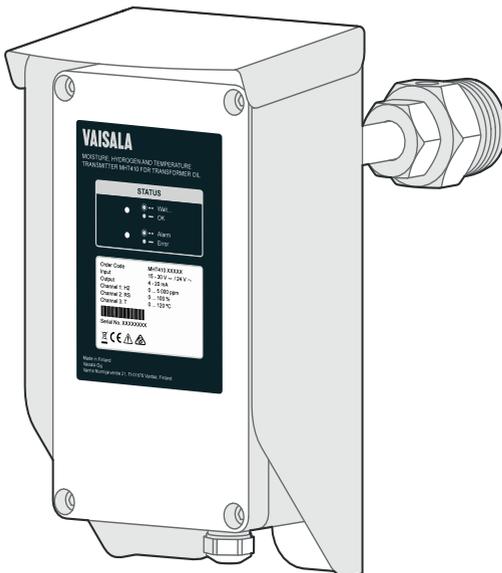


USER'S GUIDE

Vaisala Moisture, Hydrogen and Temperature Transmitter MHT410 for Transformer Oil



PUBLISHED BY

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SAFETY

Vaisala Moisture, Hydrogen and Temperature Transmitter MHT410 for Transformer Oil delivered to you has been tested for safety and approved as shipped from the factory. Note the following precautions:



Read the Quick Guide (including installation instructions) carefully before installing the product.



Ground the product and verify outdoor installation grounding periodically to minimize shock hazard.



Severe risk of death and of damage to transformer:

Pay attention to transmitter installation depth and possible energized parts inside the power transformer to minimize electric shock hazard and equipment damage.



Do not modify the unit. Improper modification can damage the product or lead to malfunction.



Do not try to close the ball valve when the transmitter is fully installed. The probe body goes through the valve into the oil flow, and trying to close the valve will damage the probe body.

If you must close the ball valve while the transmitter is on the valve, first open the small tightening nut and pull the probe body out as far as possible. Then close the valve.



To avoid damage to the installation valve of the transformer, do not step on the transmitter when the transmitter is installed.



Follow the safety regulations related to the application and installation site.

ESD Protection

Electrostatic Discharge (ESD) can cause immediate or latent damage to electronic circuits. Vaisala products are adequately protected against ESD for their intended use. However, it is possible to damage the product by delivering an electrostatic discharge when touching, removing or inserting any objects inside the equipment housing.

Use appropriate ESD protective equipment when handling the wiring and connectors under the front cover. Do not touch any parts under the circuit board cover.

2

GENERAL INFORMATION

About This Document

Table 1 Document Version History

Document Code	Date	Description
M211737EN-B	June 2015	This document. Updated the description of the <code>filt</code> command and the analog output accuracy specification. Added a clarification about the requirements for using Modbus with RS-485 User Port to calibration instructions.
M211737EN-A	May 2015	The first version.

Table 2 Related Manuals

Document Code	Description
M211736EN	Vaisala Moisture, Hydrogen and Temperature Transmitter MHT410 for Transformer Oil Quick Guide
M211784EN	Loop-Powered Display 242003 for MHT410 Technical Note

Documentation Conventions



Warning alerts you to a serious hazard. If you do not read and follow instructions very carefully at this point, there is a risk of injury or even death.



Caution warns you of a potential hazard. If you do not read and follow instructions carefully at this point, the product could be damaged or important data could be lost.



Note highlights important information on using the product.

Regulatory Compliances

Up-to-date declarations of conformity are available at request from Vaisala (www.vaisala.com).

This product is in compliance with the following EU directives:

- EMC Directive
- RoHS Directive

Conformity is shown by compliance to standards listed in [Technical Data on page 83](#).



Trademarks

HUMICAP® is a registered trademark of Vaisala Oyj.

All other trademarks are the property of their respective owners.

Software License

This product contains software developed by Vaisala. Use of the software is governed by license terms and conditions included in the applicable supply contract or, in the absence of separate license terms and conditions, by the General License Conditions of Vaisala Group.

Warranty

Visit our Internet pages for more information and our standard warranty terms and conditions: www.vaisala.com/warranty.

Please observe that any such warranty may not be valid in case of damage due to normal wear and tear, exceptional operating conditions, negligent handling or installation, or unauthorized modifications. Please see the applicable supply contract or Conditions of Sale for details of the warranty for each product.

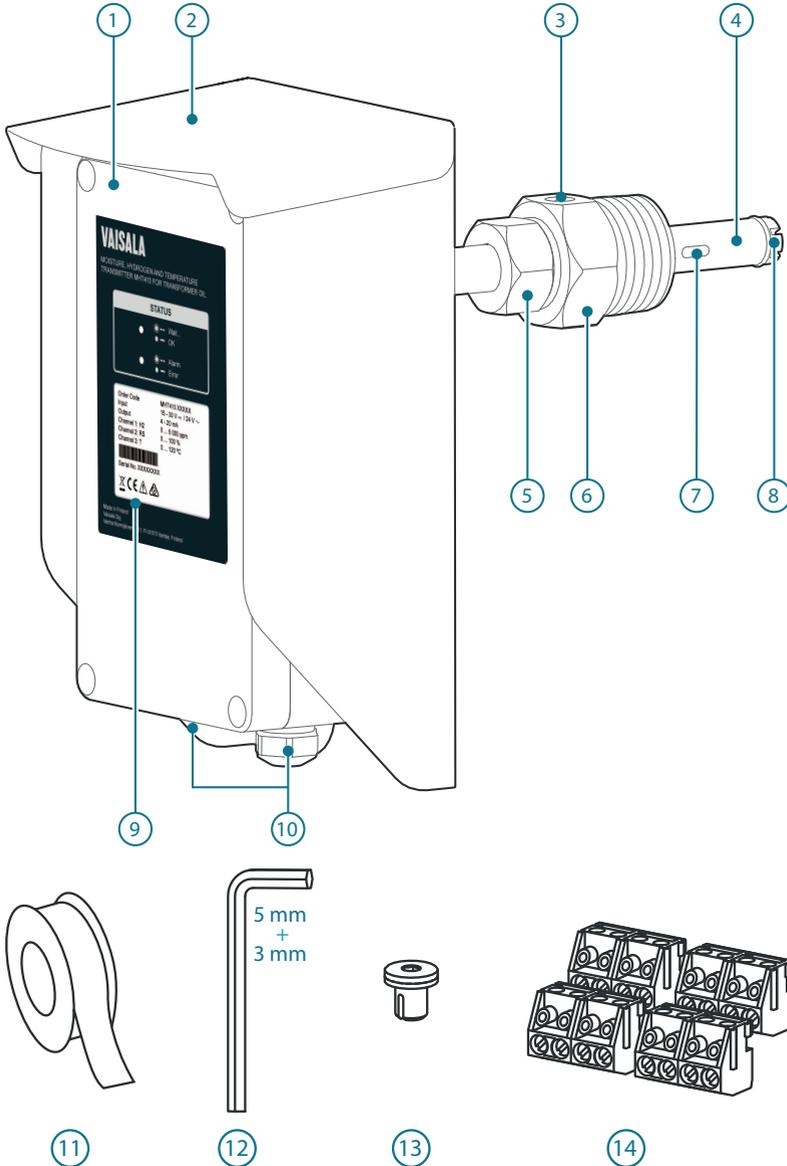
3

PRODUCT OVERVIEW

Vaisala Moisture, Hydrogen and Temperature Transmitter MHT410 for Transformer Oil is designed for online monitoring of insulating oil in power transformers. The transmitter provides an accurate real-time measurement result of moisture, hydrogen and temperature measured in oil, enabling reliable conclusions on the transformer's condition without delay.

The transmitter provides digital and analog outputs of all the measured parameters.

Product Parts and Package Contents



No.		Item
1	=	Electronics housing. The front cover is additionally connected to the housing with a grounding wire.
2	=	Weather shield
3	=	Bleed screw
4	=	Probe body
5	=	Small tightening nut, used to adjust and fix the depth of the transmitter in the valve. You can move the tightening nut and the mounting nut along the probe body.
6	=	Mounting nut, used to fasten the transmitter in the ball valve. You can move the tightening nut and the mounting nut along the probe body.
7	=	Hydrogen sensor
8	=	Moisture and temperature sensors under the filter
9	=	Product label
10	=	Lead-throughs (2 pcs) with a minimum of one cable gland (size M20x1.5) or conduit fitting. Unused lead-throughs are plugged.
Installation Kit:		
11	=	PTFE tape roll
12	=	Allen keys (3 mm and 5 mm)
13	=	Extra bleed screw and sealing ring
14	=	Extra terminal blocks (4 x 4 screw terminals)

For the dimensions of the transmitter, see [Dimensions on page 87](#).

Main Features

- Reliable online measurement of transformer oil for the following parameters:
 - Moisture: relative saturation (%RS), water activity, and water content (ppm)
 - Hydrogen concentration (ppm in oil)
 - Temperature (°C and °F)
- No need to take oil samples for measurement
- Installable and retro-fittable on a ball valve (1.5" NPT thread)
- Low maintenance requirements due to excellent long term stability
- Outputs
 - Digital: Modbus and Vaisala industrial protocol over RS-485
 - Analog: three channels with scalable current output
- Status indication LEDs in the front panel (see [Status LEDs on page 14](#))

- Built-in data logging (see [Data Logging below](#))
- USB connectivity for service connections using an optional USB M8 cable (see [Connecting via Service Port on page 38](#))
- Display options:
 - Loop-powered display for continuous use (see [Loop-Powered Display on page 29](#))
 - MI70 hand-held meter for temporary use (see [MI70 Hand-Held Indicator on page 66](#))

For detailed technical specifications, see [Technical Data on page 83](#).

Measurement Parameters and Units

Parameter	Abbreviation	Unit
H ₂ concentration in oil		
<ul style="list-style-type: none"> ■ 1 h average ■ 24 h average * 	H2	ppm
Rate of change of H ₂ concentration *		
In a day	Daily ROC	ppm/day
In a week	Weekly ROC	ppm/week
In a month	Monthly ROC	ppm/month
Moisture in oil		
Relative saturation	RS	%RS
Water activity	aw (=RS/100)	(no unit)
H ₂ O concentration in oil	H2O	ppm
Rate of change of H ₂ O concentration in oil *		
In a day	Daily ROC	ppm/day
In a week	Weekly ROC	ppm/week
In a month	Monthly ROC	ppm/month
Temperature		
Oil temperature	T	°C or °F

* Not available on analog output.

Data Logging

The transmitter automatically saves the measurement readings and other events in a log every 12 hours. The log can contain approximately 32000 entries.

The following events are logged:

- Hydrogen (ppm), moisture in oil (%RS and ppm) and temperature (°C) readings as 24 h averages, 1 h averages or instant values
- Power outages
 - Short power outages that don't turn off transmitter power (flagged "UPS")
 - Long power outages that turn off transmitter power (flagged first as "UPS" and then as "Reset")
- Manual resets (flagged as "Reset")
- Uptime and total operating time
- Occasions of exceeding hydrogen alarm level (optional)

To view the log and change the logging settings, use Vaisala industrial protocol. See [Vaisala Industrial Protocol on page 37](#) and [Log Command on page 49](#).



You can save the log as a file from PuTTY by configuring the following settings in PuTTY before opening the connection:

In the **Session > Logging** view:

- **Session logging:** Select "Printable output".
- **Log file name:** Type a name for the log file (use the file extension .txt) and browse to the save location.

To prevent the log from getting very long, consider saving and then clearing the log every few years.

Status LEDs

When the transmitter is ON, one of the LEDs is always illuminated (steady or blinking). If no LED is illuminated, the transmitter is OFF.

LED Color and Text	Description
Green, blinking:  Wait...	Transmitter is preparing H ₂ measurement after start-up or reset.
Green, steady:  OK	Transmitter is measuring.
Red, blinking:  Alarm	H ₂ concentration is above the alarm limit.
Red, steady:  Error	Transmitter is in error state.

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INSTALLATION



The installation instructions in this section are the same as in the MHT410 Quick Guide.



Before you install the transmitter:

- Go through the check list in section [Planning the Installation on the next page](#).
 - Read the Quick Guide (including installation instructions) carefully.
 - Make sure there is no negative pressure in the transformer. If there is negative pressure when you open the bleed screw during installation, air will flow into the transformer oil tank.
 - Do not open the ball valve on the transformer until you are instructed to do so in this guide.
 - Make sure the bleed screw on the mounting nut is closed.
-



Mechanical installation:

- Large wrench (50 mm)
- Medium wrench (36 mm)
- Allen key (3 mm, provided)
- PTFE tape (provided)
- Gloves
- Bucket and cloth

Electrical installation (if cable is not pre-wired):

- Allen key (5 mm, provided)
 - 2 medium wrenches (24 mm)
 - Flat head screwdriver (2.5 mm)
 - Wire-cutting pliers
 - Suitable cable. You can order the following cables from Vaisala:
 - 5 m shielded PUR cable (order code: CBL210392-5MSP)
 - 10 m shielded PUR cable (order code: CBL210392-10MSP)
-

Planning the Installation

- Choose the installation location on the transformer. See [Recommended Installation Locations on page 18](#).
- Make sure the installation valve is appropriate (female 1.5" NPT thread).

- Measure and record the installation depth in the chosen valve to achieve optimal measurement position for the sensors.

Valve in Radiator Pipe	Valve in Transformer Wall
<ul style="list-style-type: none"> ○ Moisture and temperature sensors are directly in the oil flow. This is because water molecule diffusion rate in oil is slow, and therefore moisture must be measured in moving oil. ○ Hydrogen sensor is in the valve area. This is because the hydrogen sensor needs an accurate temperature control, and therefore hydrogen must be measured in still oil. 	<p>Tip of the probe is level with transformer inner wall. No part of the probe must enter the transformer chamber. All sensors remain within the valve area.</p> <hr/> <div style="text-align: center;">  </div> <p>Severe risk of death and of damage to transformer:</p> <p>Pay attention to transmitter installation depth and possible energized parts inside the power transformer to minimize electric shock hazard and equipment damage.</p> <hr/>

- Choose the output signals: analog and/or digital.
- Choose the electrical wiring option. See [Wiring Diagrams on page 88](#).



If the transmitter was ordered with the Vaisala cable CBL210392-5M, the cable is already pre-connected to the transmitter according to Wiring Option 1.

- Make sure you have all the required tools for installing the transmitter. The required tools are presented in [Installation on page 15](#).

Recommended Installation Locations

The probe must always be installed in a valve.

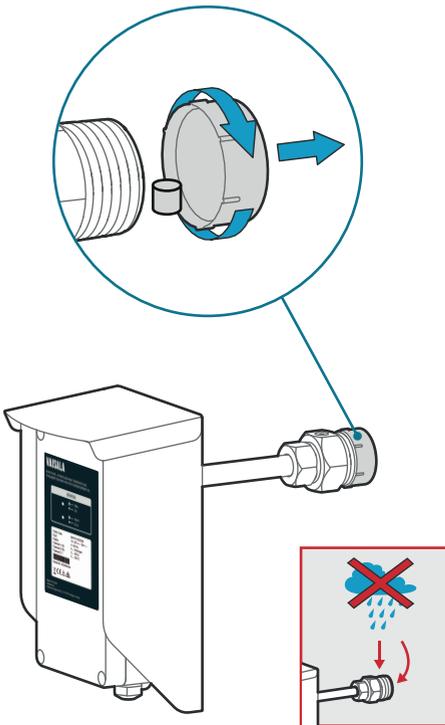
Recommendation	Description
 Recommended	<p>Straight section in the radiator's outlet pipe.</p> <p>This is the best location for the transmitter.</p> <p>The oil is measured in flow, which makes the oil sample representative and instant. This is essential especially for correct oil moisture measurement.</p> <p>Compared to the radiator inlet pipe, oil in the outlet pipe is cooled, preventing unnecessary heating of the sensors and the transmitter.</p>
 Possible alternative	<p>Side of the oil tank, high enough from the bottom to enable proper oil movement. An instrumentation valve is recommended with appropriate threads.</p> <p>This is a typical valve that is meant for oil analysis. Moisture response time is moderate depending on the oil volume and transmitter installation.</p> <hr style="border: 2px solid red;"/> <div style="display: flex; justify-content: center; gap: 20px;">   </div> <p>Severe risk of death and of damage to transformer:</p> <p>Pay attention to transmitter installation depth and possible energized parts inside the power transformer to minimize electric shock hazard and equipment damage.</p> <hr style="border: 2px solid red;"/>
 Not recommended	<p>Drain valve of the oil tank.</p> <p>The moisture response is poor due to static oil flow. There is also risk of separated water (leading to wrong results) and oil sludge (risk of sensor contamination and clogged filters).</p>

Mechanical Installation



Before you install the transmitter, make sure there is no negative pressure in the transformer. If there is negative pressure when you open the bleed screw during installation, air will flow into the transformer oil tank.

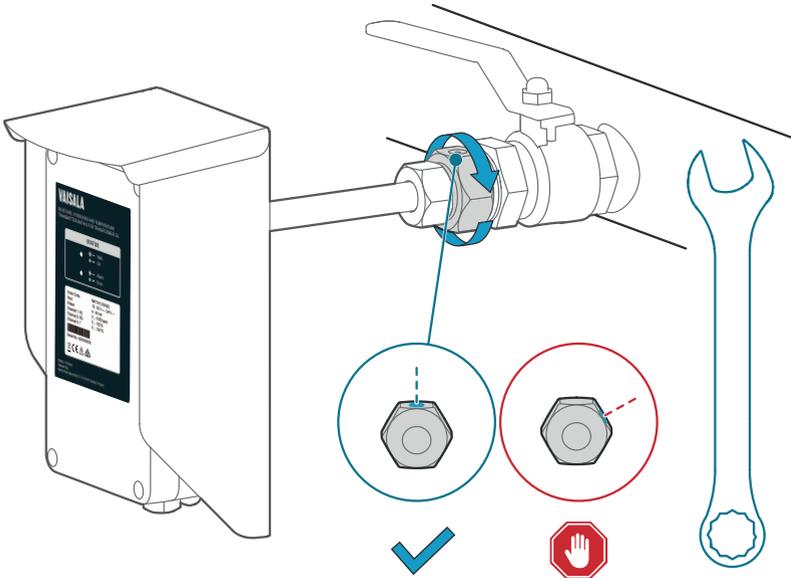
1. Remove the protective cap with sorbent packet from the mounting nut.
In case of rain, do not let any water fall on the filter.



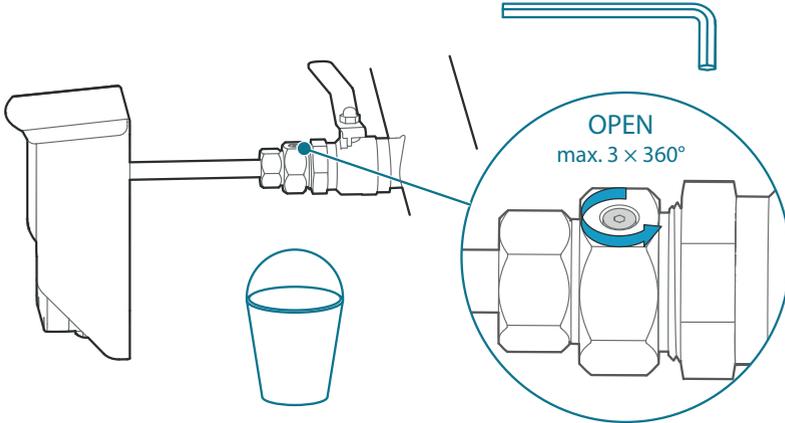
3. Fasten the mounting nut on the ball valve with your hand. Then tighten the mounting nut with a wrench. Leave the bleed screw directly on top of the nut.



Always make sure the bleed screw is closed before you turn the mounting nut with a wrench.



4. With a 3 mm Allen key, loosen the bleed screw. Place a bucket under the mounting nut.

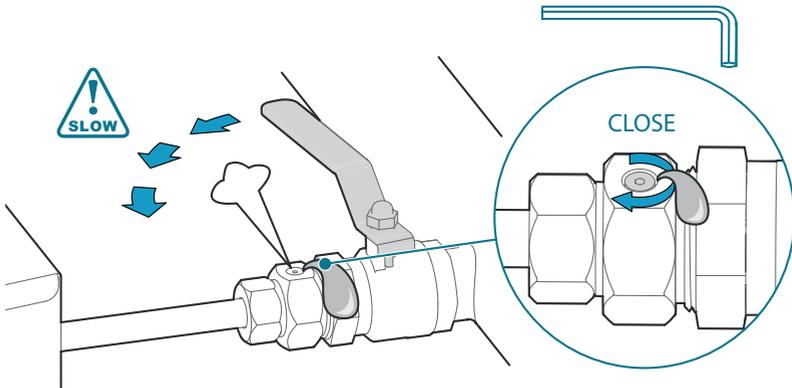


5. a. Start opening the valve **very carefully** to let air out through the bleed screw.

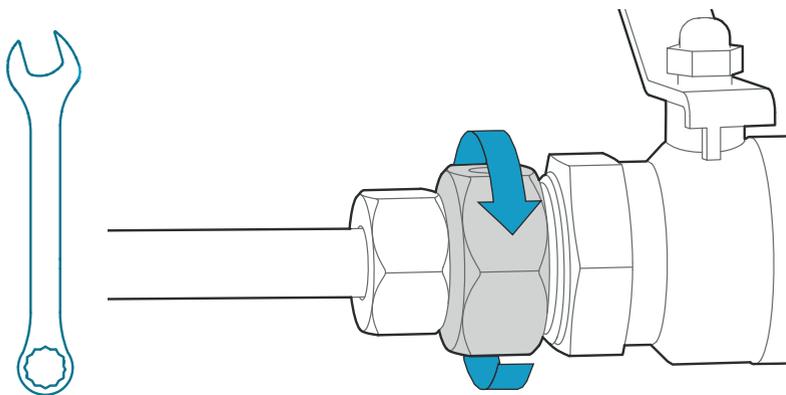


If you open the valve too quickly, the air inside the mounting nut will flow into the transformer instead.

- b. When oil flows out, close the bleed screw. Clean the area with a cloth and open the ball valve fully.

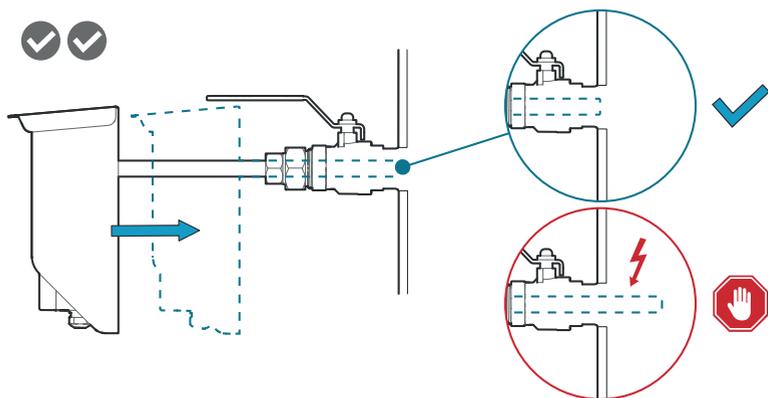
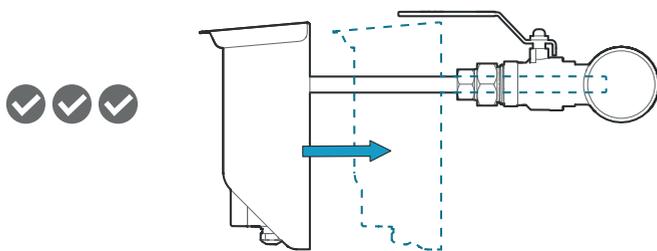


6. If needed, continue tightening the mounting nut until the connection is oil-tight.

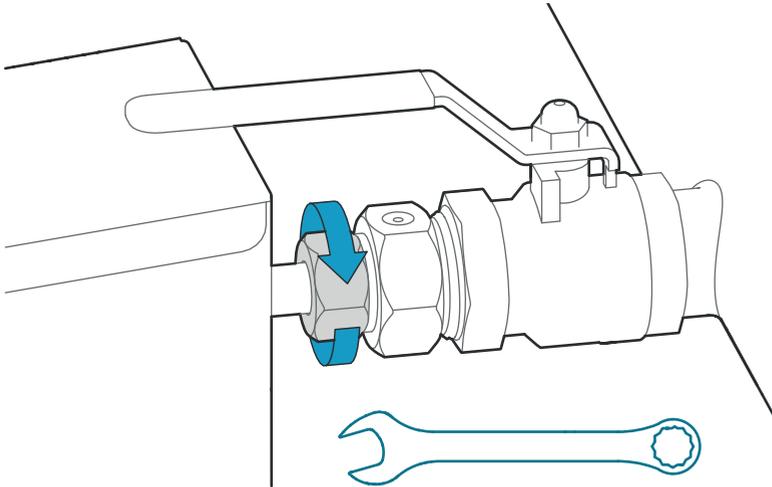


7. Push the probe to correct depth according to installation location.

Valve in Radiator Pipe	Valve in Transformer Wall
<ul style="list-style-type: none"> ○ Moisture and temperature sensors are directly in the oil flow. ○ Hydrogen sensor is in the valve area. 	<p>Tip of the probe is level with transformer inner wall. No part of the probe must enter the transformer chamber. All sensors remain within the valve area.</p> <hr style="border: 2px solid red;"/> <div style="display: flex; justify-content: center; align-items: center; gap: 10px;">   </div> <p>Severe risk of death and of damage to transformer:</p> <p>Pay attention to transmitter installation depth and possible energized parts inside the power transformer to minimize electric shock hazard and equipment damage.</p> <hr style="border: 2px solid red;"/>



8. Tighten the small tightening nut with a wrench until the probe is securely fastened.



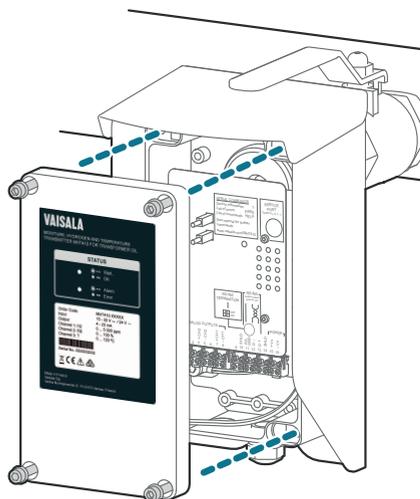
Electrical Installation



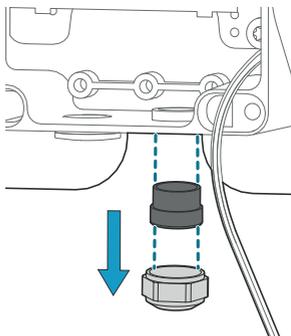
If the transmitter was ordered with the Vaisala cable CBL210392-5M, the cable is already pre-connected to the transmitter according to Wiring Option 1.

To connect the cable to the transmitter:

1. Open the electronics housing with a 5 mm Allen key to access the screw terminals.



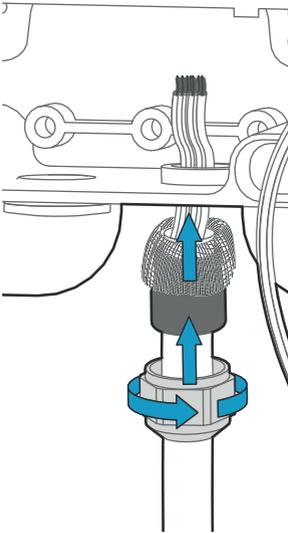
2. Hold the upper nut of the cable gland in place with a wrench (24 mm), and loosen the sealing nut of the gland with another wrench (24 mm).



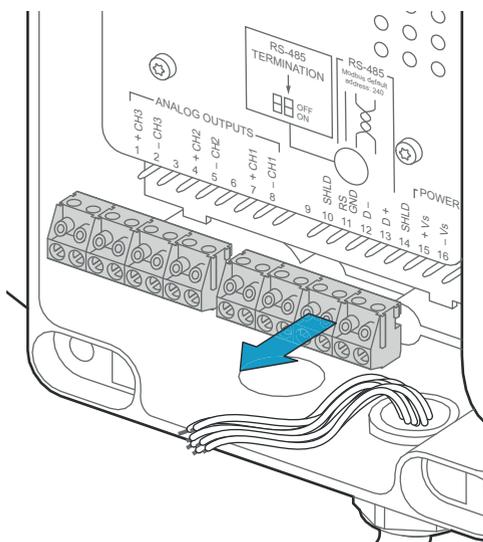
3. Lead the cable through the sealing nut and the rubber seal. Turn the shield over the edge of the rubber seal.



4. Lead the cable through the cable gland. Push the rubber seal back in place with the shield. Cut off any excess shield. Tighten the sealing nut with wrench (24 mm).



5. Pull the screw terminal blocks (2 pcs) off from the circuit board.



6. Connect the wiring to the detachable screw terminals according to your chosen electrical installation option. The options are presented in Wiring Diagrams on page 88. Note that wiring for digital output (RS-485) is the same in all wiring options.
7. When you are finished with the wiring, plug the screw terminals back in and close the electronics housing.

Loop-Powered Display

The analog outputs of the transmitter can be connected to an external loop-powered LED display (order code 242003). The display is a pre-configured Nokeval 302 display intended for Vaisala MHT410 hydrogen channel measurements.

The display also includes two alarm relays to trigger an external hydrogen warning and alarm.

This display can be configured for other parameters (moisture/temperature in oil). If needed, you can install up to three displays, each showing a different parameter.

The default display settings are presented in the Vaisala Technical Note inside the display package. If needed, configure the display functions and scaling

according to the manufacturer's instructions delivered with the display. Manufacturer's documentation is also available from www.nokeval.com.

For wiring instructions, see [Wiring the Display below](#).



Figure 1 Loop-Powered Display 242003



The loop resistance of the display must be included in the loop resistance calculation for the complete current loop. For the loop resistance of the display, refer to the manufacturer's documentation.

Wiring the Display



If one of the cable lead-throughs on your transmitter is plugged and you want to use that lead-through for the Nokeval display cable, you can order a cable gland from Vaisala. See [Spare Parts and Accessories on page 86](#).

Connect the loop-powered display to the transmitter as shown in the following wiring diagram. In the diagram, the display is connected to Channel 1 according to Wiring Option 1.

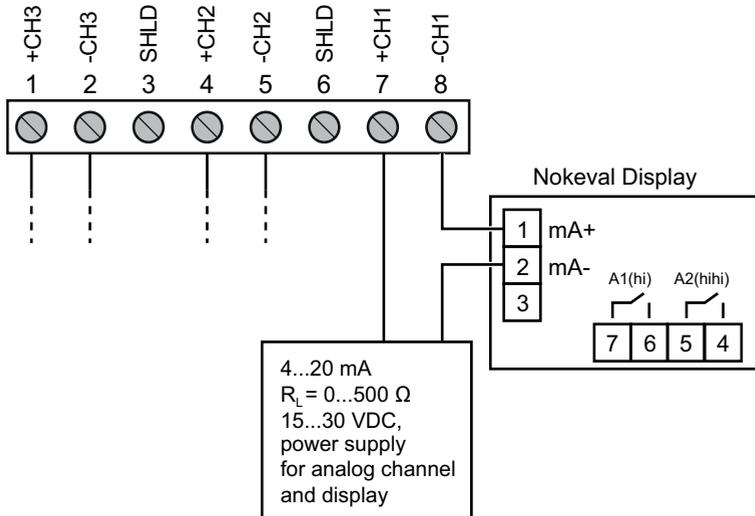


Figure 2 Example of Nokeval Display Wired to Channel 1. Transmitter Wiring According to Wiring Option 1.



All the Wiring Options (1, 2, 3, and 4) have the same principle for connecting the display:

- Wire from port 1 of the display connects to the minus port of the transmitter's analog output channel (for example, to "-CH1").
- Wire from port 2 of the display connects to where the minus port wire of the analog output channel would have connected without the display.

For wiring alternatives, see [Wiring Diagrams on page 88](#).

Checklist After Installation

After the installation, check the following indicators to make sure the installation was successful:

- No oil is leaking from the transformer and the transmitter.
- The indicator LED blinks green for some minutes and then becomes steady.
 - Steady **green** indicates that the H₂ level is below alarm limit.
 - Blinking **red** indicates that the H₂ level is above alarm limit.
- After the initial stabilization period (approx. 24 h power on), the reading is correct.

Oil Fittings Check After Installation

After the first month of continuous use, all oil fittings should be checked for leaks. An annual check thereafter is recommended.

Removing the Transmitter



To disconnect wiring:

- Allen key (5 mm, provided)
- 2 medium wrenches (24 mm)
- Flat head screwdriver (2.5 mm)

To remove transmitter:

- Large wrench (50 mm)
 - Medium wrench (36 mm)
 - Gloves
 - Bucket and cloth
-



Do not try to close the ball valve when the transmitter is fully installed. The probe body goes through the valve into the oil flow, and trying to close the valve will damage the probe body.

1. If needed, disconnect the wiring:
 - a. Open the front cover and disconnect the wires from the detachable screw terminals.

- b. Hold the upper nut of the cable gland in place with a wrench (24 mm), and loosen the sealing nut of the gland with another wrench (24 mm).
 - c. Pull the cable out of the cable gland.
 - d. Re-attach the cable gland in its place.
2. Put a bucket under the ball valve to catch any oil falling from the valve.
 3. Loosen the small tightening nut with a wrench.



To keep the larger mounting nut from opening, hold it in place with a wrench as you are opening the smaller tightening nut.

4. Pull the transmitter outward so that the probe body is out of the ball valve.
5. Close the ball valve.
6. Open the mounting nut with a wrench and pull the transmitter out. Use the cloth to clean up any spills.



Always make sure the bleed screw is closed before you turn the mounting nut with a wrench.

5

ANALOG OUTPUT

There are three analog output channels available for H₂, moisture in oil, and temperature using 4... 20 mA current outputs.

The parameter for each output is configured at the factory according to order. If needed, you can change the parameters using Vaisala Industrial Protocol. For instructions, see table [Asel Command on page 60](#).

Table 3 Analog Output Values in Different Transmitter Statuses

Transmitter Status	Analog Output Value
Normal	4...20 mA
Error	3.5 mA (default)
Measurement not ready	3.0 mA

Analog Output Overrange Behavior

If the measured hydrogen, moisture and temperature levels go below or above their scaled range, the analog output is clipped at the low (4 mA) or high (20 mA) end of the output range. This means the analog output will not indicate measurement readings that are outside the scaled ranges.

If needed, you can allow the analog outputs to extend 10 % of the range over 20 mA using the `aover` command via Vaisala Industrial Protocol (see [Table 29 on page 59](#)). With this extension, the allowed range for analog outputs is 4 mA ... 21.6 mA. The `aover` command does not affect the scaling of the outputs.

You can also change the scaling of the outputs for each channel using the `asel` command. See [Table 30 on page 60](#).

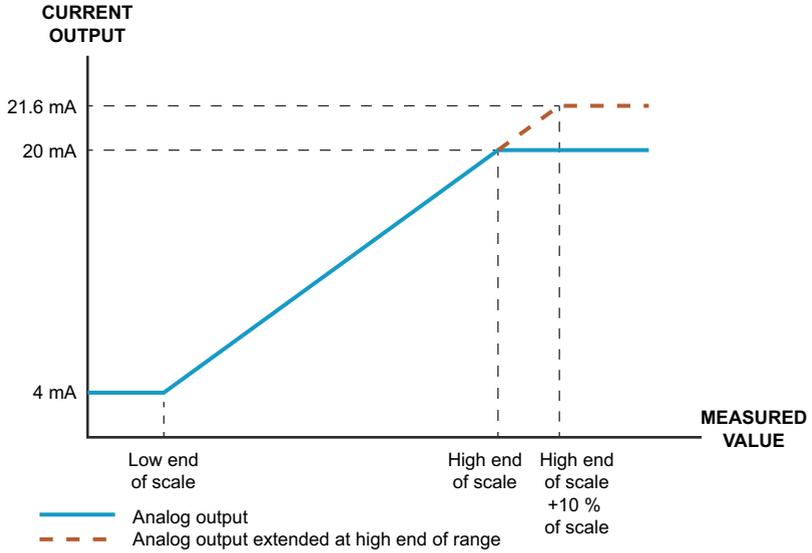


Figure 3 Analog Output Overrange Behavior

6

MODBUS

Overview of Modbus Protocol Support

MHT410 can be accessed using the Modbus serial communication protocol. The supported Modbus variant is Modbus RTU (Serial Modbus) over RS-485 interface.

The supported Modbus functions and registers are described in [Appendix: Modbus Reference on page 96](#).

By default, Modbus is enabled on MHT410. The pre-configured default software settings are presented in the following table.

Description	Default value
Serial bit rate	19200
Parity	N
Number of data bits	8 (read-only)
Number of stop bits	1
Modbus device address	240

You can change the Modbus settings using Vaisala Industrial Protocol. For instructions, see [Serial Line Output and Communication on page 48](#).



The minimum time between requests from Modbus is 1 second.

7

VAISALA INDUSTRIAL PROTOCOL

The transmitter provides an implementation of the Vaisala Industrial Protocol that can be used for service and configuration use, or for interfacing with the system to which the transmitter is integrated. The protocol is a plaintext protocol suitable for use both by human operators and automated systems.

You can access the Vaisala Industrial Protocol in two ways:

- For permanent connection, use the RS-485 line of the screw terminals.
- For temporary connection with a computer, use the service port. See [Connecting via Service Port on the next page](#).



You can use Vaisala Industrial Protocol via the RS-485 line of the screw terminals and the service port at the same time.

However, the transmitter responds to the commands one at a time from either line, which may result in delayed responses if a command is entered from one line while another command is in progress on the other line.

Table 4 Default Serial Interface Settings

Property	Description/Value
Baud rate	19200
Parity	None
Data bits	8
Stop bits	1
Flow control	None

Connecting via Service Port



- Vaisala USB service cable (219690)
 - Computer with:
 - Windows operating system
 - Free USB port
 - Terminal application (e.g. PuTTY available from www.vaisala.com/software)
 - Driver for Vaisala USB service cable installed (available on the cable installation media and at www.vaisala.com/software)
-

You can connect to the transmitter on a computer using the service port located under the transmitter cover. For a list of commands, see [Serial Commands on page 41](#).

If you have not used the Vaisala USB cable before, install the driver before attempting to use the cable. See [Installing the Driver for the USB Service Cable below](#) for detailed instructions.

For more information on using a terminal application, see [Terminal Application Settings on the facing page](#).

Connecting USB Cable

To connect the USB service cable to the service port:

1. Make sure the USB cable is connected to your computer.
2. Open the screws on the transmitter cover, and open the cover.
3. Connect the USB service cable to the service port connector on the transmitter.
4. Configure the terminal application settings as instructed in [Terminal Application Settings on the facing page](#).

Installing the Driver for the USB Service Cable

Before taking the USB service cable into use for the first time, you must install the provided USB driver on your computer (requires Windows). When installing the driver, you must accept any security prompts that may appear.

1. Check that the USB service cable is not connected. Disconnect the cable if you have already connected it.
2. Insert the media that came with the cable, or download the latest driver from www.vaisala.com/software.

3. Run the USB driver installation program (setup.exe), and accept the installation defaults. The installation of the driver may take several minutes.
4. After the driver has been installed, connect the USB service cable to a USB port on your computer. Windows will detect the new device, and use the driver automatically.
5. The installation has reserved a COM port for the cable. Verify the port number, and the status of the cable, using the Vaisala USB Instrument Finder program that has been installed in the Windows Start menu.

Windows will recognize each individual service cable as a different device, and reserve a new COM port. Remember to use the correct port in the settings of your terminal program.

Terminal Application Settings

The steps below describe how to connect to the transmitter using the PuTTY terminal application for Windows (available for download at www.vaisala.com/software) and a USB service cable:

1. Make sure the USB service cable is connected to your PC and the service port of the transmitter.
2. Start the PuTTY application.

3. Select **Connection > Serial & USB** and check that the correct COM port is selected in the **Serial or USB line to connect to** field. If you are using the PuTTY terminal application supplied by Vaisala, you can click the **USB Finder** button to open the Vaisala USB Instrument Finder program.

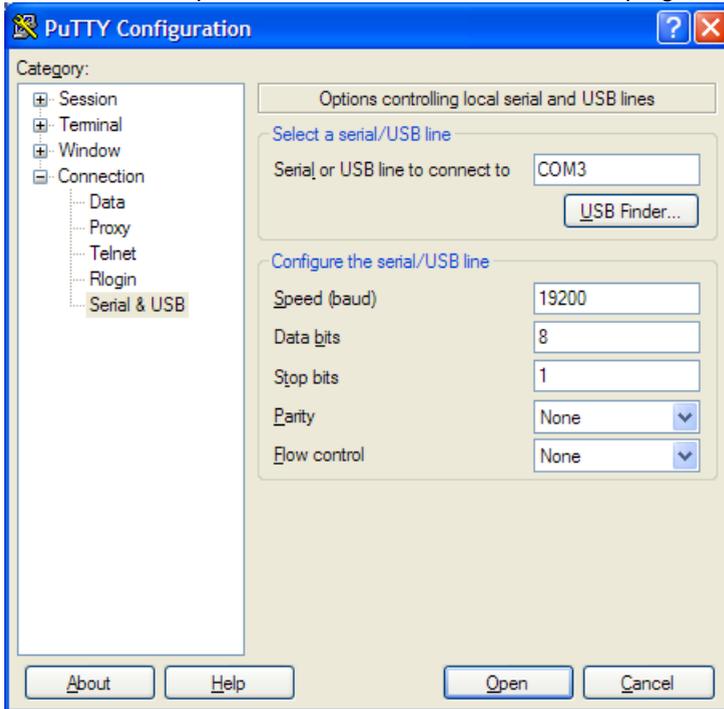


Figure 4 PuTTY Terminal Application

4. Check that the other serial settings are correct, and change if necessary.

Table 5 Service Port Serial Interface Settings

Property	Value
Baud rate	19200
Parity	None
Data bits	8
Stop bits	1
Flow control	None

5. Select **Terminal**. Use the following settings:
 - **Local Echo**: "Force on". This setting ensures that your typing is shown on the session window.
 - **Send line ends with line feeds (CR+LF)**: Selected. This setting ensures that all text lines remain visible on the session window.
6. Click the **Open** button to open the connection window and start using the serial line.

If PuTTY is unable to open the serial port you selected, it will show you an error message instead. If this happens, restart PuTTY and check the settings.

Serial Commands

The notation `<cr>` refers to the carriage return control character, which you can send in a terminal application by pressing enter on your keyboard. Before entering commands, send a `<cr>` to clear the command buffer.

You can enter the commands in uppercase or lowercase. In the command examples, the keyboard input by the user is in **bold** type.

Command	Description	Page
Device information and status		
?	Show device information.	43
??	Show device information (will respond in poll mode).	43
alarm	Show or set H ₂ alarm level.	44
errlog	Show error log records.	45
errs	Show active errors.	46
help	Show list of serial commands.	47
system	Show firmware information.	47
time	Show transmitter uptime (time since last reset).	47
vers	Show the software version information.	48
Serial line output and communication		
addr	Show or set device address.	54
close	Close connection to device in POLL mode. This command cannot be used via the Service Port.	54
form	Set output format of measurement messages.	52
log	Show measurement log records.	49
intv	Set measurement output interval.	48
open	Open connection to device in POLL mode. This command cannot be used via the Service Port.	55
r	Start continuous output of measurement messages.	51
sdelay	Show or set serial line transmission delay.	55
send	Output one measurement message.	51
seri	Set serial line settings for the RS-485 line of the screw terminals. Default is 19200 N 8 1. This command does not affect the service port settings.	56
smode	Set serial line operation mode for the RS-485 line of the screw terminals. This command does not affect the service port settings. The service port is always in <code>stop</code> mode.	57
unit	Set temperature unit to metric (°C) or non-metric (°F).	54
Analog output		
aerr	Show or set error level for analog output.	58
aover	Enable or disable analog output 10 % over range.	59
asel	Show or set analog output parameters and scaling.	60
atest	Test analog outputs by forcing them to a given value.	61

Command	Description	Page
Calibration and adjustment		
cdate	Show or set adjustment date.	62
ctext	Show or set adjustment information text.	62
h2	Start or continue hydrogen calibration and adjustment sequence.	63
Other commands		
filt	Show or set measurement filtering.	64
frestore	Restore factory settings. Clears all user settings, factory calibration remains.	65
reset	Reset the device.	65

Device Information and Status

Table 6 ? Command

Syntax	Description
?<cr>	Show listing of device information.
??<cr>	Show listing of device information when device is in poll mode and connection has not been opened using the <code>open</code> command.
<p>Example:</p> <pre>? MHT410 / 0.1.20 Serial number : L2110001 Batch number : L1940010 Sensor number : L102 Sensor model : Humicap L2 Order code : MHT410 1CXEO Cal. date : 20150414 Cal. info : Vaisala Uptime : 0000d 04:04:41 Total time : 0000d 04:04:41 Serial mode : STOP Baud P D S : 19200 N 8 1 Output interval: 1 S Serial delay : 25 Address : 0 Filter : 1.000 Ch1 output : 4 ... 20 mA Ch2 output : 4 ... 20 mA Ch3 output : 4 ... 20 mA Ch1 RS lo : 0.00 % Ch1 RS hi : 100.00 % Ch2 T lo : -40.00 'C Ch2 T hi : 100.00 'C Ch3 H2 lo : 0.00 ppm Ch3 H2 hi : 5000.00 ppm</pre>	

Table 7 Alarm Command

Syntax	Description
alarm<cr>	<p>Check the status and setpoint (ppm) of the hydrogen alarm.</p> <p>The alarm is activated when the 1-hour average for hydrogen exceeds the setpoint.</p>
alarm [on off] [setpoint]<cr>	<p>Set the hydrogen alarm status.</p> <p>on = Alarm indication is on.</p> <p>off = Alarm indication is off.</p> <p>setpoint = Hydrogen level above which the alarm is activated.</p>
<p>Example (check the hydrogen alarm status, alarm is off):</p> <pre>alarm Alarm display : OFF ? Setpoint (ppm) : 300 ?</pre>	
<p>Example (enable the hydrogen alarm and set the alarm limit to 200 ppm hydrogen):</p> <pre>alarm on 200 Alarm display : ON Setpoint (ppm) : 200</pre>	

Table 8 Errlog Command

Syntax	Description
<pre>errlog print<cr></pre>	<p>Show the error log with max. 25 last log entries.</p> <p>The error log stores the error status each time the status changes.</p> <hr/> <div style="text-align: center;">  </div> <p>You can save the error log as a file from PuTTY by configuring the following settings in PuTTY before opening the connection:</p> <p>In the Session > Logging window:</p> <ul style="list-style-type: none"> ■ Session logging: Select "Printable output". ■ Log file name: Type a name for the log file (use extension .txt) and browse for the location where to save the file.
<pre>errlog print [n] [i]<cr></pre>	<p>Show the error log with a chosen number of entries.</p> <p><i>n</i> = Number of entries to show (max. 9 999).</p> <p><i>i</i> = Optional: Index number of the first shown entry. If this parameter is not used, the list will show the last <i>n</i> number of entries.</p>
<pre>errlog save<cr></pre>	<p>Save the current error status for troubleshooting purposes.</p>
<pre>errlog clear<cr></pre>	<p>Remove all entries from the error log.</p> <hr/> <div style="text-align: center;">  </div> <p>Clearing the error log may make troubleshooting more difficult later if a problem occurs.</p>

Syntax	Description
<p>Example (show error log):</p> <pre>errlog print index RecNum Reset Days Time ERRS H2err 1 1 1 0 00:00 8 0 2 2 2 0 00:37 8 0 3 3 2 0 00:37 0 0 4 4 2 0 00:38 8 0 5 5 2 0 01:10 0 0 6 6 2 0 01:15 8 0 7 7 3 0 00:36 2 0 ... </pre>	
<p>Example (show the last 5 entries):</p> <pre>errlog print 5 index RecNum Reset Days Time ERRS H2err 27 27 19 0 04:59 8 0 28 28 19 0 05:11 0 0 29 29 19 0 05:18 8 0 30 30 19 0 05:21 0 0 31 31 19 0 05:22 8 0 </pre>	
<p>Example (save the current error status):</p> <pre>errlog save New value stored. </pre>	
<p>Example (remove all entries from the error log):</p> <pre>errlog clear Erase all Error Log data? (Y/N) y Erasing... Error Log cleared. </pre>	

Table 9 Errs Command

Syntax	Description
<pre>errs<cr></pre>	<p>Show currently active errors.</p> <p>The possible errors and their remedies are listed in Possible Error Messages via Vaisala Industrial Protocol on page 79.</p>
<p>Example (no errors active):</p> <pre>errs No errors</pre>	

Table 10 Help Command

Syntax	Description
help<cr>	Show a list of available commands.
<p>Example:</p> <pre> help Stop mode commands: ADDR AERR ALARM AOVER ASEL ATEST CDATE CLOSE CTEXT ERRLOG ERRS FILT FORM FRESTORE H2 HELP INTV LOG R RESET SDELAY SEND SERI SMODE SYSTEM TIME UNIT VERS ? Poll mode commands: OPEN SEND ?? </pre>	

Table 11 System Command

Syntax	Description
system<cr>	Show firmware information.
<p>Example:</p> <pre> system Device Name : MHT410 Copyright : Copyright (c) Vaisala Oyj 2015. All rights reserved. SW Name : MHP410 SW date : 2015-05-05 SW version : 1.0.0 OS version : TSF 1.0 </pre>	

Table 12 Time Command

Syntax	Description
time [mode]<cr>	<p>Show transmitter uptime (time since last reset). Default output: hh:mm:ss.</p> <p>mode = alternative output option (optional)</p> <ul style="list-style-type: none"> ■ 1 = include days (dddd hh:mm:ss) ■ 2 = include decimals of seconds (hh:mm:ss.sss) ■ 3 = include days and decimals of seconds ■ 4 = include total operating time
<p>Example (show transmitter uptime in hh:mm:ss):</p> <pre> time Uptime : 00:50:04 </pre>	
<p>Example (show transmitter uptime with days):</p> <pre> time 1 Uptime : 0002d 01:50:39 </pre>	

Table 13 Vers Command

Syntax	Description
<code>vers<cr></code>	Show the software version information.
Example: <pre>vers MHT410 / 1.0.0</pre>	

Serial Line Output and Communication

Measurement Output

Table 14 Intv Command

Syntax	Description
<code>intv<cr></code>	Show the output interval of the automatically repeating measurement messages (<code>x</code> command and run mode). This command has no effect on the operation of the analog output.
<code>intv [iii uu] <cr></code>	Set the output interval. <i>iii</i> = interval, range 1 ... 255 <i>uu</i> = unit for interval setting: <ul style="list-style-type: none"> ■ s = seconds ■ min = minutes ■ h = hours
Example (set the output interval to 1 second): <pre>intv 1 s</pre> Output interval: 1 S	

Table 15 Log Command

Syntax	Description
<pre>log print<cr></pre>	<p>Show the measurement log with max.100 last log entries.</p> <hr/>  <p>You can save the log as a file from PuTTY by configuring the following settings in PuTTY before opening the connection:</p> <p>In the Session > Logging window:</p> <ul style="list-style-type: none"> ■ Session logging: Select "Printable output". ■ Log file name: Type a name for the log file (use extension .txt) and browse for the location where to save the file. <p>To prevent the log from getting very long, consider saving and then clearing the log every few years.</p> <hr/>
<pre>log print [n] [i]<cr></pre>	<p>Show the measurement log with a chosen number of entries.</p> <p><i>n</i> = Number of entries to show (max. 32767).</p> <p><i>i</i> = Optional: Index number of the first shown entry. If this parameter is not used, the list will show the last <i>n</i> number of entries.</p>
<pre>log alarm [on off]<cr></pre>	<p>Enable or disable storing a log item when the H₂ concentration (1 hour average) exceeds the alarm level. Logging continues once an hour until the H₂ level returns below the alarm limit or until alarm logging is disabled. The log entries contain the additional tag "H2alarm".</p> <p>You set the H₂ alarm level using the <code>alarm</code> command (see Table 7 on page 44).</p>

Syntax	Description
<code>log filt [on off]<cr></code>	<p>Enable or disable the filtering of measurement values in the log.</p> <p><code>on</code> = For each parameter, the 24 h average value is stored. The log entries contain the additional tag "F".</p> <p><code>off</code> = For H₂, 1 h average is stored. For RS and T, instant values are stored.</p>
<code>log save<cr></code>	Save the current measurement values in the log. The log entry contains the additional tag "12h Tst".
<code>log clear<cr></code>	Remove all entries from the measurement log.
<p>Example (show up to 100 last entries in the log):</p> <pre>log print index Reset Days Uptime Total Time RS (%)H2O(ppm)Temp('C)H2(ppm)Flags 1 2 0 00:08 0 00:17 10.000 13.900 45.406 18.0 12h Tst 2 2 0 00:13 0 00:22 10.000 13.900 45.467 18.0 12h Tst 3 5 0 00:37 0 00:59 10.000 13.900 45.303 18.0 12h Tst 4 5 0 00:52 0 01:14 10.000 13.900 45.278 18.0 12h Tst 5 7 0 12:00 0 13:14 10.000 13.900 45.887 18.0 12h 6 11 0 00:04 0 13:18 10.000 13.900 45.495 18.0 12h 7 11 0 00:12 0 13:26 10.000 12.900 45.716 18.1 12h 8 12 0 00:03 0 13:29 10.000 13.900 45.531 18.2 12h</pre>	
<p>Example (show the last 5 entries):</p> <pre>log print 5 index Reset Days Uptime Total Time RS (%)H2O(ppm)Temp('C)H2(ppm)Flags 4 5 0 00:52 0 01:14 10.000 13.900 45.278 18.0 12h Tst 5 7 0 12:00 0 13:14 10.000 13.900 45.887 18.0 12h 6 11 0 00:04 0 13:18 10.000 13.900 45.495 18.0 12h 7 11 0 00:12 0 13:26 10.000 12.900 45.716 18.1 12h 8 12 0 00:03 0 13:29 10.000 13.900 45.531 18.2 12h</pre>	
<p>Example (show 5 entries starting from the 3rd entry):</p> <pre>log print 5 3 index Reset Days Uptime Total Time RS (%)H2O(ppm)Temp('C)H2(ppm)Flags 3 5 0 00:37 0 00:59 10.000 13.900 45.303 18.0 12h Tst 4 5 0 00:52 0 01:14 10.000 13.900 45.278 18.0 12h Tst 5 7 0 12:00 0 13:14 10.000 13.900 45.887 18.0 12h 6 11 0 00:04 0 13:18 10.000 13.900 45.495 18.0 12h 7 11 0 00:12 0 13:26 10.000 12.900 45.716 18.1 12h</pre>	
<p>Example (enable storing a log item when H₂ alarm level is exceeded):</p> <pre>log alarm on Alarm loggings: OFF -> ON</pre>	
<p>Example (disable filtering the measurement values in the log):</p> <pre>log filt off 24h rolling average filter: ON -> OFF</pre>	

Table 16 R Command

Syntax	Description
<code>r<cr></code>	Start the continuous outputting of measurement values as an ASCII text string to the serial line. The probe keeps outputting measurement messages at the interval that has been set with the <code>intv</code> command until stopped with the <code>s</code> command.
<p>Example:</p> <pre> r T= 45.1 'C RS= 10.0 % H2O= 13.9 ppm aw= 0.100 H2= 17 ppm T= 45.0 'C RS= 10.0 % H2O= 13.9 ppm aw= 0.100 H2= 17 ppm T= 45.0 'C RS= 10.0 % H2O= 13.9 ppm aw= 0.100 H2= 17 ppm T= 45.1 'C RS= 10.0 % H2O= 13.9 ppm aw= 0.100 H2= 17 ppm T= 45.1 'C RS= 10.0 % H2O= 13.9 ppm aw= 0.100 H2= 18 ppm T= 45.1 'C RS= 10.0 % H2O= 13.9 ppm aw= 0.100 H2= 18 ppm T= 45.1 'C RS= 10.0 % H2O= 13.9 ppm aw= 0.100 H2= 18 ppm T= 45.2 'C RS= 10.0 % H2O= 13.9 ppm aw= 0.100 H2= 18 ppm ... </pre>	

Table 17 Send Command

Syntax	Description
<code>send<cr></code>	Output a single measurement message. The output uses the format defined with the <code>form</code> command.
<code>send [aaa]<cr></code>	Output a single measurement message when the transmitter is in poll mode and connection has not been opened using the <code>open</code> command. aaa = Address of the transmitter, range 0 ... 255. Set with the <code>addr</code> command.
<code>send ROC<cr></code>	Output the rate-of-change readings for H ₂ and H ₂ O (daily, weekly and monthly ROC for each parameter).
<p>Example (transmitter in stop mode, no address needed):</p> <pre> send T= 45.1 'C RS= 10.0 % H2O= 13.9 ppm aw= 0.100 H2= 17 ppm </pre>	
<p>Example (transmitter in poll mode, with address 10):</p> <pre> send 10 T= 45.1 'C RS= 10.0 % H2O= 13.9 ppm aw= 0.100 H2= 17 ppm </pre>	

Measurement Output Format

Table 18 Form Command

Syntax	Description
<code>form<cr></code>	Show the currently used measurement format.
<code>form /<cr></code>	Reset measurement format to default.
<code>form [sss]<cr></code>	Set a new measurement format. sss = String consisting of modifiers and abbreviations for measured parameters. See Table 19 on the facing page and Table 20 on the facing page . Maximum length is 150 characters. Maximum length may be shorter when text strings are used.
<p>Example (show currently used measurement format, default format shown here):</p> <pre>form 3.1 "T=" t " " U3 3.1 "RS=" rs " " U4 6.1 "H2O=" h2o " " U5 4.3 "aw=" aw " " 6.0 "H2=" h2 " " U5 \r \n</pre> <p>Output example (continuous output in RUN mode):</p> <pre>T= 45.0 'C RS= 10.0 % H2O= 13.9 ppm aw= 0.100 H2= 18 ppm</pre>	
<p>Example (change the order of the output to show H₂ first, with Modulus-65536 checksum at the end):</p> <pre>form 6.0 "H2=" h2 " " U5 3.1 "T=" t " " U3 3.1 "RS=" rs " " U4 6.1 "H2O=" h2o " " U5 4.3 "aw=" aw " " cs4 #r #n OK</pre> <p>Output example (continuous output in RUN mode):</p> <pre>H2= 18 ppm T= 45.0 'C RS= 10.0 % H2O= 13.9 ppm aw= 0.1 0E22</pre>	
<p>Example (show H₂O in ppm without decimals, with start of text (ASCII character 002) and end of text (003) ASCII codes, and without line feed and carriage return at the end):</p> <pre>form #002 6.0 "H2=" h2 " " U5 3.1 "T=" t " " U3 3.1 "RS=" rs " " U4 6.0 "H2O=" h2o " " U5 4.3 "aw=" aw " " #003 OK</pre> <p>Output example (continuous output in RUN mode):</p> <pre>H2= 18 ppm T= 45.0 'C RS= 10.0 % H2O= 14 ppm aw= 0.100</pre>	

Table 19 Output Parameters for Form Command

Measurement Parameter	Abbreviation in Form Command
Relative saturation of water in oil, %RS	rs
Water activity in oil, aw (range 0.0 ... 1.0)	aw
Water content in oil, ppm	h2o
Hydrogen content in oil, ppm. One hour average.	h2
Oil temperature, °C or °F	t

Table 20 Modifiers for Form Command

Modifier	Description
x.y	Length modifier (number of digits and decimal places).
#t	Tabulator.
#r	Carriage-return.
#n	Line feed.
""	String constant, length 1 ... 15 characters.
#xxx	ASCII code value (decimal) of a special character; for example, #027 for ESC.
addr	Transmitter address (0 ... 254).
date	Uptime in days.
err	Error code, ASCII encoded hexadecimal notation.
sn	Probe serial number.
time	Uptime (hh:mm:ss).
ux	Name of the measurement unit using x number of characters (1 ... 9). For example, u3 shows the name of the measurement unit with three characters.
cs2	Modulus-256 checksum of message sent so far, ASCII encoded hexadecimal notation.
cs4	Modulus-65536 checksum of message sent so far, ASCII encoded hexadecimal notation.
csx	NMEA xor-checksum of message sent so far, ASCII encoded hexadecimal notation.



You can also use the backslash character \ instead of the hash character #.

Table 21 Unit Command

Syntax	Description
<code>unit<cr></code>	Show the current temperature unit system (metric °C on non-metric °F).
<code>unit [m n]<cr></code>	Change the temperature unit. m = Metric unit, °C n = Non-metric unit, °F
Example (show current unit and check the output):	
<pre>unit Units : Metric send T= 45.0 'C RS= 10.0 % H2O= 13.9 ppm aw= 0.100 H2= 18 ppm</pre>	
Example (change temperature unit from °C to °F and check the output):	
<pre>unit n Units : Non metric send T=113.0 'F RS= 10.0 % H2O= 13.9 ppm aw= 0.100 H2= 18 ppm</pre>	

Serial Line Communication

Table 22 Addr Command

Syntax	Description
<code>addr<cr></code>	Show current device address and prompt for a new address. Addresses are required for POLL mode.
<code>addr [aaa]<cr></code>	Set new device address. aaa = address, 0 ... 255
Example (shows 0 as current address, enter 5 as the new address):	
<pre>addr Address : 0 ? 5</pre>	

Table 23 Close Command

Syntax	Description
<code>close<cr></code>	Close the connection that was opened with the <code>open</code> command. This command cannot be used via the service port.
Example:	
<pre>close line closed</pre>	

Table 24 Open Command

Syntax	Description
open [aaa]	Connect to a transmitter that is in poll mode. aaa = transmitter address, 0 ... 255 If you do not know the address of the transmitter, use the ?? command to view the transmitter information. This command cannot be used via the service port.
<p>Example (target transmitter in poll mode, with address 5):</p> <pre>open 5 MHT410 5 line opened for operator commands</pre>	

Table 25 Sdelay Command

Syntax	Description
sdelay<cr>	Show serial line transmission delay.
sdelay [delay]<cr>	Set a new serial line transmission delay. delay = 0 ... 255. Value corresponds to four milliseconds (for example, 5 = 0.020 second transmission delay) Note that setting a too short delay may result in missing characters at the beginning of the transmission (requirements vary depending on use case).
<p>Example (set serial delay to 0.1 seconds using the delay value 25):</p> <pre>sdelay 25 Serial delay : 25</pre>	

Table 26 Seri Command

Syntax	Description
<code>seri<cr></code>	Show current serial line settings for the RS-485 line of the screw terminals. This command does not affect the service port settings.
<code>seri [p b d s] <cr></code>	Set new serial line settings. The new settings will be taken into use when the transmitter is reset or powered up. b = baud rate (300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600) p = parity <ul style="list-style-type: none"> ■ n = none ■ e = even ■ o = odd d = data bits (7 or 8) s = stop bits (1 or 2) For Modbus, baud rate must be 9600 ... 57600 and parity must be none.
Example (show current settings):	
<pre>seri Baud P D S : 19200 N 8 1</pre>	
Example (set baud rate to 9600, and reset the transmitter take the new baud rate in use):	
<pre>seri 9600 N 8 1 Baud P D S : 9600 N 8 1 reset MHT410 / 0.1.20</pre>	

Table 27 Smode Command

Syntax	Description
<pre>smode<cr></pre>	<p>Show current start-up operating mode for the RS-485 line of the screw terminals, and prompt to enter new mode.</p> <p>This command does not affect the service port settings. The service port is always in <code>stop</code> mode.</p>
<pre>smode [mode]<cr></pre>	<p>Set serial line start-up operating mode. The new mode is taken into use when the transmitter is reset or powered up.</p> <p>Available modes:</p> <p><code>stop</code> = No automatic output. All commands available. Default mode.</p> <p><code>run</code> = Automatic output of measurement messages. You can stop the output with the <code>s</code> command, and recontinue with the <code>r</code> command.</p> <p><code>poll</code> = No automatic output. Will respond to addressed <code>send</code> command and <code>??</code> command. You can use other commands after opening a connection using an addressed <code>open</code> command. Use with RS-485 buses where multiple transmitters can share the same line.</p> <p><code>modbus</code> = Modbus protocol is used for communication, including measurement output. See Modbus on page 36.</p>
<p>Example (set serial mode to poll, and reset the transmitter to start up in that mode):</p> <pre> smode poll Serial mode : POLL reset MHT410 / 1.0.0 </pre>	

Analog Output

Table 28 Aerr Command

Syntax	Description
<code>aerr<cr></code>	Show error levels for the analog outputs channel by channel and prompt to enter a new value.
<code>aerr [ch1 ch2 ch3]<cr></code>	<p>Set new error levels for analog outputs.</p> <p>ch1 = Error level of the analog output for channel 1.</p> <p>ch2 = Error level of the analog output for channel 2.</p> <p>ch3 = Error level of the analog output for channel 3.</p> <p>When you set new error levels, make sure they are outside the scaled output range 4 ... 20 mA (or 4.0 ... 21.6 mA if <code>aover</code> extension is on, see Aover Command on the facing page).</p>
<p>Example (show current error levels, default levels shown here):</p> <pre> aerr Ch1 error out : 3.500 mA ? Ch2 error out : 3.500 mA ? Ch3 error out : 3.500 mA ? </pre>	
<p>Example (set the error level to 21 mA on all channels):</p> <pre> aerr 21 21 21 Ch1 error out : 21.000 mA Ch2 error out : 21.000 mA Ch3 error out : 21.000 mA </pre>	

Table 29 Aover Command

Syntax	Description
<code>aover<cr></code>	Check whether the high end of the analog outputs is extended by 10 percent of the range (from 20 mA to 21.6 mA).
<code>aover [off on]<cr></code>	Enable or disable the analog output overrange extension. <code>off</code> = The range of the analog outputs is 4 ... 20 mA. <code>on</code> = The range of the analog outputs is 4 ... 21.6 mA. The scaling of the outputs is not affected.

Example (check whether the analog output range is extended (extension is off), and enable the extension):

```

aover
AOVER                :      OFF
aover on
AOVER                :      ON

```

For example, channel 3 outputs temperature with output 4 ... 20 mA (-40 ... 100 °C). After giving the `aover on` command, the range is 4 ... 21.6 mA (-40 ... 124 °C). Note that the 100 °C point is still at 20 mA.

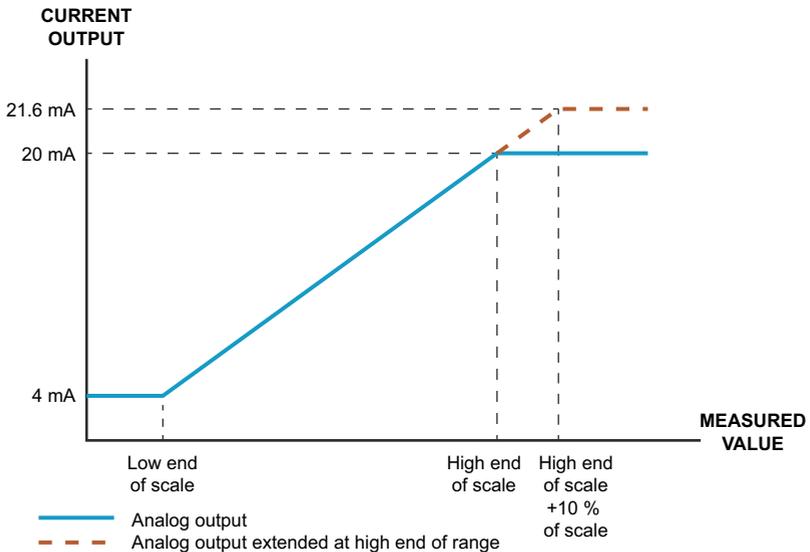


Figure 5 Analog Output Overage Behavior

Table 30 Asel Command

Syntax	Description
<pre>asel<cr></pre>	Show analog output parameters and scaling and prompt to enter new scaling.
<pre>asel [ch1 ch2 ch3] [ch1low ch1high ch2low ch2high ch3low ch3high]<cr></pre>	Set analog output parameters and scaling. ch1 = Output parameter for channel 1. <ul style="list-style-type: none"> ■ rs = relative saturation of water, %RS ■ aw = water activity (range 0.0 ... 1.0) ■ h2o = water content, ppm ■ h2 = hydrogen content, ppm ■ t = temperature, °C ch2 = Output parameter for channel 2. The options are the same as for channel 1. ch3 = Output parameter for channel 3. The options are the same as for channel 1. ch1low = Low limit for channel 1 output scaling. ch1high = High limit for channel 1 output scaling. ch2low = Low limit for channel 2 output scaling. ch2high = High limit for channel 2 output scaling. ch3low = Low limit for channel 3 output scaling. ch3high = High limit for channel 3 output scaling.

Syntax	Description
<p>Example (show current parameters and scaling for each channel):</p> <pre> asel Ch1 RS lo : 0.00 % ? Ch1 RS hi : 100.00 % ? Ch2 T lo : -40.00 'C ? Ch2 T hi : 100.00 'C ? Ch3 H2 lo : 0.00 ppm ? Ch3 H2 hi : 5000.00 ppm ? </pre>	
<p>Example (change channel 1 to output water activity, adjust scaling to 0 ... 1 for channel 1, and to 0 ... 2000 ppm for channel 3):</p> <pre> asel aw t h2 0 1 -40 100 0 2000 Ch1 aw lo : 0.00 Ch1 aw hi : 1.00 Ch2 T lo : -40.00 'C Ch2 T hi : 100.00 'C Ch3 H2 lo : 0.00 ppm Ch3 H2 hi : 2000.00 ppm </pre>	

Table 31 Atest Command

Syntax	Description
<pre> atest [ch1 ch2 ch3] </pre>	<p>Set analog channel to defined output value (in mA).</p> <p>You can then measure the output with a calibrated multimeter.</p> <p>ch1 = Output level for channel 1 in mA.</p> <p>ch2 = Output level for channel 2 in mA.</p> <p>ch3 = Output level for channel 3 in mA.</p>
<p>Example (enable analog output test mode, set level to 20 mA on all channels):</p> <pre> atest 20 20 20 Analog output test mode: ON CH1: 20.000 mA CH2: 20.000 mA CH3: 20.000 mA </pre>	
<p>Example (disable analog output test mode, resume normal output):</p> <pre> atest Analog output test mode: OFF CH1: 7.568 mA CH2: 13.714 mA CH3: 4.038 mA </pre>	

Calibration and Adjustment

Table 32 Cdate Command

Syntax	Description
<code>cdate<cr></code>	Show the date of the last adjustment.
<code>cdate [yyyymmdd]<cr></code>	Set a new calibration and adjustment date (format "yyyymmdd").
Example (show current calibration date): <pre>cdate Cal. date : 20150201</pre>	
Example (set new calibration date): <pre>cdate 20150630 Cal. date : 20150630</pre>	

Table 33 Ctext Command

Syntax	Description
<code>ctext<cr></code>	Show adjustment information text.
<code>ctext [text]<cr></code>	Set a new calibration and adjustment information text.
Example (show current calibration text): <pre>ctext Cal. info : Vaisala</pre>	
Example (set new calibration text): <pre>ctext H2 cal DGA lab sample Cal. info : H2 cal DGA lab sample</pre>	

Table 34 H2 Command

Syntax	Description
h2<cr> da <cr>	Start H ₂ adjustment and save the current H ₂ reading measured by the transmitter. When you start the adjustment with the h2 command, normal measurement stops temporarily and the transmitter goes into error state. Measurement returns to normal when you exit the H ₂ calibration.
h2<cr> db<cr>	Continue H ₂ adjustment and enter the H ₂ concentration of the DGA sample. After the adjustment, set the adjustment date and information using the cdate and ctext commands.
<p>Example (save current H₂ reading measured by the transmitter):</p> <pre> h2 <cr> SSN=b11.04rt.10432tnlx, FW=3.85F , MDN=104400-FF02-P1, DF=0xB4B4v, L ... 7997.00 34.0852 50.11176 186.69 2654140 2652818 23 0.0 0 22.2649 0 0 wait <"ESC key"> H2scan: da Current H2 value is 14.4 ppm...wait... ... 79842.00 33.8725 50.11766 186.97 2654214 2652858 359 14.4 0 28.5654 200 200 wait <"+" key"> Quit hydrogen measurement module command line operation </pre>	
<p>Example (enter the H₂ concentration of the DGA sample):</p> <pre> h2 <cr> SSN=b11.04rt.10432tnlx, FW=3.85F , MDN=104400-FF02-P1, DF=0xB4B4v, L ... 7997.00 34.0852 50.11176 186.69 2654140 2652818 23 0.0 0 22.2649 0 0 wait <"ESC key">H2scan: db Enter actual hydrogen in ppm: 10 Set hydrogen to 10.0ppm (Y/N)? y Enter Today's Date: Month: 4 Day: 14 Year: 2015 ...wait... ... 79842.00 33.8725 50.11766 186.97 2654214 2652858 359 10.0 10 28.5654 200 200 wait <"+" key"> Quit hydrogen measurement module command line operation </pre>	



Table 34 on the previous page is a simplified example of the H₂ calibration and adjustment sequence with the H₂ calibration commands.

To calibrate and adjust the H₂ measurement correctly, follow the instructions in section [H2 Calibration and Adjustment on page 75](#).

Other Commands

Table 35 Filt Command

Syntax	Description
<code>filt [f.fff] <cr></code>	<p>Set the speed at which the latest moisture and temperature measurement (approximately one measurement per second) is integrated into readings.</p> <p>The command affects both analog output and serial line output.</p> <p>This command does not affect the H₂ reading.</p> <p>f.fff = Measurement filter setting, range 0.001 ... 1.0. The default value is 1.0 (no filtering).</p> <p>When filtering is used, the output is calculated based on the following formula:</p> $[(new\ result * filter\ value) + (filtered\ reading * (1.0 - filter\ value))]$ <p>With filter value 1 the transmitter takes only the latest measurement into account, but with filter value 0.1 the new output is a combination of previous measurements (90%) and the latest measurement (10%).</p> <p>Filter value examples:</p> <ul style="list-style-type: none"> ■ 1.0 = No filtering, the latest measurement is output directly without integrating previous measurements. ■ 0.5 = The reading output shows ~75% of the measurement change after two one-second measurement cycles and ~93% after four cycles. ■ 0.1 = The reading output shows ~90% of the measurement change after 22 measurements.
<code>filt<cr></code>	View the current setting and prompt to enter a new value.
Example (view the current value and set filtering to value 0.5):	
<code>filt</code>	
Filter	: 1.000 ? 0.5

Table 36 Frestore Command

Syntax	Description
<pre>frestore<cr></pre>	Restore factory settings. Clears all user settings, including serial communication settings, transmitter address, and analog output configurations. H ₂ calibration remains.
Example: <pre>frestore</pre> Factory settings restored	

Table 37 Reset Command

Syntax	Description
<pre>reset<cr></pre>	Reset the transmitter. The transmitter will restart as if it had just been powered on.
Example: <pre>reset</pre> MHT410 / 1.0.0	

8

MI70 HAND-HELD INDICATOR

You can use the Vaisala MI70 Hand-Held Indicator as a temporary display for the transmitter.

MI70 shows the readings for all the parameters measured by the transmitter. You can also view the trend of the measurement on the graphical display, and compare the moisture and temperature readings of MHT410 to a Vaisala MM70 reference probe.

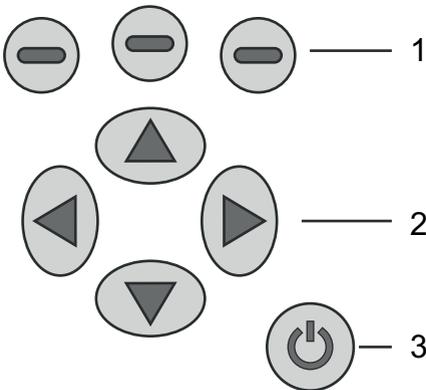


The MI70 Hand-Held Indicator is intended to be used as display only. You cannot use the MI70 to configure and calibrate MHT410.

To configure the transmitter, use Vaisala Industrial Protocol (see [Vaisala Industrial Protocol on page 37](#)). For H₂ calibration instructions, see [H₂ Calibration and Adjustment on page 75](#).

MI70 Indicator Overview

Indicator Keypad



1 = Function keys. The functions change according to what you are doing with the indicator.

2 = Arrow keys:

- Up/down key: Move up and down in a menu.
- Right key: Enter a sub-menu.
- Left key: Return to the previous menu level.

To open the main menu, press any of the arrow keys and then the function key **OPEN**.

3 = Power On/Off key.

Basic Display

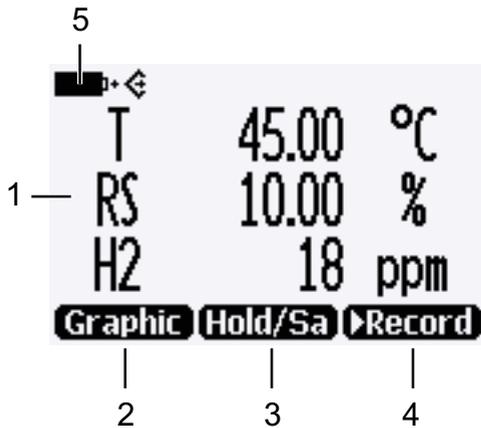


Figure 6 MI70 Basic Display

- 1 = Up to three measured parameters. You can change the shown parameters in **Main menu > Display > Quantities and units**.
- 2 = Function key **Graphic** shows the readings as a curve.
- 3 = Function key **Hold/Save** freezes the display and you can save the reading in the MI70 memory.
- 4 = Function key **Record** is a quick access to the **Recording/Viewing** menu.
- 5 = Battery indicator. Shows current status (charge) of the battery.

You can change the default function key shortcuts (**Graphic**, **Hold/Save**, **Record**) to other menus or functions in **Main menu > Settings > User interface > Program shortcut keys**.

Graphical Display

The graphical display shows you the measurements as a curve. From the curve you can examine the data trend and history of the last minutes.

To open the graphical display, select **Graphic** in the basic display or select **Main menu > Display > Graphic history > Show**.

To zoom in and out, press the up/down arrow keys.

To move back and forward in the timeline, use the left/right arrow keys.

Main Menu

To open the main menu:

1. Go to the basic display.
2. Press any arrow key, then select **OPEN**.

In the main menu, you can configure the MI70 settings and basic display.

You can also perform certain operations with the transmitter. For more information:

- [Holding and Saving the Display on the facing page](#)
- [Recording Data on page 70](#)
- [Comparing Readings with MM70 Probe on page 73](#)

Installing and Recharging the MI70 Batteries

If you are using **alkaline** batteries, unscrew the back plate of the indicator and insert the alkalines. Do not attempt to recharge standard alkaline batteries.

If MI70 is ordered with **rechargeable** battery, it is already in place as shipped from the factory.

To recharge the batteries:

1. Plug in charger connector to the indicator. The plug is located at the top of the indicator, covered by rubber seal.
2. Connect the charger to wall socket. A battery symbol in the left corner of the display starts to roll.

The recharge duration depends on the charge level of the battery. Typical duration is 4 hours. The recommended first recharging time is 6 hours.

3. When the battery symbol stops rolling, disconnect the charger.



It is not recommended to use MI70 during the first recharging. Later on MI70 can be used while recharging.

Connecting MI70 to Service Port



- MI70 Indicator or MM70 Moisture Meter (includes MI70 indicator, a moisture-in-oil probe and a ball valve)
- Connection cable (Vaisala order code 219980)
- Power supply for MHT410

1. Open the screws on the transmitter cover, and open the cover.
2. Connect the cable (219980) to the service port connector on the transmitter and to port I or II of MI70 indicator.
3. Switch the MI70 indicator on.

Holding and Saving the Display

With the **Hold/Save** function, you can freeze a certain display reading. This reading can be saved in the MI70 memory and it will be available even after MI70 is disconnected from the transmitter.

To save a display:

1. In the basic display, select **Hold/Save**. Alternatively, select **Main menu > Display > Hold/Save display > Hold**.
2. Press **Save**.

To view the saved display:

1. In the basic display, select **Record > View recorded data**. Alternatively, select **Main menu > Recording/Viewing > View recorded data**.

A list of saved displays and data recordings appears. The icons on the left of the date and time indicate whether the file is a saved display or a longer recording of data:

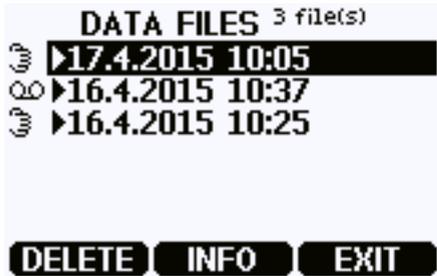


= Saved display



= Data recording

2. Select the saved display based on date and time by pressing the right arrow key.



Recording Data

With MI70, you can record transmitter measurement data over a certain period at chosen intervals. These recordings are saved in MI70 memory and are available even after MI70 is disconnected from the transmitter.

Starting and Stopping the Recording

You can record the measurement of the parameters that are currently shown on the MI70 basic display. You can change the shown parameters in **Main menu > Display > Quantities and units**.

1. In the basic display, select **Record > Record data**. Alternatively, select **Main menu > Recording/Viewing > Record data**.
2. If needed, change the interval and duration of the recording in the **RECORD DATA** view. The measurement intervals and maximum recording times are shown in [Table 38 on the facing page](#).



If you set the duration to "Memory full", the recording will continue until the MI70 memory is full or until you stop the recording manually. The maximum recording time will be shown when you start the recording.

3. Select **Start/Stop recording > Start**.

The recording will continue until the duration has passed or until you stop the recording manually.

You can switch the MI70 off during recording to save battery. A progress bar is shown on the display every 10 seconds (or all the time, if charger is connected). The progress bar shows the amount of recorded data.



Do not disconnect the probe when the data recording is on, even if the indicator is off. This may cause loss of recorded data.

4. To stop the recording manually, in the basic display select **Record > Record data > Start/stop recording > Stop**.

Table 38 Measurement Intervals and Max. Recording Times

Recording Interval	Maximum Recording Time (memory full)		
	1 Parameter	2 Parameters	3 Parameters
1 s	45 min	22 min	15 min
5 s	3 h	113 min	75 min
15 s	11 h	5 h	3 h
30 s	22 h	11 h	7 h
1 min	45 h	22 h	15 h
5 min	9 days	4 days	3 days
15 min	28 days	14 days	9 days
30 min	56 days	28 days	18 days
1 h	113 days	56 days	37 days
3 h	339 days	169 days	112 days
12 h	1359 days	678 days	451 days

Viewing Recorded Data

1. In the basic display, select **Record > View recorded data**. Alternatively, select **Main menu > Recording/Viewing > View recorded data**.

A list of saved displays and data recordings appears. The icons on the left of the date and time indicate whether the file is a saved display or a longer recording of data:



= Saved display

 = Data recording

2. Select the recording based on date and time by pressing the right arrow key.



Deleting Recorded Files

You can delete recorded data files one by one or all files at the same time.

To delete a single data file:

1. In the basic display, select **Record > View recorded data**. Alternatively, select **Main menu > Recording/Viewing > View recorded data**.
2. Select the data file based on date and time, and select **DELETE**.
3. Confirm by selecting **YES**.

To delete all data files (recordings and saved displays):

1. In the basic display, select **Record**. Alternatively, select **Main menu > Recording/Viewing**.
2. Select **Clear data memory**.
3. Confirm by selecting **YES**.

Comparing Readings with MM70 Probe



- Vaisala HUMICAP® Hand-held Moisture Meter for Oil MM70

You can use MI70 to compare the measurement readings of MHT410 to an MM70 reference probe.

The indicator shows the readings from both devices at the same time. You can also show the difference in reading for water activity (Δa_w) and temperature (ΔT).

1. Install the MM70 probe in the same transformer as MHT410. For instructions, see the MM70 User's Guide (available at www.vaisala.com/manuals).
2. Turn off the MI70 indicator.
3. If MHT410 is not connected to MI70, connect it to one of the MI70 ports (I or II).
4. Connect the MM70 probe to the other MI70 port.
5. Turn on the MI70.

The basic display now shows the readings from both devices. The port of the device is indicated next to the measured parameter. You can change the shown parameters in **Main menu > Display > Quantities and units**.

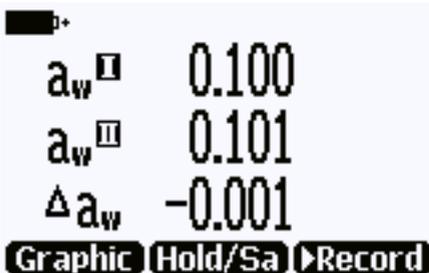


Figure 7 Example of MI70 Display with MHT410 in Port I and MM70 Probe in Port II. Shown Parameters: a_w (I), a_w (II), Δa_w .

Changing the Rechargeable Battery Pack



You can order a new rechargeable battery pack from Vaisala.

1. Open the back plate of the indicator by opening the screw of the back plate.
2. Remove the old battery pack. Detach the black connector by gently pulling it up from the wires.
3. Connect the black connector of the new battery pack. Make sure the position of the connector is as shown in [Figure 8 below](#) (red and black wires are on the upper edge of the connector). Do not push the connector with conducting material.
4. Place the battery pack, close the back plate and tighten the screw.
5. Recharge the indicator before use. For more information, see [Installing and Recharging the MI70 Batteries on page 68](#).

In case you are installing a battery pack and you have a device with alkaline batteries, remove the metal contact before installing the battery pack.

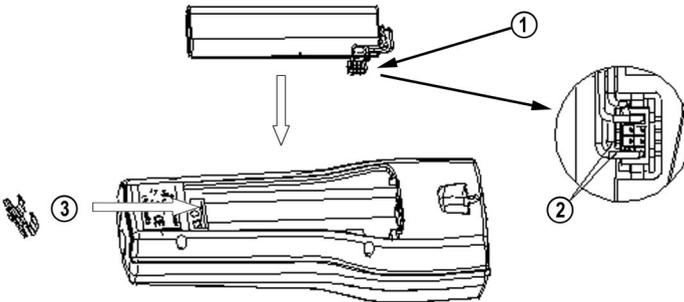


Figure 8 Installing the Battery Pack

9

CALIBRATION AND ADJUSTMENT

MHT410 is fully calibrated and adjusted as shipped from factory.

H₂ Calibration and Adjustment

You can calibrate MHT410 for H₂ by comparing the H₂ reading on the MHT410 to the H₂ concentration of a laboratory-analyzed DGA oil sample. There is no need to remove the transmitter from the transformer to perform calibration and adjustment.

In the calibration procedure, you take a DGA oil sample from the transformer and save the H₂ concentration measured by the transmitter at that time. When you have analyzed the H₂ concentration of the sample, you enter the analyzed H₂ reading to MHT410. The transmitter then implements the adjustment to the H₂ measurement.

Follow the instructions in sections [Taking DGA Sample and Saving Current H₂ Reading](#) below and [Entering DGA H₂ Reading to Transmitter](#) on page 77.

Taking DGA Sample and Saving Current H₂ Reading



- Tools for taking a DGA oil sample
- Connection to the transmitter using Vaisala Industrial Protocol in one of the following ways:
 - Service port (see [Connecting via Service Port on page 38](#))
 - RS-485 line of the screw terminals (User Port configured for Modbus by default: to enable command entry, switch mode via Service Port)



In the following instructions, the keyboard input by the user is in **bold type**.



When you start the adjustment with the `h2` command, normal measurement stops temporarily and the transmitter goes into error state. Measurement returns to normal when you exit the H_2 calibration.

1. Take the DGA oil sample from the transformer.
2. Open the connection on Vaisala Industrial Protocol (see [Connecting via Service Port on page 38](#)).
3. Start the calibration sequence with the command `h2`. The transmitter starts outputting H_2 measurement data.

```
h2
SSN=b11.04rt.10432tn1x, FW=3.85F , MDN=104400-FF02-P1, DF=0xB4B4v,
L
...
```

4. Stop the output by pressing the **Esc** key:

```
...
7997.00  34.0852  50.11176  186.69  2654140  2652818    23
0.0      0    22.2649      0      0 wait
<"ESC key">
H2scan:
```

5. Save the H_2 reading with the `da` command:

```
H2scan: da
Current H2 value is 14.4 ppm...wait...
```

6. When the H_2 measurement output resumes, exit the calibration sequence by pressing the **+** key:

```
...
79842.00  33.8725  50.11766  186.97  2654214  2652858    359
14.4      0    28.5654      200      200 wait <" + key">
Quit hydrogen measurement module command line operation
```



Do not exit the calibration sequence before the H_2 measurement output has resumed.

If the H_2 output does not resume automatically, issue the command `g` to start the H_2 output, and then exit the calibration sequence.

Entering DGA H₂ Reading to Transmitter



- Connection to the transmitter using Vaisala Industrial Protocol in one of the following ways:
 - Service port (see [Connecting via Service Port on page 38](#))
 - RS-485 line of the screw terminals (User Port configured for Modbus by default: to enable command entry, switch mode via Service Port)



When you start the adjustment with the `h2` command, normal measurement stops temporarily and the transmitter goes into error state. Measurement returns to normal when you exit the H₂ calibration.

1. Open the connection on Vaisala Industrial Protocol (see [Connecting via Service Port on page 38](#)).
2. Start the calibration sequence with the command `h2`. The transmitter starts outputting H₂ measurement data.

```
h2
SSN=b11.04rt.10432tnlx, FW=3.85F , MDN=104400-FF02-P1, DF=0xB4B4v,
L
...
```

3. Stop the output by pressing the **Esc** key:

```
...
7997.00 34.0852 50.11176 186.69 2654140 2652818 23
0.0 0 22.2649 0 0 wait
<"ESC key">
H2scan:
```

4. Enter the DGA H₂ reading with the `db` command:

```
H2scan: db
Enter actual hydrogen in ppm: 10
Set hydrogen to 10.0ppm (Y/N)? y
Enter Today's Date:
Month: 4
Day: 14
Year: 2015
...wait...
```

5. When the H₂ measurement output resumes, exit the calibration sequence by pressing the **+** key:

```
...
79842.00 33.8725 50.11766 186.97 2654214 2652858 359
10.0 10 28.5654 200 200 wait <"+ key">
Quit hydrogen measurement module command line operation
```



Do not exit the calibration sequence before the H₂ measurement output has resumed.

If the H₂ output does not resume automatically, issue the command `g` to start the H₂ output, and then exit the calibration sequence.

6. Enter the calibration date and information using the `cdate` and `ctext` commands. For example:

```
cdate 20150630
Cal. date       : 20150630
ctext H2 cal DGA lab sample
Cal. info      : H2 cal DGA lab sample
```

RS & T Calibration and Adjustment

MHT410 is calibrated at the factory for RS and T. The recommended calibration interval for RS & T is 3 years. Vaisala provides calibration and adjustment services. For more information, visit the Vaisala calibration website at www.vaisala.com/calibration.

10

TROUBLESHOOTING

Error States

MHT410 has the following states that indicate a problem with the transmitter:

- Error indication on analog outputs at 3.5 mA (default):
 - With hydrogen measurement errors, the hydrogen channel is in error state.
 - With moisture in oil measurement errors, the moisture in oil channel is in error state.
 - With temperature measurement errors, the temperature and moisture in oil channels are in error state.
 - With general errors, all three channels are in error state.
- Error messages on the serial line:
 - Modbus statuses (see [Modbus Device Status Bits on page 100](#))
 - Vaisala Industrial Protocol error list

Table 39 Possible Error Messages via Vaisala Industrial Protocol

Error Number and Text	Description	Action
0001 Temperature measurement error	Temperature measurement raw value is outside the allowed range.	Remove the transmitter from the transformer and visually check the integrity of the transmitter and the sensor area of the probe body.
0002 Frequency measurement error	Moisture measurement raw value is outside the allowed range.	Contact Vaisala technical support (see Technical Support on page 82).

Error Number and Text	Description	Action
0004 H ₂ measurement error	H ₂ module has reported an error.	Check the connection to the H ₂ module: <ol style="list-style-type: none"> 1. Connect using Vaisala Industrial protocol. 2. Open the connection to H₂ module by giving the command <code>h2</code>. 3. Verify whether the transmitter starts outputting H₂ measurement data. 4. Close the connection to H₂ module by pressing the + key.
0008 H ₂ module communication error	No message was received from H ₂ module in the last 5 seconds.	Contact Vaisala technical support (see Technical Support on page 82).
0010 RH sensor failure	Capacitance value is outside the allowed range.	Remove the transmitter from the transformer and visually check the integrity of the transmitter and the sensor area of the probe body. Contact Vaisala technical support (see Technical Support on page 82).
0020 Temperature too high/low	Measured temperature is outside the error limits (below -45 °C or above +125 °C).	Ensure that the operating temperature is within the valid range -40 ... +120 °C. If the error persists, contact Vaisala technical support (see Technical Support on page 82).

Error Number and Text	Description	Action
0040 Program flash CRC error	Internal transmitter failure.	Contact Vaisala technical support (see Technical Support on the next page).
0080 Parameter flash check sum error		
0100 INFOA check sum error		
0200 SCOEFES check sum error		
0400 CURRENT check sum error		
0800 DEFAULT (factory) check sum error		
1000 General flash failure W/R		

In case of constant error, please contact Vaisala. See [Technical Support on the next page](#).

Changing Bleed Screw

If oil starts flowing out from the bleed screw on the mounting nut, tighten the bleed screw. If oil still flows out, change the bleed screw.



-
- New bleed screw (provided in the MHT410 installation kit)
 - Medium wrench (36 mm)
 - Large wrench (50 mm)
 - Allen key (3 mm, provided in the MHT410 installation kit)
-

1. Loosen the tightening nut of the transmitter.
2. Pull the transmitter outward so that the probe body is out of the ball valve.
3. Close the ball valve.
4. Turn the mounting nut so that the bleed screw is on top of the nut.
5. Remove the bleed screw from the mounting nut.
6. Install a new bleed screw and tighten it firmly.
7. Tighten the mounting nut until the connection is oil-tight.
8. Push the probe to the same installation depth.
9. Tighten the small tightening nut with a wrench until it the probe is securely fastened.

Technical Support

For technical questions, contact the Vaisala technical support by e-mail at helpdesk@vaisala.com. Provide at least the following supporting information:

- Name and model of the product in question
- Serial number of the product
- Name and location of the installation site
- Name and contact information of a technically competent person who can provide further information on the problem.

For contact information of Vaisala Service Centers, see www.vaisala.com/servicecenters.

11

TECHNICAL DATA

Table 40 Measurement Performance

Property	Specification
Hydrogen measurement	
Measurement range (in oil)	0 ... 5000 ppm
Accuracy (in oil temp. range -20 ... +60 °C, -4 ... +140 °F)	±20 % of reading or ±25 ppm (whichever is greater)
Repeatability	±10 % of reading or ±15 ppm (whichever is greater)
Minimum detection limit	20 ppm
Typical long-term stability	3 % of reading / year
Cross sensitivity to other gases	< 2 % (CO ₂ , C ₂ H ₂ , C ₂ H ₄ , CO)
Response time	
63 % of full response	2.5 hours (when sensor is not in reference cycle)
90 % of full response	17 hours
Warm-up time	2 hours, 12 hours for full specification
Sensor	Catalytic palladium-nickel alloy film solid-state sensor
Moisture in oil measurement	
Measurement range (in oil)	0...100 %RS
Accuracy (including non-linearity, hysteresis and repeatability) at 20 °C (68 °F)	
0 ... 90 %RS	±2 %RS
90 ... 100 %RS	±3 %RS
Response time (90 % of full response at +20 °C in still oil)	10 min
Sensor	HUMICAP® 180L2
Temperature measurement	
Measurement range	-40 ... +120 °C (-40 ... +248 °F)
Accuracy at +20 °C (+68 °F)	± 0.2 °C (0.36 °F)
Sensor	Pt1000 RTD Class F0.1 IEC 60751

Table 41 Operating Environment

Property	Specification
Oil type	Mineral oil
Operating humidity range	0 ... 100 %RH, condensing
Operating temperature range (electronics)	-40 ... +60 °C (-40 ... 140 °F)
Storage temperature range	-40 ... +60 °C (-40 ... 140 °F)
Pressure tolerance (probe, short-term)	Max. 10 bara
Pressure tolerance (probe, continuous)	Max. 4 bara
Integrated protection for short power outages	> 3 seconds
<p>Electromagnetic compatibility:</p> <ul style="list-style-type: none"> ■ Complies with EMC standard EN61326-1, Industrial environment ■ Complies with CISPR22 class B emission limits when DC powered ■ Fulfills the requirements of IEC 61000-6-5 in the following tests: <ul style="list-style-type: none"> ○ IEC 61000-4-2 ○ IEC 61000-4-3 ○ IEC 61000-4-4 ○ IEC 61000-4-5 ○ IEC 61000-4-6 ○ IEC 61000-4-8 (100 A/m continuous) ○ IEC 61000-4-11 ○ IEC 61000-4-12 <p>(The list will be continuously updated)</p>	

Table 42 Connections And Outputs

Property	Specification
Operating voltage	15 ... 30 VDC, 24 VAC ($\pm 15\%$) (power supply input is galvanically isolated)
Power consumption	4 W, typical
Analog output (current)	Three isolated 4 ... 20 mA, passive
External load	Max. 500 Ω
Isolation	Max 1.5 kV (DC)
Error status indication in case of device error	3.5 mA default, user configurable for each channel
Accuracy of analog outputs	$\pm 0.125\%$ full scale
Temperature dependence of the analog outputs	$\pm 0.006\%$ / °C full scale
Digital output	Isolated RS-485 half-duplex, RS-485 (Service Port)
Protocols	MODBUS RTU, serial ASCII commands
Screw terminals	Wire size AWG 22-14 Single wire (solid) 1.5 mm ² Stranded wire (flex.) 1.0 mm ² Recommended wire torque 0.4 Nm

Table 43 Mechanics

Property	Specification
Mechanical connection on transmitter	1.5" NPT (male)
Cable bushing (optional)	M20x1.5 for cable diameter 8 ... 11mm/0.31 ... 0.43"
Conduit fitting (optional)	1/2" NPT
Interface cable (optional, pre-assembled)	5 meters, 9.2 mm outer diameter
Housing material	AlSi 10 Mg
Housing classification	IP66
Transmitter weight without cables	4.1 kg

Table 44 Other

Property	Specification
Self-diagnostics indication	Status LEDs, analog output, MODBUS
Integrated data logging capabilities	Non-volatile memory, up to 44 years storage with default logging

Property	Specification
Individual functional test reports	Calibration test reports for moisture, hydrogen and temperature Probe leak test report (5 bara nominal)
Factory warranty	5 years

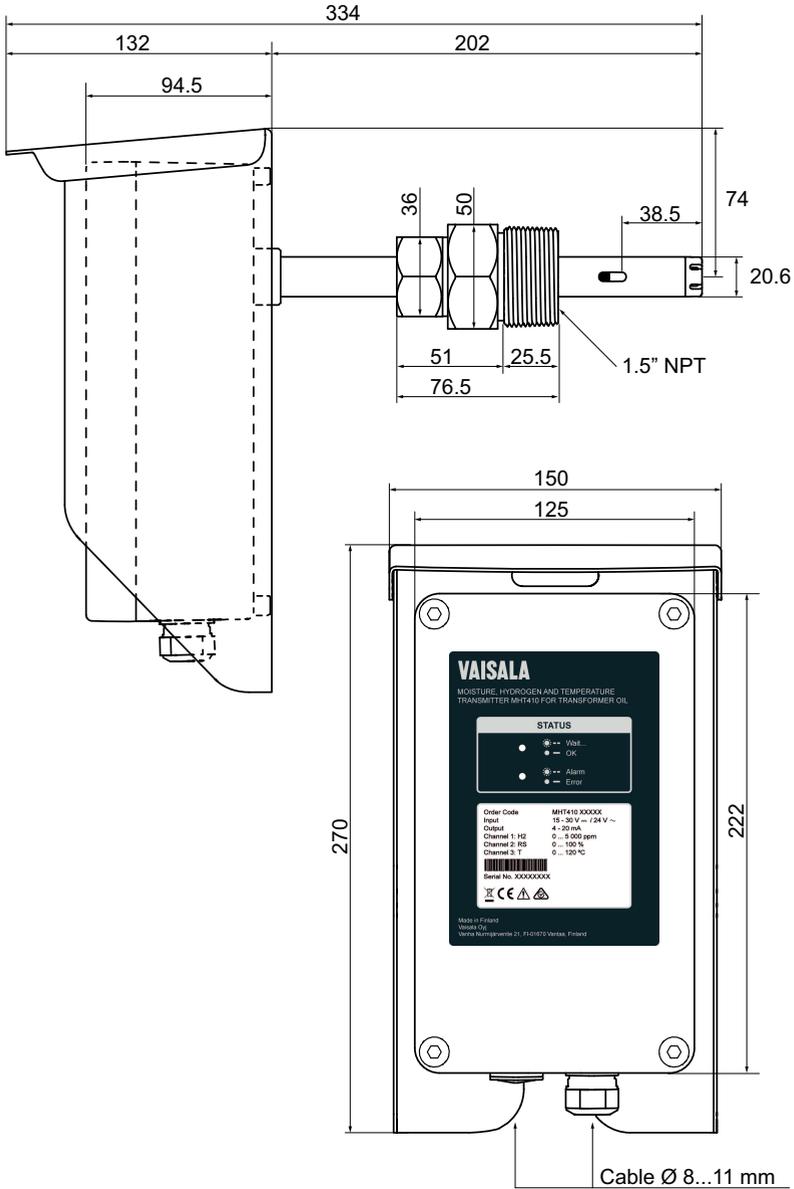
Table 45 Display with Relays (External Option)

Property	Specification
Pre-configured range for hydrogen	0 ... 5000 ppm
Pre-configured alarm relays (user re-configurable)	Relay 1 trigger limit 200 ppm (hi) Relay 2 trigger limit 1500 ppm (hihi)
Input	4... 20 mA, loop-powered
Accuracy	0.05 % of span (-10 ... +60 °C) 2 x solid state (SSR) Max. 250 VAC, 150 mA
Display	4-digit red LED, 14.5 mm
Dimensions	100 x 100 x 57 mm (WHD)
Case protection	IP65
Case material and color	ABS-plastic, grey
Cable glands	2 x M16x1.5

Spare Parts and Accessories

Part number	Description
219690	USB cable for PC connection
242422	External DIN rail power 100 ... 240 VAC to 24 VDC
CBL210392-5MSP	5 meter shielded PUR cable
CBL210392-10MSP	10 meter shielded PUR cable
214728SP	Cable gland
236620SP	Detachable screw terminal block
242003	Loop-powered external display, Nokeval 302 (with alarm relays)
219980	MI70 connection cable
214780SP	Conduit fitting

Dimensions



Wiring Diagrams

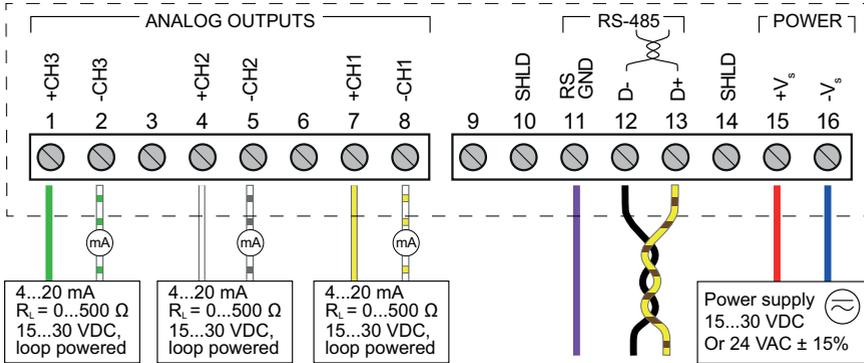


Figure 9 Wiring Option 1: Separate Loop Powering and Galvanic Isolation for Analog Outputs. In transmitters ordered with Vaisala cable CBL210392-5M, the cable is pre-wired according to this option.

Table 46 Vaisala Cable CBL210392-5M Wire Colors (When Pre-Wired)

Terminal	Wire Color
+CH3	Green
-CH3	White-Green
+CH2	White
-CH2	Gray-White
+CH1	Yellow
-CH1	White-Yellow
RSGND	Purple
D-	Black
D+	Yellow-Brown
+Vs	Red
-Vs	Blue

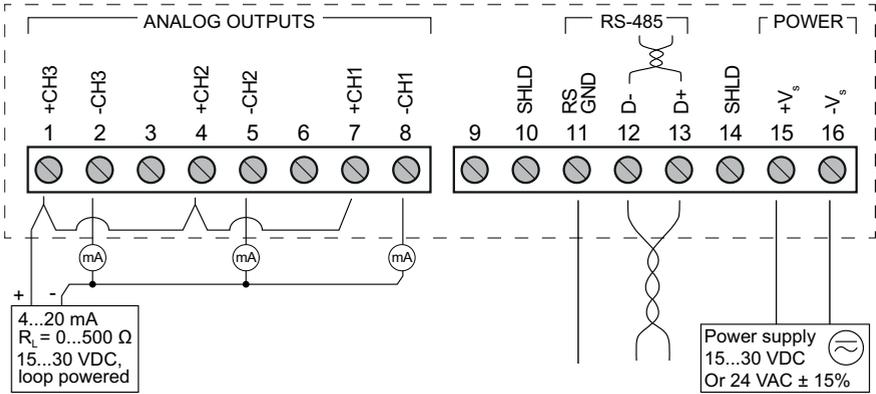


Figure 10 Wiring Option 2: Common Loop Powering And Galvanic Isolation for Analog Outputs

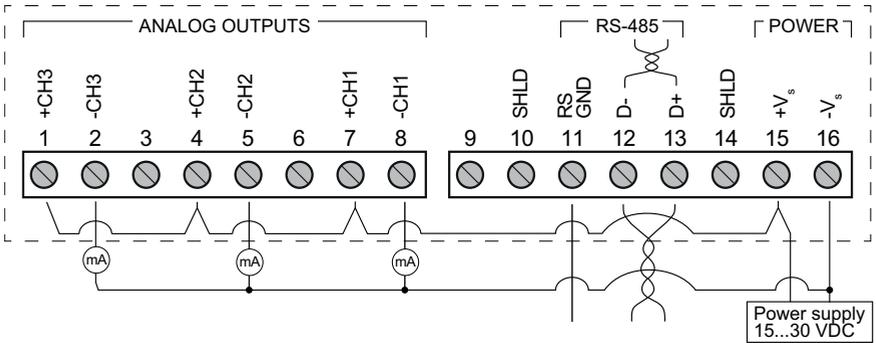


Figure 11 Wiring Option 3: Non-Isolated Configuration for Analog Outputs Sharing Transmitter Power Supply

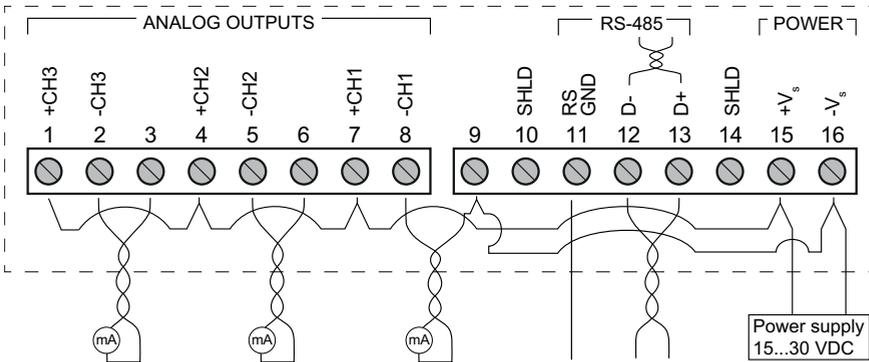


Figure 12 Wiring Option 4: Alternative Wiring to Option 3, Providing Reduced Current Loop Area for Analog Outputs

Recycling



Recycle all applicable material.



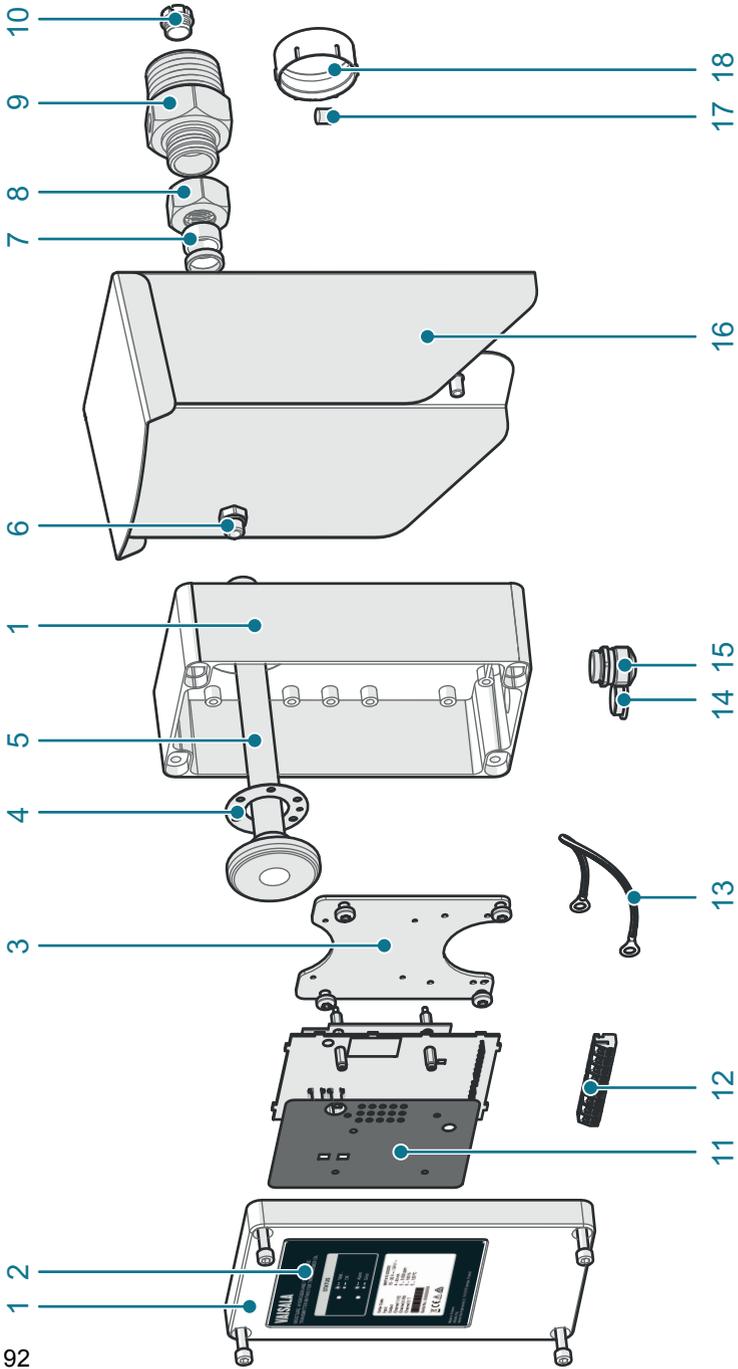
Disposal of Vaisala products is to be done according to local laws and regulations. We encourage end-users to segregate the products from other waste at end-of-life and use best available recycling practices to minimize related environmental impacts.

Almost all of the parts in our products can be recovered as material or energy. If applicable, Vaisala recommends removing the battery unit before recycling the rest of the device as typical electronic waste. The battery unit can be recycled separately in accordance with local waste management practices and regulations. Integrated small sized batteries are typically left in place and removed by professionals at the recycling facilities.

Table 47 Materials for Recycling

Part		Materials
Packaging		
1	Product package	Cardboard
2	Padding foam	Polyethylene
Device parts		
1	Electronics housing and front cover	AISI 10Mg

Part		Materials
2	Product label	Polyester
3	Circuit board mounting plate	EN 1.4404
4	Flange gasket	Silicone
5	Probe shaft	Outer shaft: EN 1.4404 Inner plastic: Polyphenylene sulfide, glass-fiber reinforced
6	Ventilation valve	Polyester
7	Sealing ring	PTFE
8	Tightening nut	EN 1.4404
9	Mounting nut	EN 1.4404
10	Filter	EN 1.4404
11	Circuit board cover	Polypropylene
12	Terminal blocks	Polyamide PA66
13	Grounding cable	Copper wire
14	Plug for cable lead-through	Polystyrol
15	Cable gland	Nickel-plated brass
16	Weather shield	EN 1.4404
17	Sorbent packet	Silica
18	Thread cap	LDPE
Screws		A4



A

APPENDIX: OPERATING PRINCIPLE

Power transformers are critical components in the electric grid. Age, increased load levels and network failures all take a toll on transformers, increasing the risk of unpredicted faults and outages.

- Hydrogen levels and their rate of change indicate the severity of a fault situation.
- Moisture has a direct impact on the lifetime of a transformer. Oil moisture has a significant effect on transformer cellulose condition and the oil's ability to insulate. These changes in moisture levels can occur rapidly.

Continuously monitoring hydrogen and moisture levels with an in-situ probe is the first step in extending the life of a transformer through implementation of predictive maintenance practices leading to lower total cost of ownership.

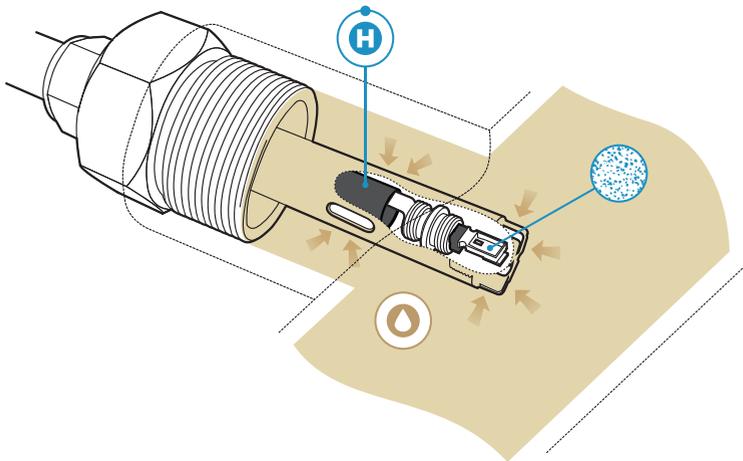


Figure 13 Measuring Hydrogen and Moisture in Oil with MHT410

The optimal locations for the MHT410 hydrogen, moisture and temperature sensors are presented in [Table 48 on the next page](#).

Table 48 Optimal Sensor Locations

Valve in Radiator Pipe	Valve in Transformer Wall
<ul style="list-style-type: none"> ■ Moisture and temperature sensors are directly in the oil flow. This is because water molecule diffusion rate in oil is slow, and therefore moisture must be measured in moving oil. ■ Hydrogen sensor is in the valve area. This is because the hydrogen sensor needs an accurate temperature control, and therefore hydrogen must be measured in still oil. 	<p>Tip of the probe is level with transformer inner wall. No part of the probe must enter the transformer chamber. All sensors remain within the valve area.</p> <hr style="border: 1px solid red;"/> <div style="text-align: center;">  </div> <p>Severe risk of death and of damage to transformer:</p> <p>Pay attention to transmitter installation depth and possible energized parts inside the power transformer to minimize electric shock hazard and equipment damage.</p> <hr style="border: 1px solid red;"/>

Method Used for Measuring Moisture in Oil

MHT410 measures water in oil in terms of relative saturation (%RS) which can be determined as follows: relative saturation indicates the amount of water oil in the scale of 0 ... 100 %RS. In this scale, 0 %RS is an indication of completely water free oil and 100 %RS an indication of oil fully saturated with water. Water is present in free form.

The most advanced feature which distinguishes the measurement of relative saturation (%RS) from the traditional measurement of absolute water content (in ppm) is that the saturation point remains stable regardless of the oil type, aging of oil or additives used. As relative saturation exceeds 90 %RS in any system, there is a risk for segregation (especially if the temperature decreases). The relative saturation is used for alarming at the point of > 90 %RS that the risk for free water in the system is obvious.

The most important advantages of this system are the fact that relative saturation is immune to the aging of oil and to additives, and that the MHT410 transmitter can be used for continuous on-line measurements.

Transformer Oil

The determination of moisture in oil is an essential part of a comprehensive transformer maintenance program. Aging and deterioration increase the

capacity of oil to absorb water. The primary interest in transformers is to measure the water not in oil but in the cellulosic insulation around the transformer windings. The MHT410 method provides for a reliable detection of the aging of oil and possible leakages.

Moisture level in oil is a true indicator of moisture present in the paper insulation. Heating and cooling have a considerable effect on moisture levels in oil. The paper insulation around the transformer windings tends to lose moisture as temperature rises. This moisture is absorbed by the oil surrounding it.

Oil-immersed transformers rely on the oil for cooling, protection from corrosion and as an important component of their insulation. Excessive moisture content in oil causes accelerated aging of the insulation materials and reduces their dielectric strength. In extreme cases, this can result in arcing and short circuits within the windings. Accurate moisture measurements can also warn about leaks in the oil system, as water is absorbed from the surrounding air.

The water solubility of oil is also temperature dependent. In general, water solubility increases as temperature rises, see [Figure 14](#) below.

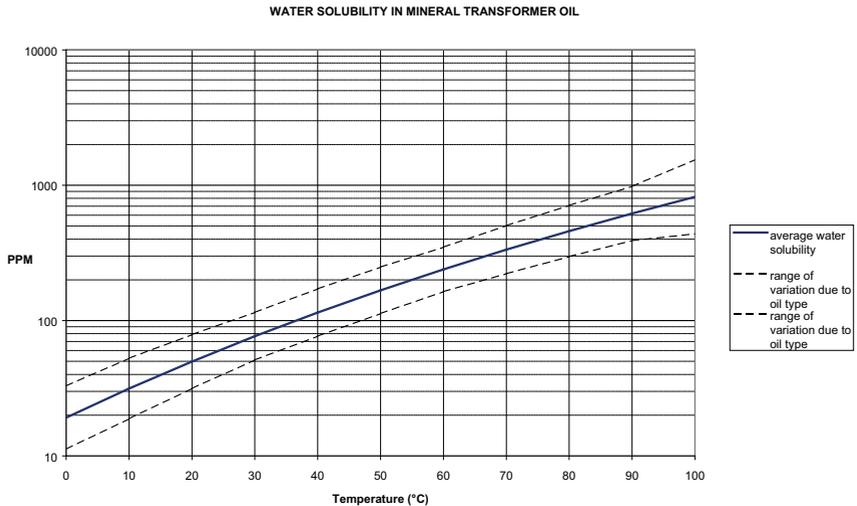


Figure 14 Water Solubility of Transformer Oils versus Temperature. The margins show the range of variation of water solubility found in mineral oils.

In addition, it must be noted that the capacity of oil to absorb water depends both on the chemical structure of the oil and the additives.

B

APPENDIX: MODBUS REFERENCE

Function Codes

Conformance class 0 function codes are enough to access the measurement data and configuration settings of MHT410.

Device identification data can be read out only with the function code dedicated for that purpose (43 / 14).

Table 49 Supported Function Codes

Function Code	Name	Class	Notes
03 (0x03)	Read Holding Registers	Class 0	See Measurement Data (Read Only) on page 98 for available registers.
43 / 14 (0x2B / 0x0E)	Read Device Identification		See Device Identification Objects on page 101 for available device identification objects.

Register Map

All data available via the Modbus interface is grouped in three contiguous blocks of registers as described in [Table 50 below](#).

Table 50 MHT410 Modbus Register Blocks

Logical Address (decimal)	Data Format	Description
1 ... 54	32-bit IEEE float	Measurement data (read only)
257 ... 271	16-bit signed integer	
513 ... 513	16-bit signed integer	Status registers (read-only)

The addresses are 1-based decimal Modbus data model addresses. Subtract 1 to get address field values used in Modbus Protocol Data Unit (PDU).

Data Encoding

All numeric values are available both in 32-bit IEEE floating point and 16-bit signed integer formats.

32-Bit Floating Point Format

Floating point values are represented in standard IEEE 32-bit floating point format. Least-significant 16 bits of floating point numbers are placed at the smaller Modbus address as specified in Open Modbus TCP Specification, Release 1.0. This is also known as "little-endian" or "Modicon" word order.



Despite the specification, some Modbus masters may expect "big-endian" word order (most-significant word first). In such case, you must select "word-swapped" floating point format in your Modbus master for MHT410 Modbus registers.

A "quiet NaN" value is returned for unavailable values. A quiet NaN is, for example, 0x7FC00000; however, the master should understand any NaN value.



A complete 32-bit floating point value should be read and written in a single Modbus transaction.

16-Bit Integer Format

16-bit integer values are scaled to include the necessary decimals (see corresponding register table for the scaling factor) and represented as described in the following table.

Table 51 16-bit Signed Integer Format Details

Value	Description
0x0000...0x7FFE	Value in range 0...32766
0x8002...0xFFFF	Value in range -32766...-1 (2's complement)
0x8000	Value is not available (quiet NaN)



Some values may exceed the signed 16-bit range even in normal operation. To access such values, use the floating point registers instead.

Measurement Data (Read Only)

Table 52 Modbus Measurement Data Registers

Logical Address (decimal)	PDU Address (hexa-decimal)	Register Description		Data Format	Unit
1	00 00	H ₂ , 1 hour average	LSW	32-bit float	ppm (in oil)
2	00 01		MSW		
3	00 02	H ₂ , 24 hour average	LSW	32-bit float	ppm (in oil)
4	00 03		MSW		
5	00 04	H ₂ , Daily ROC	LSW	32-bit float	ppm (in oil)
6	00 05		MSW		
7	00 06	H ₂ , Weekly ROC	LSW	32-bit float	ppm (in oil)
8	00 07		MSW		
9	00 08	H ₂ , Monthly ROC	LSW	32-bit float	ppm (in oil)
10	00 09		MSW		
15	00 0E	Oil moisture, relative saturation	LSW	32-bit float	%RS
16	00 0F		MSW		
17	00 10	Oil moisture, current	LSW	32-bit float	ppm
18	00 11		MSW		
19	00 12	Oil moisture, 24 h average	LSW	32-bit float	ppm
20	00 13		MSW		
21	00 14	Oil moisture, Daily ROC	LSW	32-bit float	ppm
22	00 15		MSW		
23	00 16	Oil moisture, Weekly ROC	LSW	32-bit float	ppm
24	00 17		MSW		
25	00 18	Oil moisture, Monthly ROC	LSW	32-bit float	ppm
26	00 19		MSW		
27	00 1A	Oil temperature	LSW	32-bit float	°C
28	00 1B		MSW		
257	01 00	H ₂ , 1 h average		16-bit integer	ppm (in oil)
258	01 01	H ₂ , 24 h average		16-bit integer	ppm (in oil)
259	01 02	H ₂ , Daily ROC		16-bit integer	ppm (in oil)
260	01 03	H ₂ , Weekly ROC		16-bit integer	ppm (in oil)

Logical Address (decimal)	PDU Address (hexadecimal)	Register Description	Data Format	Unit
261	01 04	H ₂ , Monthly ROC	16-bit integer	ppm (in oil)
264	01 07	Oil moisture, relative saturation	16-bit integer	%RS*10
265	01 08	Oil moisture, current	16-bit integer	ppm*10
266	01 09	Oil moisture, 24h average	16-bit integer	ppm*10
267	01 0A	Oil moisture, Daily ROC	16-bit integer	ppm*10
268	01 0B	Oil moisture, Weekly ROC	16-bit integer	ppm*10
269	01 0C	Oil moisture, Monthly ROC	16-bit integer	ppm*10
270	01 0D	Oil temperature	16-bit integer	°C *10
513	02 00	Device status bits	16-bit	See Status Registers on the next page.

Legend:

- PDU address = Actual address bytes used in a Modbus Protocol Data Unit
 LSW = Least Significant Word (bits 15...0)
 MSW = Most Significant Word (bits 31...16)
 16-bit integer = Numeric value in range -32768...32767
 32-bit float = Floating point number encoded according to IEEE 754

A complete 32-bit value (two Modbus registers) must be read and written in a single Modbus transaction.

A “quiet NaN” (0x7FC00000) value is returned for unavailable floating-point values and NaN (0x8000) for unavailable integer values (e.g. in case of measurement error).

Several registers may be read in one transaction, even if there are gaps in the register map. Registers not listed above contain typically value NaN or 0.

Values may be unavailable in case of device failure. Read status registers or exception status outputs to check for failures.

Status Registers

Table 53 Modbus Status Registers for MHT410

Register Description	Logical Address	Data Format
Device status bits	513	16-bit integer

Table 54 Modbus Device Status Bits

Output (bit number)	Output Name	Notes
0	Critical Error active	Maintenance needed.
1	Error active	Device may recover automatically.
2	RH measurement error	Remove the transmitter from the transformer and visually check the integrity of the transmitter and the sensor area of the probe body.
3	T measurement error	Contact Vaisala technical support (see Technical Support on page 82).
4	H ₂ measurement error	<p>Check the connection to the H₂ module:</p> <ol style="list-style-type: none"> 1. Connect using Vaisala Industrial protocol. 2. Open the connection to H₂ module by giving the command <code>h2</code>. 3. Verify whether the transmitter starts outputting H₂ measurement data. 4. Close the connection to H₂ module by pressing the + key. <p>Contact Vaisala technical support (see Technical Support on page 82).</p>
5	Other error	Contact Vaisala technical support (see Technical Support on page 82).
6	H ₂ alarm level exceeded	

Device Identification Objects

MHT410 Modbus conforms to the extended identification level defined in the Modbus Application Protocol Specification V1.1b. Both stream access and individual access to the objects is supported. Basic device identification consists of objects 0x00...0x02. Those values should be used if the device must be identified to establish its Modbus capabilities.

Table 55 MHT410 Device Identification Objects

Object ID (Decimal)	Object ID (Hexa-decimal)	Object Name	Example Contents
0	00	VendorName	"Vaisala"
1	01	ProductCode	"MHT410"
2	02	MajorMinorVersion	Software version (for example "1.2.3")
3	03	VendorUrl	"http://www.vaisala.com/"
4	04	ProductName	"Vaisala Moisture, Hydrogen and Temperature Transmitter MHT410 for Transformer Oil"
128	80	SerialNumber	Transmitter serial number (for example, "K0710040")
129	81	Calibration date	Date of the factory calibration
130	82	Calibration text	Information text of the factory calibration

Object numbers above 127 are Vaisala-specific device information objects.

Exception Responses

Table 56 MHT410Modbus Exception Responses

Code	Name	Reason
01	ILLEGAL FUNCTION	Unsupported function code
02	ILLEGAL DATA ADDRESS	Address out of valid ranges
03	ILLEGAL DATA VALUE	Otherwise invalid request

Accessing unavailable (unsupported or temporarily missing) measurement data does not generate an exception. "Unavailable" value (a quiet NaN for floating point data or 0x0000 for integer data) is returned instead. An exception is generated only for any access outside the register blocks defined in [Table 50 on page 96](#).

C

APPENDIX: MOISTURE PPM CALCULATION FOR TRANSFORMER OILS

Traditionally, moisture in transformer oil is measured in ppm units. The ppm output shows the average mass concentration of water in oil.

MHT410 has an option for ppm output.

Calculation Model with Average Coefficients

The calculation model of MHT410 is based on the average water solubility behavior of transformer oils. The ppm output is calculated as follows:

$$ppm = a_w \times 10^{(A/(T+273.15)+B)},$$

where

- a_w = water activity
- A, B = coefficients (average or oil specific)
- T = temperature (°C)

Generally, moisture in oil measurement with MHT410 has an accuracy of $\pm 2 \dots 3$ % of the reading. If additional accuracy is needed, see [Calculation Model with Oil-specific Coefficients below](#).

Calculation Model with Oil-specific Coefficients

For additional accuracy, an oil-specific calculation model can be used. An oil sample has to be sent to Vaisala for modeling. As a result, the specific coefficients (A and B: see formula in [Calculation Model with Average Coefficients above](#)) for the transformer oil are determined by Vaisala. Using these coefficients increases measurement accuracy.

The determined coefficients of the transformer oil can be programmed to the MHT410 by Vaisala.



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