)	GOOSE not supported.
Gs3	1,2	What is the behavior when one or more subscribed GOOSE messages isn't received or syntactically incorrect (missing GOOSE)	GOOSE not supported.
Gs4	1,2	What is the behavior when a subscribed GOOSE message is out-of-order	GOOSE not supported.
Gs5	1,2	What is the behavior when a subscribed GOOSE message is duplicated	GOOSE not supported.
Gs6	1	Does the device subscribe to GOOSE messages with/without the VLAN tag	GOOSE not supported.
Gs7	1	<p>May the GOOSE data set contain:</p> <ul style="list-style-type: none"> <li>structured data objects (FCD)</li> <li>timestamp data attributes</li> </ul>	GOOSE not supported.
Gs8	1,2	Subscribed FCD supported common data classes are	GOOSE not supported.
Gs9	1,2	Are subscribed GOOSE with test=T (Ed1) / simulation=T (Ed2) accepted in test/simulation mode	GOOSE not supported.

## PIXIT for GOOSE Performance

ID	ED	Description	Value/Clarification
Gf1	1,2	Performance class	GOOSE not supported.
Gf2	1,2	GOOSE ping-pong processing method	GOOSE not supported.
Gf3	1,2	Application logic scan cycle (ms)	GOOSE not supported.
Gf4	1	Maximum number of data attributes in GOOSE dataset (value and quality has to be counted as separate attributes)	GOOSE not supported.

## PIXIT for Control Model

ID	ED	Description	Value/Clarification	
Ct1	1	What control models are supported (compare PICS)	DOns	N
			SBOns	N
			DOes	N
			SBOes	N
Ct2	1,2	Is the control model fixed, configurable and/or dynamic	Fixed	
Ct3	-	Is TimeActivatedOperate supported (compare PICS or SCL)	Deprecated	
Ct4	1,2	Is "operate-many" supported (compare sboClass)	N	
Ct5	1	Will the DUT activate the control output when the test attribute is set in the SelectWithValue and/or Operate request (when N test procedure Ct12 is applicable)	N	
Ct6	-	What are the conditions for the time (T) attribute in the SelectWithValue and/or Operate request	Deprecated	
Ct7	-	Is pulse configuration supported (compare pulseConfig)	Deprecated	
Ct8	1	What is the behavior of the DUT when the check conditions are set	Synchrocheck	N
			Interlock-check	N
		Is this behavior fixed, configurable, online changeable	Not applicable	

ID	ED	Description	Value/Clarification	
Ct9	1,2	Which additional cause diagnosis are supported	Unknown	N
			Not-supported	N
			Blocked-by-switching-hierarchy	N
			Select-failed	N
			Invalid-position	N
			Position-reached	N
			Parameter-change-in-execution	N
			Step-limit	N
			Blocked-by-Mode	N
			Blocked-by-process	N
			Blocked-by-interlocking	N
			Blocked-by-synchrocheck	N
			Command-already-in-execution	N
			Blocked-by-health	N
			1-of-n-control	N
			Abortion-by-cancel	N
			Time-limit-over	N
			Abortion-by-trip	N
			Object-not-selected	N
			Edition 2 specific values:	
			Object-already-selected	N
			No-access-authority	N
			Ended-with-overshoot	N
			Abortion-due-to-deviation	N
			Abortion-by-communication-loss	N
			Blocked-by-command	N
None	N			
Inconsistent-parameters	N			
Locked-by-other-client	N			
Ct10	1,2	How to force a "test-not-ok" respond with SelectWithValue request	Not applicable	
Ct11	1,2	How to force a "test-not-ok" respond with Select request	Not applicable	
Ct12	1,2	How to force a "test-not-ok" respond with Operate request	DOns	N
			SBOns	N
			DOes	N
			SBOes	N

ID	ED	Description	Value/Clarification	
Ct13	1,2	Which origin categories are supported	bay-control	N
			station-control	N
			remote-control	N
			automatic-bay	N
			automatic-station	N
			automatic-remote	N
			maintenance	N
		process	N	
Ct14	1,2	What happens if the orCat value is not supported or invalid	DOns	N
			SBOs	N
			DOes	N
			SBOes	N
Ct15	1,2	Does the IED accept a SelectWithValue / Operate with the same control value as the current status value	DOns	N
			SBOs	N
			DOes	N
			SBOes	N
		Is this behavior configurable	Configurable	N
Ct16	1	Does the IED accept a select/operate on the same control object from 2 different clients at the same time	DOns	N
			SBOs	N
			DOes	N
			SBOes	N
Ct17	1	Does the IED accept a Select/SelectWithValue from the same client when the control object is already selected (Tissue #334)	SBOs	N
			SBOes	N
Ct18	1,2	Is for SBOes the internal validation performed during the SelectWithValue and/or Operate step	Not applicable	
Ct19	-	Can a control operation be blocked by Mod=Off or [On-]Blocked (Compare PIXIT-Sr5)	Deprecated	
Ct20	1,2	Does the IED support local / remote operation	Not applicable	
Ct21	1,2	Does the IED send an InformationReport with LastApplError as part of the Operate response- for control with normal security	SBOs	N
			DOns	N
Ct22	2	How to force a "parameter-change-in-execution"	SBOs	N
			SBOes	N
Ct23	1,2	Can a controllable object be forced to keep its old state e.g. Internal Controllable Objects may not be accessible to force this, whereas a switch like Circuit Breaker outside the DUT can?	Not applicable	
Ct24	1,2	When CDC=DPC is supported, is it possible to have DPC (Controllable Double Point) go to the intermediate state? (00)	Not applicable	
Ct25	1,2	Do any objects have Operate Timeout > 0	DOes	N
			SBOes	N

ID	ED	Description	Value/Clarification	
Ct26	2	Does the IED support control objects with external signals	DOns	N
			SBOs	N
			DOes	N
			SBOes	N
Ct27	2	Does the IED support DPC control objects with external signals	DOns	N
			SBOs	N
			DOes	N
			SBOes	N

## PIXIT for Time Synchronization Model

ID	ED	Description	Value/Clarification	
Tm1	1	What time quality bits are supported (may be set by the IED)	LeapSecondsKnown	Y
			ClockFailure	Y
			ClockNotSynchronized	N
Tm2	1,2	Describe the behavior when the time server(s) ceases to respond What is the time server lost detection time	Relies on internal clock. It can take up to 1024 seconds to detect time server lost but the time server lost event is not reported	
Tm3	1,2	How long does it take to take over the new time from time server	Up to 1024 s. (17 min.).	
Tm4	1,2	When is the time quality bit "ClockFailure" set	When real-time clock fails that bit will be set.	
Tm5	1,2	When is the time quality bit "Clock not Synchronized" set	Not supported.	
Tm6	-	Is the timestamp of a binary event adjusted to the configured scan cycle	Deprecated.	
Tm7	1	Does the device support time zone and daylight saving	Time is UTC so no direct support for timezone and DST.	
Tm8	1,2	Which attributes of the SNTP response packet are validated	Leap indicator not equal to 3	N
			Mode is equal to SERVER	N
			OriginateTimestamp is equal to value sent by the SNTP client as Transmit Timestamp	N
			RX/TX timestamp fields are checked for reasonableness	N
			SNTP version 3 and/or 4	4
		other (describe)	NA	
Tm9	1,2	Do the COMTRADE files have local time or UTC time and is this configurable	Not applicable.	



## PIXIT for File Transfer Model

ID	ED	Description	Value/Clarification
Ft1	1	What is structure of files and directories Where are the COMTRADE files stored Are comtrade files zipped and what files are included in each zip file	File transfer not supported.
Ft2	1,2	Directory names are separated from the file name by	File transfer not supported.
Ft3	1	The maximum file name size including path (recommended 64 chars)	File transfer not supported.
Ft4	1,2	Are directory/file name case sensitive	File transfer not supported.
Ft5	1,2	Maximum file size for SetFile	File transfer not supported.
Ft6	1	Is the requested file path included in the MMS fileDirectory respond file name	File transfer not supported.
Ft7	1	Is the wild char supported MMS fileDirectory request	File transfer not supported.
Ft8	1,2	Is it allowed that 2 clients get a file at the same time	File transfer not supported.

## PIXIT for Service Tracking Model

ID	ED	Description	Value/Clarification
Tr1	2	Which ACSI services are tracked by LTRK.GenTrk	Not applicable.

# MICS

## Logical Nodes List

The following table contains the list of logical nodes implemented in the device:

<b>L: System Logical Nodes</b>
LPHD (physical device information)
LLN0 (logical node zero)
<b>G: Logical Nodes for Generic References</b>
GGIO (generic process I/O)
<b>S: Logical Nodes for Sensors and Monitoring</b>
SIML (insulation medium supervision [liquid])

## SIML—Insulation medium supervision (liquid)

The IEC 61850-7-4 ed.1 SIML node was extended with data objects defined in technical report IEC 61850-90-4, ed.1.

SIML				
DO Name	CDC	Explanation	M/O/C/E	Remarks
LNNName		Shall be inherited from Logical-Node Class (see IEC 61850-7-2)		
<b>Data Objects</b>				
<b>Common Logical Node Information</b>				
Mod	INC	Mode	M	
Beh	INS	Behavior	M	
Health	INS	Health	M	
NamPlt	LPL	Name plate	M	
<b>Measured Values</b>				
H2O	MV	Relative saturation of moisture in insulating liquid (in %)	O	
H2OTmp	MV	Temperature of insulating liquid at point of H <sub>2</sub> O measurement	O	
H2	MV	Measurement of Hydrogen (H <sub>2</sub> in ppm)	O	
H2Oppm	MV	Measurement of moisture (H <sub>2</sub> O in ppm)	E	
H2RoC	MV	Hydrogen rate of change (H <sub>2</sub> RoC in ppm/day)	E	
MstRoC	MV	Moisture rate of change (H <sub>2</sub> O RoC in ppm/day)	E	
<b>Status Information</b>				
InsAlm	SPS	Insulation liquid critical (refill isolation medium)	M	
H2Alm	SPS	Hydrogen alarm	O	
MstAlm	SPS	Moisture sensor alarm	O	
H2RoCAIm	SPS	Hydrogen rate of change alarm	E	
H2ORoCAIm	SPS	Moisture rate of change alarm	E	
H2Wrn	SPS	Hydrogen warning	E	
MstWrn	SPS	Moisture sensor warning	E	

SIML				
DO Name	CDC	Explanation	M/O/C/E	Remarks
H2RoCWrn	SPS	Hydrogen rate of change warning	E	
MstRoCWrn	SPS	Moisture rate of change warning	E	
<b>Settings</b>				
H2AlmSpt	ASG	Hydrogen alarm set point	E	
MstAlmSpt	ASG	Moisture sensor alarm set point	E	
H2RoCAImSpt	ASG	Hydrogen rate of change alarm set point	E	
MstRoCAImSpt	ASG	Moisture rate of change alarm set point	E	
H2WrnSpt	ASG	Hydrogen warning set point	E	
MstWrnSpt	ASG	Moisture sensor warning set point	E	
H2RoCWrnSpt	ASG	Hydrogen rate of change warning set point	E	
MstRoCWrnSpt	ASG	Moisture rate of change warning set point	E	

## PICS

### ACSI Basic Conformance Statement

The basic conformance statement is defined in the following table.

		Client/ Subscriber	Server/ Publisher	Value/ Comments
<b>Client-Server Roles</b>				
B11	Server side (of TWO-PARTY-APPLICATION-ASSOCIATION)		Y	
B12	Client side of (TWO-PARTY-APPLICATION-ASSOCIATION)		-	
<b>SCSMs Supported</b>				
B21	SCSM: IEC 61850-8-1 used		Y	
B22	SCSM: IEC 61850-9-1 used		N	Deprecated Ed2
B23	SCSM: IEC 61850-9-2 used		N	
B24	SCSM: other		N	
<b>Generic Substation Event Model (GSE)</b>				
B31	Publisher side		N	
B32	Subscriber side		-	
<b>Transmission of Sampled Value Model (SVC)</b>				
B41	Publisher side		N	
B42	Subscriber side		-	

- = not applicable

Y = supported

N or empty = not supported

# ACSI Models Conformance Statement

The ACSI models conformance statement is defined below.

	Client/ Subscriber	Server/ Publisher	Value/ Comments
If Server side (B11) and/or Client side (B12) supported			
M1	Logical device	Y	
M2	Logical node	Y	
M3	Data	Y	
M4	Data set	Y	
M5	Substitution	N	
M6	Setting group control	N	
<b>Reporting</b>			
M7	Buffered report control	N	
M7.1	sequence-number	N	
M7.2	report-time-stamp	N	
M7.3	reason-for-inclusion	N	
M7.4	data-set-name	N	
M7.5	data-reference	N	
M7.6	buffer-overflow	N	
M7.7	entryID	N	
M7.8	BufTm	N	
M7.9	IntgPd	N	
M7.10	GI	N	
M7.11	conf-revision	N	
M8	Unbuffered report control	Y	
M8.1	sequence-number	Y	
M8.2	report-time-stamp	Y	
M8.3	reason-for-inclusion	Y	
M8.4	data-set-name	Y	
M8.5	data-reference	Y	
M8.6	BufTm	Y	
M8.7	IntgPd	Y	
M8.8	GI	Y	
M8.9	conf-revision	Y	
<b>Logging</b>			
M9	Log control	N	
M9.1	IntgPd	N	
M10	Log	N	
M11	Control	Y	
M17	File Transfer	N	
M18	Application association	Y	

	Client/ Subscriber	Server/ Publisher	Value/ Comments
M19	GOOSE Control Block	N	
M20	Sampled Value Control Block	N	
<b>If GSE (B31/32) is supported</b>			
M12	GOOSE	N	
M13	GSSE	N	Deprecated Ed2
<b>If SVC (B41/42) is supported</b>			
M14	Multicast SVC	N	
M15	Unicast SVC	N	
For all IEDs			
M16	Time	Y	Time source with required accuracy shall be available. Only Time Master are SNTP (Mode 4 response) time server. All other Client / Server devices require SNTP (Mode 3 request) clients

Y = service is supported

N or empty = service is not supported

## ACSI Service Conformance Test

The ACSI service conformance statement is defined below (depending on the statements in ACSI Basic Conformance Statement and in ACSI Models Conformance Statement).

	Ed.	Services	AA: TP/MC	Client (C)	Server (S)	Comments
<b>Server</b>						
S1	1,2	GetServerDirectory (LOGICAL-DEVICE)	TP		Y	
<b>Application Association</b>						
S2	1,2	Associate			Y	
S3	1,2	Abort			Y	
S4	1,2	Release			Y	
<b>Logical Device</b>						
S5	1,2	GetLogicalDeviceDirectory	TP		Y	
<b>Logical Node</b>						
S6	1,2	GetLogicalNodeDirectory	TP		Y	
S7	1,2	GetAllDataValues	TP		Y	
<b>Data</b>						
S8	1,2	GetDataValues	TP		Y	
S9	1,2	SetDataValues	TP		Y	
S10	1,2	GetDataDirectory	TP		Y	
S11	1,2	GetDataDefinition	TP		Y	
<b>Data Set</b>						
S12	1,2	GetDataSetValues	TP		Y	

	<b>Ed.</b>	<b>Services</b>	<b>AA: TP/MC</b>	<b>Client (C)</b>	<b>Server (S)</b>	<b>Comments</b>
S13	1,2	SetDataSetValues	TP		N	
S14	1,2	CreateDataSet	TP		N	
S15	1,2	DeleteDataSet	TP		N	
S16	1,2	GetDataSetDirectory	TP		Y	
<b>Substitution</b>						
S17	1	SetDataValues	TP		N	
<b>Setting Group Control</b>						
S18	1,2	SelectActiveSG	TP		N	
S19	1,2	SelectEditSG	TP		N	
S20	1,2	SetSGValues	TP		N	
S21	1,2	ConfirmEditSGValues	TP		N	
S22	1,2	GetSGValues	TP		N	
S23	1,2	GetSGCBValues	TP		N	
<b>Reporting</b>						
<b>Buffered Report Control Block (BRCB)</b>						
S24	1,2	Report	TP		N	
S24-1	1,2	data-change (dchg)			N	
S24-2	1,2	quality-change (qchg)			N	
S24-3	1,2	data-update (dupd)			N	
S25	1,2	GetBRCBValues	TP		N	
S26	1,2	SetBRCBValues	TP		N	
<b>Unbuffered Report Control Block (URCB)</b>						
S27	1,2	Report	TP		Y	
S27-1	1,2	data-change (dchg)			Y	
S27-2	1,2	qchg-change (qchg)			Y	
S27-3	1,2	data-update (dupd)			Y	
S28	1,2	GetURCBValues	TP		Y	
S29	1,2	SetURCBValues	TP		Y	
<b>Logging</b>						
<b>Log Control Block</b>						
S30	1,2	GetLCBValues	TP		N	
S31	1,2	SetLCBValues	TP		N	
<b>Log</b>						
S32	1,2	QueryLogByTime	TP		N	
S33	1,2	QueryLogAfter	TP		N	
S34	1,2	GetLogStatusValues	TP		N	
<b>Generic substation event model (GSE)</b>						
<b>GOOSE</b>						
S35	1,2	SendGOOSEMessage	MC		N	

Ed.	Services	AA: TP/MC	Client (C)	Server (S)	Comments
<b>GOOSE-CONTROL-BLOCK</b>					
S36	1,2	GetReference	TP	N	
S37	1,2	GetGOOSEElementNumber	TP	N	
S38	1,2	GetGoCBValues	TP	N	
S39	1,2	SetGoCBValues	TP	N	
<b>GSSE</b>					
S40	1	SendGSSEMessage	MC	N	Deprecated in Edition 2
<b>GSSE-CONTROL-BLOCK</b>					
S41	1	GetReference	TP	N	Deprecated in Edition 2
S42	1	GetGSSEElementNumber	TP	N	Deprecated in Edition 2
S43	1	GetGsCBValues	TP	N	Deprecated in Edition 2
S44	1	SetGsCBValues	TP	N	Deprecated in Edition 2
<b>Transmission of Sampled Value Model (SVC)</b>					
<b>Multicast SVC</b>					
S45	1,2	SendMSVMessage	MC	N	
<b>Multicast Sampled Value Control Block</b>					
S46	1,2	GetMSVCBValues	TP	N	
S47	1,2	SetMSVCBValues	TP	N	
<b>Unicast SV</b>					
S48	1,2	SendUSVMessage	TP	N	
<b>Unicast Sampled Value Control Block</b>					
S49	1,2	GetUSVCBValues	TP	N	
S50	1,2	SetUSVCBValues	TP	N	
<b>Control</b>					
S51	1,2	Select		N	
S52	1,2	SelectWithValue	TP	N	
S53	1,2	Cancel	TP	N	
S54	1,2	Operate	TP	N	
S55	1,2	Command-Termination	TP	N	
S56	1,2	TimeActivated-Operate	TP	N	
<b>File Transfer</b>					
S57	1,2	GetFile	TP	N	
S58	1,2	SetFile	TP	N	
S59	1,2	DeleteFile	TP	N	
S60	1,2	GetFileAttributeValues	TP	N	
S61	1,2	GetServerDirectory (FILE-SYSTEM)	TP	N	

Ed.	Services	AA: TP/MC	Client (C)	Server (S)	Comments
<b>Time</b>					
T1	1,2	Time resolution of internal clock		2 <sup>-9</sup> seconds	Nearest negative power of 2 <sup>-n</sup> in seconds (number 0 .. 24)
T2	1,2	Time accuracy of internal clock		Unspecified	TL (ms) (low accuracy), T3 < 7) (only Ed2) T0 (ms) (<= 10 ms), 7 <= T3 < 9 T1 (μs) (<= 1 ms), 10 <= T3 < 13 T2 (μs) (<= 100 μs), 13 <= T3 < 15 T3 (μs) (<= 25 μs), 15 <= T3 < 18 T4 (μs) (<= 25 μs), 15 <= T3 < 18 T5 (μs) (<= 1 μs), T3 >= 20
T3	1,2	Supported TimeStamp resolution		2 <sup>-24</sup> seconds	Nearest value of 2 <sup>-n</sup> in seconds (number 0 .. 24)

## TICS Mandatory IntOp TISSUES

The table below gives an overview of the implemented IntOp Tissues.



### NOTICE

- Tissue 49, 190, 191, 275 and 278 are part of tissue #453, all other technical tissues in the table are mandatory if applicable.
- Editorial tissues are marked as "NA".
- Final proposal on tissue 45 is not defined yet

Part	TISSUE No.	Description	Impl. Y/NA
8-1	116	GetNameList with empty response?	Y
	165	Improper Error Response for GetDataSetValues	Y
	183	GetNameList error handling	Y
	246	Control negative response (SBOs) with LastAppLError	NA
	545	Skip file directories with no files	NA
7-4	None		
7-3	28	Definition of APC	NA
	54	Point def xVal, not cVal	NA
	55	Ineut = Ires?	NA
	63	mag in CDC CMV	NA
	65	Deadband calculation of a Vector and trigger option	NA
	219	operTm in ACT	NA
	270	WYE and DEL rms values	NA
1199	BCR	NA	



Part	TISSUE No.	Description	Impl. Y/NA
7-2	30	control parameter T	NA
	31	Typo	NA
	32	Typo in syntax	NA
	35	Typo Syntax Control time	NA
	36	Syntax parameter DSet-Ref missing	NA
	37	Syntax GOOSE "T" type	NA
	39	Add DstAddr to GoCB	NA
	40	GOOSE Message "AppID" to "GoID"	NA
	41	GsCB "AppID" to "GsID"	NA
	42	SV timestamp: "EntryTime" to "TimeStamp"	NA
	43	Control "T" semantic	NA
	44	AddCause - Object not sel	NA
	45	Missing AddCauses	NA
	46	Synchro check cancel	NA
	47	“.” in LD Name?	Y
	49	BRCB TimeOfEntry (part of #453)	NA
	50	LNNName start with number?	Y
	51	ARRAY [0..num] missing	NA
	52	Ambiguity GOOSE SqNum	NA
	53	Add DstAddr to GsCB, SV	NA
	151	Name constraint for control blocks etc.	Y
	166	DataRef attribute in Log	NA
	185	Logging - Integrity period	NA
	189	SV Format	NA
	190	BRCB: EntryId and TimeOfEntry (part of #453)	NA
	191	BRCB: Integrity and buffering reports (part of #453)	NA
	278	EntryId not valid for a server (part of #453)	NA
333	Enabling of an incomplete GoCB	NA	
453	Combination of all reporting and logging tissues	NA	
1281	Trigger option GI is by default	NA	
6	1	Syntax	Y
	5	tExtensionAttributeNameEnum is restricted	Y
	8	SIUnit enumeration for W	Y
	10	Base type for bitstring usage	Y
	17	DAI/SDI elements syntax	Y
	169	Ordering of enum differs from 7-3	NA
	245	Attribute RptId in SCL	NA
	529	Replace sev - Unknown by unknown	Y

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# Sensor software update

Follow these steps to update the CoreSense hydrogen and moisture sensor.

The update procedure consists of two main steps:

- Prepare USB key
- Update CoreSense with USB Key

To prepare the USB key:

- 1** Obtain the CoreSense software image from ABB.
- 2** Extract the compressed content to USB key (make sure NOT to create a folder; install at the root of the USB filesystem)

Follow these additional instructions to update the software:

- 1** Remove the sensor cover (see "Removing the cover" on page 22).
- 2** Insert the ABB update USB key (see "Figure 3 CoreSense port and relay connections" on page 23).
- 3** Press the reset button.
- 4** The software update process takes place. During the update process the SYSTEM LED blinks YELLOW.
- 5** Upon a successful update, the SYSTEM LED will blink GREEN.
- 6** Remove the ABB Update USB key.
- 7** Press the reset button.
- 8** Using your laptop, connect to the web interface to verify the software version in the Help tab (see "Tabs of the CoreSense web interface" on page 33).
- 9** Re-install the sensor cover as per "Reinstalling the cover" on page 29.

Should the update fail, the SYSTEM LED will blink RED. Contact ABB in such a situation.

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APPENDIX F

# CoreSense default factory values

The table below contains all the values as they were configured at the factory.

Parameters	Description	Default value	Details
<b>Hydrogen</b>			
hydrogen.sensor-offset	hydrogen sensor offset correction	0	See “Hydrogen settings” on page 36.
hydrogen.slope-correction	hydrogen slope correction	1.0	
hydrogen.roc24h-trigger	hydrogen rate of change over 24h trigger (in ppm/day)	80	
hydrogen.level-warning	hydrogen level warning (in ppm)	100	
hydrogen.level-critical	hydrogen level critical (in ppm)	250	
hydrogen.roc24h-warning	hydrogen rate of change 24h warning	10	
hydrogen.roc24h-critical	hydrogen rate of change over 24h critical	25	
<b>Moisture</b>			
moisture.sensor-offset	moisture sensor offset correction	0	See “Moisture settings” on page 37.
moisture.slope-correction	moisture slope correction	1	
moisture.level-warning	moisture level warning (in ppm)	20	
moisture.level-critical	moisture level critical (in ppm)	30	
moisture.roc24h-trigger	moisture rate of change over 24h trigger (in ppm/day)	15	
moisture.roc24h-warning	moisture rate of change over 24h warning	5	
moisture.roc24h-critical	moisture rate of change over 24h critical	10	
moisture.oil-A	moisture oil A	1666.33	
moisture.oil-B	moisture oil B	7.36	
<b>System</b>			
system.settings-changes-allow-on-all-interfaces	Boolean:true		See “Communication settings” on page 39.
system.h2-420-min	Integer:0 # Hydrogen 420 value for 4 mA	0	
system.h2-420-max	Integer:1000 # Hydrogen 420 value for 20 mA	1000	
system.h2o-420-min	Integer:0 # Moisture 420 value for 4 mA	0	
system.h2o-420-max	Integer:80 # Moisture 420 value for 20 mA	80	
<b>Hardware</b>			
hardware.modbus-tcp-port	Integer:502	502	
hardware.dnp3-tcp-port	Integer:20000	20000	

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APPENDIX G

# System events

Name	Description	Recommended action
Date_Time_chg	Manual Modification of system date and time	—
Hydrogen_Warning_Level_chg	Hydrogen Warning Level set point changed	—
Hydrogen_Alarm_Level_chg	Hydrogen Alarm Level set point changed	—
Hydrogen_Warning_Delta_chg	Hydrogen Warning rate of change set point changed	—
Hydrogen_Alarm_Delta_chg	Hydrogen Alarm rate of change set point changed	—
Hydrogen_Warning_Publishing_off	Hydrogen Warning Level disabled	—
Hydrogen_Warning_Publishing_on	Hydrogen Warning Level enabled	—
Hydrogen_Alarm_Publishing_off	Hydrogen Alarm Level disabled	—
Hydrogen_Alarm_Publishing_on	Hydrogen Alarm Level enabled	—
Hydrogen_Warning_Level_ack	Hydrogen Warning Level acknowledged	—
Hydrogen_Alarm_Level_ack	Hydrogen Alarm Level acknowledged	—
Hydrogen_Warning_Delta_ack	Hydrogen Warning rate of change acknowledged	—
Hydrogen_Alarm_Delta_ack	Hydrogen Alarm rate of change acknowledged	—
System_restart	System restart	—
Hydrogen_Level_Warning	Hydrogen Level above Warning Threshold	Investigate the transformer condition
Hydrogen_Level_Alarm	Hydrogen Level above Alarm Threshold	Investigate the transformer condition
Hydrogen_Delta24_Warning	Hydrogen rate of change above Warning Threshold	Investigate the transformer condition
Hydrogen_Delta24_Alarm	Hydrogen rate of change above Alarm Threshold	Investigate the transformer condition
System_Warning. BOARD_OVER_TEMP	The system will report this WARNING when internal temperature is above the defined threshold	Make sure that the ambient temperature is within specifications
System_Warning. H2_SENSOR_OVER_TEMP	The system will report this WARNING when oil temperature is above the defined threshold with respect to the hydrogen probe	Make sure that the oil temperature is within specifications

<b>Name</b>	<b>Description</b>	<b>Recommended action</b>
System_Warning. H2_OFF_RANGE	The system will report this WARNING when the hydrogen value is out of the measurement range	This event indicates that the hydrogen measurement is outside its specified maximum range
System_Warning. H2O_OFF_RANGE	The system will report this WARNING when the moisture value is out of the measurement range	This event indicates that the moisture measurement is outside its specified maximum range
System_Warning SYSTEM_LOW_SPACE	The system will report this WARNING when it is running out of disk space	Contact ABB Service
SYSTEM_CRITICAL . H2_SENSOR_FATAL_ERROR	The system will report this ALARM when the hydrogen probe is in a fatal error condition	Power cycling may resolve this issue. If the condition persists, contact ABB Service
SYSTEM_CRITICAL .H2_SENSOR_NOT_READY	The system will report this ALARM when the hydrogen probe does not reach its ready state	Power cycling may resolve this issue If the condition persists, contact ABB Service
SYSTEM_CRITICAL.NO_NEW_H2_MEASUREMENT	The system will report this ALARM when it is no longer able to communicate with the hydrogen probe	Contact ABB Service
SYSTEM_CRITICAL.NO_NEW_H2O_MEASUREMENT	The system will report this ALARM when it is no longer able to communicate with the moisture probe	Contact ABB Service
THERMAL_PUMP_DISABLED	The system will report this Warning when the thermal pump is not enabled.	—



# Definition of exported values



## NOTICE

CoreSense records only the last 120 days of operation.

## Hydrogen.csv

See the table below for a description of the fields exported when using the Export button in the Hydrogen, Moisture or Event tab of the web interface.

Column name	Description
LOCAL TIME	Local timestamp for the measurement
AVERAGE (ppm)	Measured value
RoC 24h (ppm/day)	Calculated 24h rate-of-change value
RAW (ppm)	Native value without any treatment or post processing
CORRECTED (ppm)	Value after applying optional offset and bias

## Moisture.csv

See table below for a description of the exported fields.

Column name	Description
LOCAL TIME	Local timestamp for the measurement
TEMPERATURE (Celsius)	Oil temperature
RAW (aw)	Moisture measured in aw unit
PPM	Moisture converted to ppm units
CORRECTED (ppm)	Value after applying optional offset and bias
AVERAGE (ppm)	Measured value
RoC 24h (ppm/day)	Calculated 24h rate-of-change value

# Events.csv

See table below for a description of the exported fields.

<b>Column name</b>	<b>Description</b>
LOCAL TIME	Local timestamp for the measurement
EVENT	Name of the event
DESCRIPTION	Description of the event
ACKNOWLEDGED BY	When applicable, who acknowledged the event
ACKNOWLEDGED ON	When applicable, timestamp for acknowledgment
COMMENT	When applicable, optional comment from the person who acknowledged the event
RoC 24h (ppm/day)	Calculated 24h rate-of-change value

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