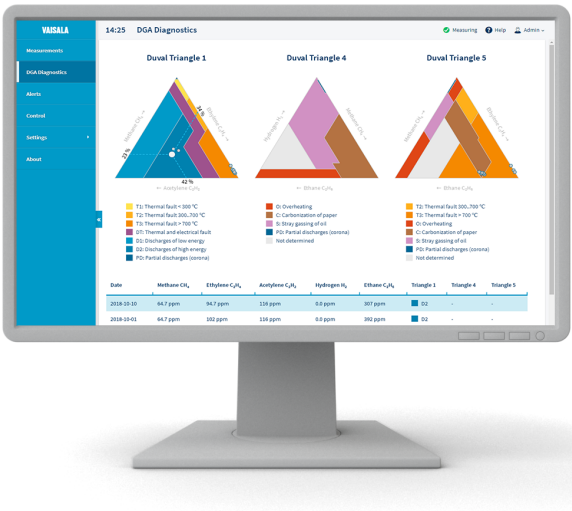
M211858EN-F

User Guide

Vaisala Optimus™ DGA Monitor for Transformers

OPT100



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1. About This Document

1.1 Version Information

Table 1 Document Versions (English)

Document Code	Date	Description
M211858EN-F	June 2019	This version. Applicable from software version 1.8.0 onwards. Added sections: • Configuring User Interface Security (page 39) • Setting Device Name (page 33) Updated sections: • Basic Features and Options (page 7) • About Page (page 27) • DNP3 Protocol (page 18) • Configuring DNP3 Protocol (page 40) • Changing Administrator Password (page 35) • OPT100 Technical Specification (page 56)
M211858EN-E	April 2019	Applicable from software version 1.7.0 onwards. Added sections: • Notes for Normal Operation (page 9) • IEC 61850 Protocol (page 18) • Configuring IEC 61850 Protocol (page 41) • DGA Diagnostics Page (page 23) • Changing Administrator Password (page 35) • Starting Autocalibration Manually (page 47) • Resolving a Device Error (page 54) Updated sections: • Overview of User Interface (page 19) • Updating DGA Monitor Software (page 45) • Problem Situations (page 53)
M211858EN-D	July 2018	Applicable from software version 1.4.0 onwards. Added content for gas level alert feature and relay control. Updated description of Status LEDs. Updated Troubleshooting.

1.2 Related Manuals

Table 2 Related Manuals

Document Code	Name
M211857EN	*OPT100 Installation Guide*

1.3 Documentation Conventions

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

CAUTION! 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.

Tip gives information for using the product more efficiently.

Lists tools needed to perform the task.

Indicates that you need to take some notes during the task.

1.4 Trademarks

OPTIMUS™ is a trademark of Vaisala Oyj.

All other product or company names that may be mentioned in this publication are trade names, trademarks, or registered trademarks of their respective owners.

2. Product Overview

2.1 Overview of OPT100 DGA Monitor

OPT100 is a device for monitoring the internal condition of an electrical transformer using dissolved gas analysis (DGA), also known as fault gas analysis. OPT100 is intended to be installed next to the transformer, and connected to it by two oil lines. OPT100 draws oil from a transformer, measures the concentrations of hydrogen, moisture, and several hydrocarbons in the oil, and returns the oil back to the transformer.

Measurement results can be transferred via communication interfaces to the substation's SCADA (Supervisory Control And Data Acquisition) system. The data is also available for viewing by human operators through the browser-based user interface.

More Information

- OPT100 Technical Specification (page 56)

2.2 Basic Features and Options

- Measurement of seven fault gases and moisture in oil
- Several calculated parameters and gas ratios available
- Ethernet and RS-485 interfaces for SCADA integration
- Modbus protocol (RTU and TCP)
- Three configurable relay outputs
- Gas level alerts for measured values and rate of change (ROC)
- IP66 rated enclosure
- Optional software features:
  - DGA diagnostics using Duval triangles
  - DNP3 (Distributed Network Protocol) over Ethernet
  - IEC 61850 protocol over Ethernet
- Installation options:
  - Ground mounting set
  - Wall mounting set
  - Weather shield

2.3 Measured Parameters

Table 3 Measured Parameters

Parameter	Output Unit(s)	Description
Methane (CH_4)	ppm_v	Measured from extracted gas
Ethane (C_2H_6)	ppm_v	Measured from extracted gas

Parameter	Output Unit(s)	Description
Ethylene (C_2H_4)	ppm_v	Measured from extracted gas
Acetylene (C_2H_2)	ppm_v	Measured from extracted gas
Carbon monoxide (CO)	ppm_v	Measured from extracted gas
Carbon dioxide (CO_2)	ppm_v	Measured from extracted gas
Hydrogen (H_2)	ppm_v	Measured in-oil
Moisture (H_2O)	ppm_w and %RS	Measured in-oil as relative saturation (%RS). See Calculating Relative Moisture Saturation Inside Transformer (page 8).

Table 4 Calculated Parameters

Property	Output Unit(s)	Description
Total dissolved combustible gases (TDCG)	ppm_v	Combined total of H_2, CO, CH_4, C_2H_6, C_2H_4, and C_2H_2.
Rate of change (ROC)	ppm_v	Available for single gases and TDCG for 24 h, 7 d, and 30 d periods.
Gas ratios for: • CH_4/H_2 • C_2H_2/C_2H_4 • C_2H_2/CH_4 • C_2H_6/C_2H_2 • C_2H_4/C_2H_6 • CO_2/CO	Ratio	Ratio is calculated from 24 h average values of the gases.

2.3.1 Calculating Relative Moisture Saturation Inside Transformer

CAUTION! DGA monitor measures relative oil moisture (%RS) inside its enclosure. The temperature of the moisture sensor location does not represent the temperature inside the transformer tank or inside the oil circulation pipes. Additionally, oil sampling through the steel pipes changes the oil temperature. As relative moisture saturation is strongly **temperature dependent**, the %RS measured and output by DGA monitor is not equal to %RS inside the transformer tank.

However, DGA monitor does output both the measured %RS and the temperature where it was measured. To calculate the %RS in the true temperature inside the transformer, use the following equation.

$$\%RS_{T2} = \%RS_{T1} \times 10^{\left(\frac{A(T2-T1)}{(T1+273.15)\times(T2+273.15)}\right)}$$

$\%RS_{(T1)}$	Relative moisture saturation output by DGA monitor
T1	Temperature of the in-oil measurement chamber inside DGA monitor
T2	Temperature at location where new relative moisture saturation is needed at
A	-1662.70

A is a water solubility coefficient. Vaisala uses this standard value in all of its oil moisture transmitters. You can also use this equation with an oil-specific coefficient if it has been determined for your oil.

2.4 Notes for Normal Operation

In normal operation the DGA monitor performs measurement cycles automatically without any operator involvement. Integration with a SCADA system is recommended for convenient monitoring of measurement results and system status. Status LEDs on the enclosure door indicate system status on a general level, and detailed status is available from the browser-based user interface.

Note the following for successful operation:

- Keep the doors of the DGA monitor enclosures closed and locked during normal operation. This is important for keeping the inside of the DGA monitor clean and the measurement environment stable.
- Keep the measurement running continuously to achieve the best measurement performance.
- If the DGA monitor will be unpowered for a long time (for example, due to a transformer maintenance), set the system to **Standby**. See Stopping Measurement (page 48).

2.5 Parts with Ground Mounting Set

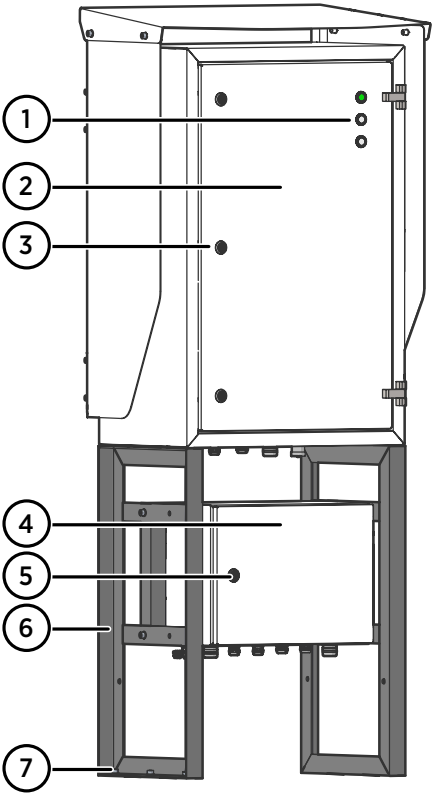


Figure 1 OPT100 Front Parts with Ground Mounting Set

1 Status LEDs
2 OPT100 DGA Monitor
3 Door lock (3 pcs)
4 Power supply unit
5 Door lock
6 Mounting stand
7 Wedge anchors (6 pcs)

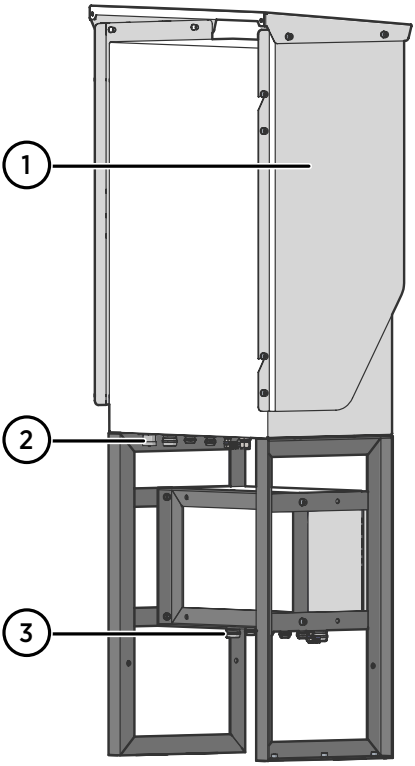


Figure 2 OPT100 Rear Parts with Ground Mounting Set

1 Weather shield
2 Cable glands and oil connections for DGA Monitor
3 Cable glands for power supply unit

2.6 Parts with Wall Mounting Set

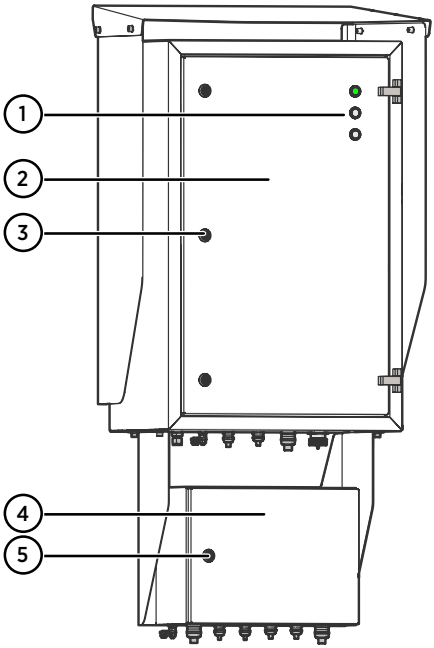


Figure 3 OPT100 Front Parts with Wall Mounting Set

1 Status LEDs
2 OPT100 DGA Monitor
3 Door lock (3 pcs)
4 Power supply unit
5 Door lock

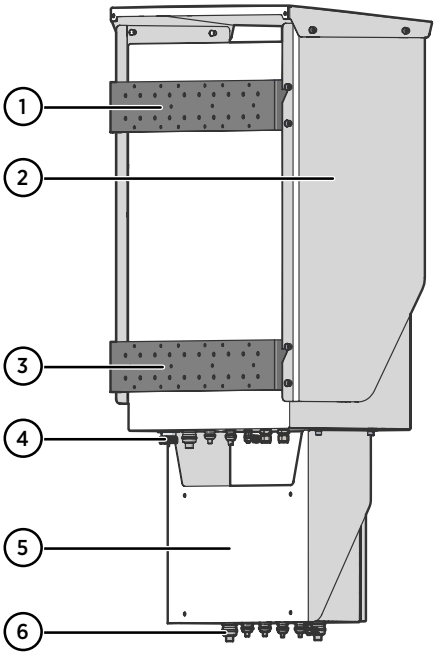


Figure 4 OPT100 Rear Parts with Wall Mounting Set

1 Installation beam (upper)
2 Weather shield
3 Installation beam (lower)
4 Cable glands for DGA Monitor
5 Cradle for power supply unit
6 Cable glands for power supply unit

2.7 Cable Glands and Connectors

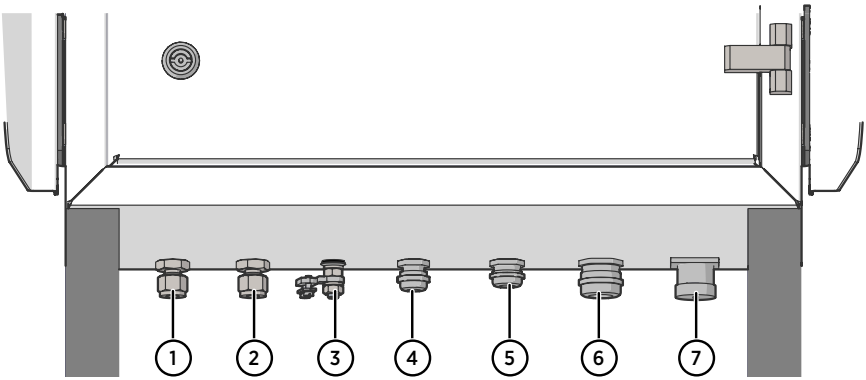


Figure 5 OPT100 DGA Monitor Cable Glands and Connectors

1 **Oil Out**: connection for oil return line
2 **Oil In**: connection for oil intake
3 ⏚ Ground terminal
4 **RS-485**: cable gland for RS-485 connection
5 **Relay control out**: cable gland for relay control to power supply unit
6 **DC in**: 24 VDC connection from power supply unit
7 **Ethernet**: external RJ45 connector for permanent Ethernet connection

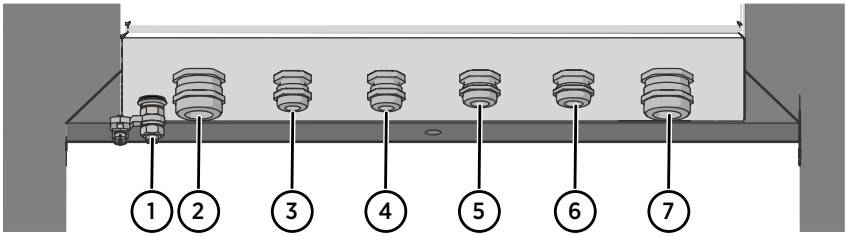


Figure 6 OPTPSU1 Power Supply Unit Cable Glands and Connectors

1 ⏚ Ground terminal
2 **AC in**: Mains power input. 100 ... 240 VAC, 50 ... 60 Hz, 10 A
3 Spare
4 Spare
5 **Relay out**: Relay output. Max 250 VAC, 10 A
6 **Relay control in**: Relay control from DGA monitor
7 **DC out**: DC out to DGA monitor. 24 VDC, 20 A

2.8 Interior Parts

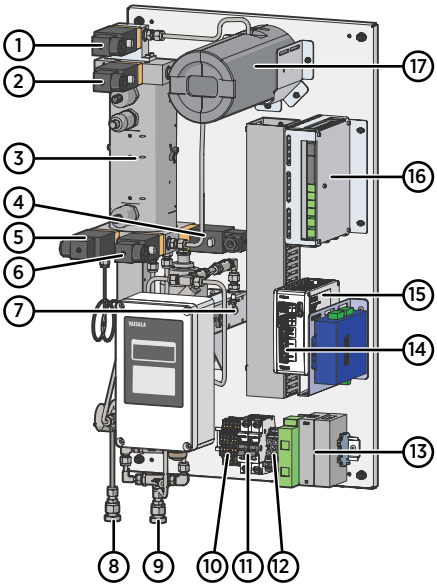


Figure 7 Inside OPT100 DGA Monitor Enclosure

1 Valve 5 (bleed valve). Must be manually accessed during initialization and uninstallation.
2 Valve 4
3 Oil block
4 Valve 3
5 Valve 2
6 Valve 1
7 In-oil measurement of hydrogen and moisture
8 Oil out
9 Oil in
10 Terminal blocks for RS-485 output (Y1) and relay control (Y2)
11 Circuit breakers for DC power: main breaker (F2) and breaker for heating power (F1)
12 Terminal block for DC in (Y3)
13 Surge arresters
14 Ethernet connectors:
   - ETH0 Connection for SCADA, wired to external Ethernet connector
   - ETH1 Service port for temporary local use, with IP address 192.168.28.2
15 Processing unit
16 Control unit
17 Optical measurement module for extracted gases

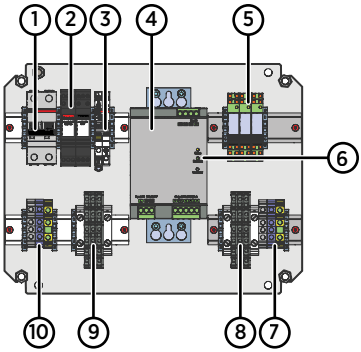


Figure 8 Inside OPTPSU1 Power Supply Unit Enclosure

1 Circuit breaker for AC power (F1)
2 Surge arresters
3 Power switch (S1)
4 Power supply
5 Relays (3 pcs). Each relay has a LED that is lit when the relay is active.
6 DC OK LED. If flashing, check DC wiring.
7 DC out terminal block (X5)
8 Relay control terminal block (X4)
9 Relay output terminal block (X3)
10 Mains power in terminal block (X1)

2.9 Status LEDs

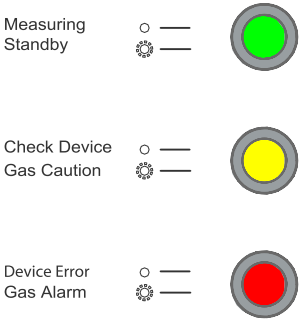


Figure 9 Status LEDs

Table 5 Meaning of Status LEDs

Color	Meaning
Green	DGA monitor is operating normally and performing measurement cycles.
Green (flashing)	DGA monitor is in standby mode. User interaction is required to begin measurement.
Yellow	DGA monitor requires user interaction. For example, it is being initialized, or has been uninstalled.
Yellow (flashing)	Gas level alert is active, caution limit exceeded.
Red	DGA monitor is in error state. User interaction is required.
Red (flashing)	Gas level alert is active, alarm limit exceeded.

2.10 Gas Level Alerts

DGA monitor has individual gas level alerts for measured gases and total dissolved combustible gases (TDCG). Each gas has four possible alerts (latest measured value, ROC 1 day, ROC 7 days, ROC 30 days) and two separate limits (caution and alarm). Additionally, moisture alerts (ppm and %RS) can be configured for latest measured values.

Active gas level alerts are communicated in the user interface, status LEDs, and output protocols. They also control relay activation. Once activated, alerts remain active until acknowledged by the **admin** user, or the automatic acknowledgement feature (if enabled). See Acknowledging Gas Level Alerts (page 32).

In addition to alert limits themselves, DGA monitor implements some additional rules to prevent unnecessary alerts:

- Only reliable measurement results can activate alerts. If the DGA monitor has been in the standby state, it must complete 3 measurement cycles before alarms can be activated.
- Alerts will not be activated during the first autocalibration after installation.
- A single large jump in the measured value that exceeds the alert limit will not activate an alert. The previous measurement must be at least 75% of the latest measurement for an alert to be activated. If the measured value remains over the limit when the next measurement cycle is completed, the alert is activated.

2.11 Modbus Protocol

Data measured by DGA monitor can be read using Modbus protocol. Supported Modbus variants are:

- Modbus RTU (serial Modbus) over the RS-485 interface
- Modbus TCP over the Ethernet interface

Table 6 Modbus RTU Communication Settings

Property	Specification
Baud rate	19200
Parity	Even
Data bits	8
Stop bits	1
Modbus RTU slave address	240

Table 7 Modbus TCP Communication Settings

Property	Specification
IP address of Modbus server	IP address of DGA monitor on interface ETH0
Modbus server port	502

More Information

- Modbus Registers (page 63)

2.12 DNP3 Protocol

DNP3 protocol is an optional feature and requires a license. If a license is not installed on the DGA monitor, you cannot enable the protocol. Contact Vaisala for acquiring the license.

Data measured by DGA monitor can be read using DNP3 (Distributed Network Protocol) over the external Ethernet connection. DNP3 protocol can also be disabled if it is not needed.

You can download the DNP3 device profile in XML format from the **Settings > Network > DNP3** page of the user interface. It is needed to configure your DNP3 master system. A description of the interface is also available as a separate PDF document.

2.13 IEC 61850 Protocol

IEC 61850 protocol is an optional feature and requires a license. If a license is not installed on the DGA monitor, you cannot enable the protocol. Contact Vaisala for acquiring the license.

Data measured by DGA monitor can be read using IEC 61850 protocol over the external Ethernet connection. IEC 61850 protocol can also be disabled if it is not needed.

The following supporting documents describe the data and functionality available through IEC 61850 protocol:

- IED Capability Description (ICD) file
- Protocol Implementation Conformance Statement (PICS)
- Model Implementation Conformance Statement (MICS)

You can download the documents from the OPT100 user interface at **Settings > Network > IEC 61850**.

3. User Interface

3.1 Overview of User Interface

DGA monitor runs a web server on its processing unit. This web server provides the user interface of the DGA monitor. The user interface can be accessed through Ethernet using a standard web browser; no special software is needed.

Access rights are based on two fixed user accounts that are present on every DGA monitor:

- **Admin**: full access for commissioning, configuration, and maintenance tasks. Requires password to log in. Browser session expires after 3 hours of inactivity.
- **User**: limited access for viewing data and system settings. Cannot configure or control the DGA monitor. Does not require a password. Browser session expires after one year of inactivity.

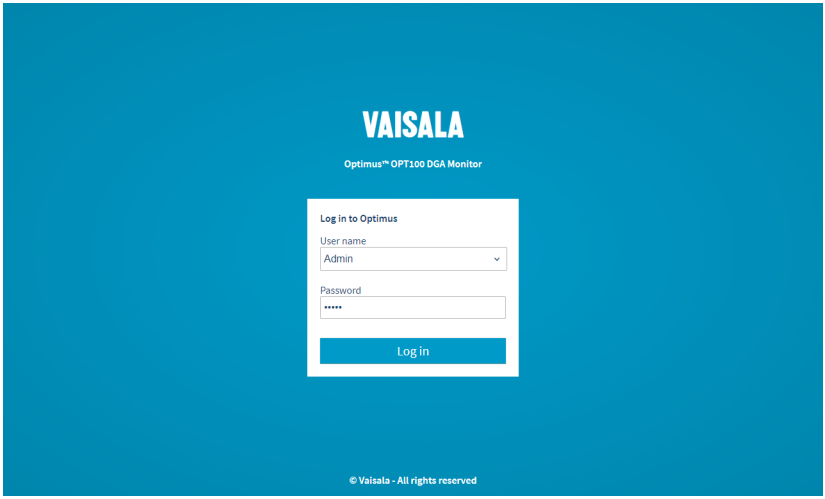
The same Ethernet network that connects to the SCADA system can be used to access the user interface. Additionally, local access to the interface is provided by direct access to **ETH1** port of the processing unit.

3.1.1 Connecting to User Interface

- Laptop computer with:
  - RJ45 Ethernet connector
  - Web browser (Google Chrome™, Microsoft Internet Explorer®, or Mozilla Firefox®)
- Ethernet cable with RJ45 connectors for temporary use
- Administration password for this DGA Monitor

1. Connect your computer to the same network as the DGA monitor. If you are connecting locally, connect the network cable between your computer and the port marked **ETH1** on the processing unit inside the DGA monitor.
2. Open a web browser on the computer, and enter the IP address of the DGA monitor in the address bar:
   - If you are connecting locally through the ETH1 port, use the following IP address: **192.168.28.2**
   - If you are connecting through the network meant for SCADA integration, use the IP address that has been assigned to the DGA monitor.
3. Your web browser may warn you that your connection is not secure. This is expected and happens when the user interface of the DGA monitor is secured using a certificate that is not trusted by your browser. Since the user interface is secured using a self-signed certificate by default, this will always happen for new devices. If you know that user interface security has not been configured to use a trusted certificate, continue regardless of the warning. HTTPS traffic is always encrypted even if the certificate is not trusted.

4. Choose the appropriate user level:
   - Select **Admin** to perform installation and maintenance tasks.
   - Select **User** to view data without making changes to the system.



5. If logging in as **Admin**, enter the unique admin password for this OPT100 DGA Monitor. The password is included in the OPT100 delivery documentation.
   No password is required for the **User** account.
6. Select **Log in**. The user interface opens in your browser.

3.1.2 Measurements Page

Measurements page provides the measurement data in graph and table format.

Figure 10 Measurement Graph

1 Pop-up that shows the values at the point below the cursor.
2 Graph area. Use the mouse wheel to adjust the zoom level of the y-axis.
3 Quick selection buttons for preset time windows.
4 Drop-down menu for selecting the parameter set that is shown.
5 Parameters that are shown on the left y-axis. To show and hide parameters, select their color tab.
6 Time slider for selecting the time window shown in the graph area. To adjust the size of the time window, drag the edges of the slider. To move the time window, drag the slider.
7 Measurement parameters on the right y-axis. Drag individual parameters to this area to show them on the right y-axis. This is useful when one of the parameters has a different range of values than the rest.

Graph lines show empty gaps if data is missing from two consecutive measurement cycles or for more than three hours. Data may be missing for several reasons. For example, DGA monitor may have been turned off, in standby mode, or measurement cycles have not produced reliable results for some or all measurement parameters.

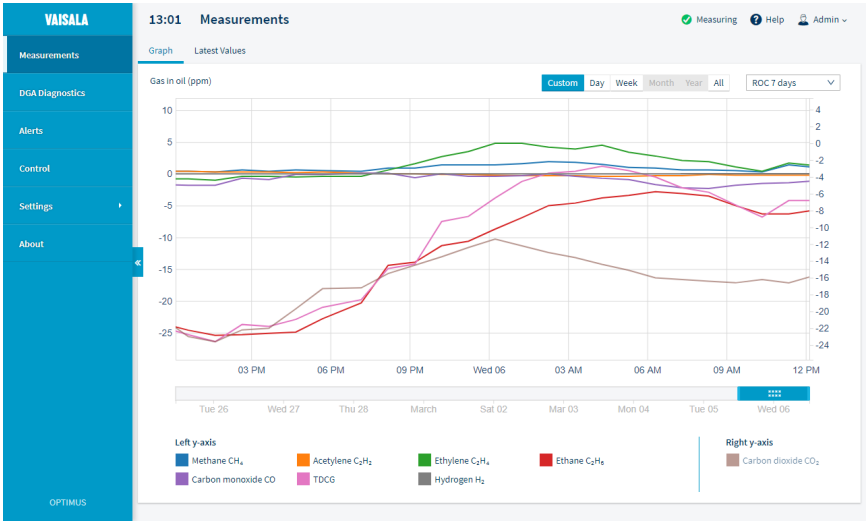


Figure 11 Measurement Graph for 1 Day Rate of Change Values

To download all of the measured data into a file, select **Latest values > Download Data**. The format of the file is CSV (comma separated value), and you can easily import it into common spreadsheet programs.

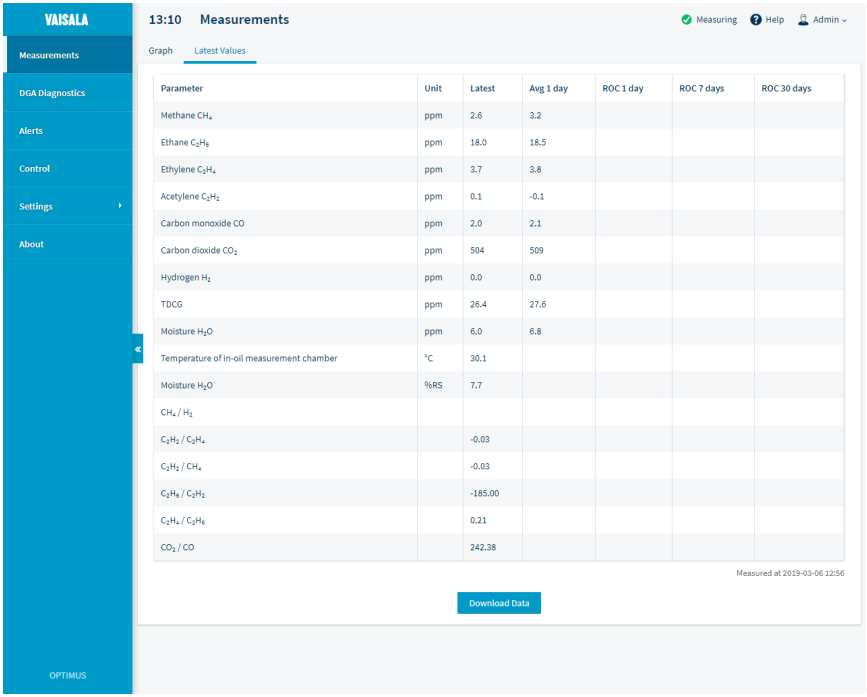


Figure 12 Table of Latest Values

3.1.3 DGA Diagnostics Page

CAUTION! This software utilizes publicly available and commonly used dissolved gas analysis (DGA) method for transformer fault diagnostics purposes, Duval Triangles (IEC 60599, Annex B).
Customer acknowledges and agrees that Vaisala shall not assume any risk or liability in connection with the use or application of the diagnostics data by the Customer or any other user of such data. The use and/or application of any such data shall be at the sole risk and liability of the Customer or the user.

DGA Diagnostics is an optional feature and requires a license. Contact Vaisala for acquiring the license.

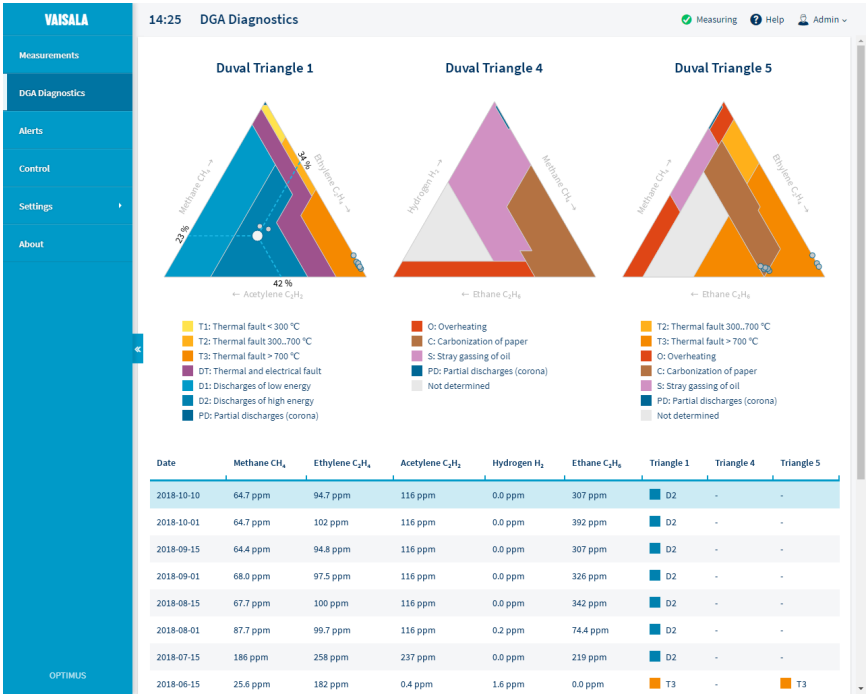


Figure 13 Duval Triangles on the DGA Diagnostics Page

DGA Diagnostics page shows the progression of selected data points from the past year overlaid on top of Duval triangles:

- **Triangle 1**: Classic Duval triangle for DGA in oil-filled transformers using methane, ethylene, and acetylene
- **Triangle 4**: Diagnosis of low-temperature faults in oil-filled transformers using hydrogen, methane, and ethane
- **Triangle 5**: Diagnosis of low-temperature faults in oil-filled transformers using methane, ethylene, and ethane

DGA monitor automatically selects the data points according to criteria described in section Criteria for Data Points in DGA Diagnostics (page 24). The data points are listed in a table below the triangles. Clicking a table row highlights the data point in the overlay and displays the gas ratios as percentages.

3.1.3.1 Criteria for Data Points in DGA Diagnostics

DGA Diagnostics view shows up to 24 data points from the past year. A data point that meets selection criteria is automatically selected at roughly two week intervals. If less than one year of data is available, all of the data is used.

The data points are 24 hour average values for the included gases and must meet the following criteria for each point:

- At least 5 reliable measurement points must exist in the previous 24 hours. Reliability criteria are the same as for gas alert functionality.
- At least one of the following conditions is true:
  - Concentration of all triangle 1 gases is higher than OPT100 accuracy as listed in Table 8 (page 25)
  - At least one of the triangle 1 gases is above the limit based on IEC 60599 as listed in Table 8 (page 25)

Table 8 Data Point Selection Criteria

Gas	OPT100 Accuracy Specification in ppm	Limits Based on IEC 60599
Acetylene(C_2H_2)	2	4
Methane (CH_4)	10	30
Ethane (C_2H_6)	10	30
Ethylene (C_2H_4)	10	30
Hydrogen (H_2)	25	50

3.1.4 Alerts Page

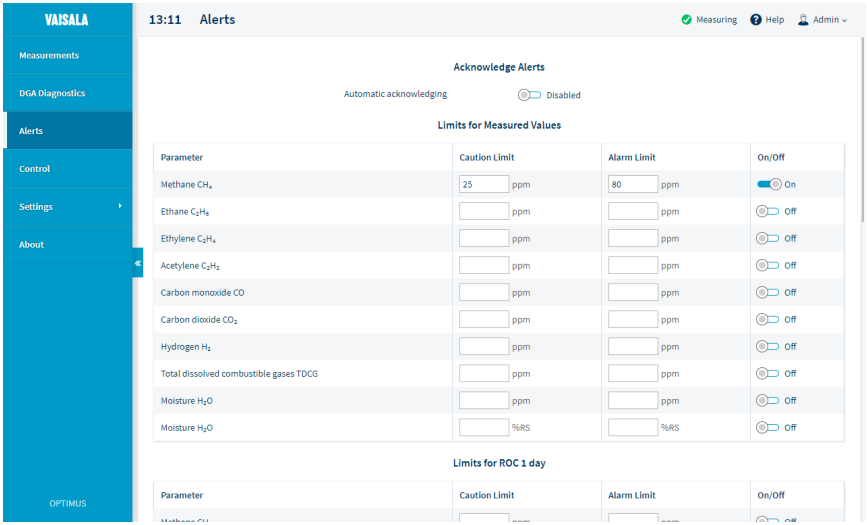


Figure 14 Alerts Page

You can configure gas level alerts on the **Alerts** page. There are separate rows for each individual alert that you can configure. By default, all alerts are off, and automatic acknowledgement is off.

3.1.5 Control Page

Control page shows the current status of the DGA monitor and contains the controls for initialization, starting and stopping the measurement, and uninstalling the DGA monitor. Only relevant controls are shown, and they can only be used by the **Admin** user.

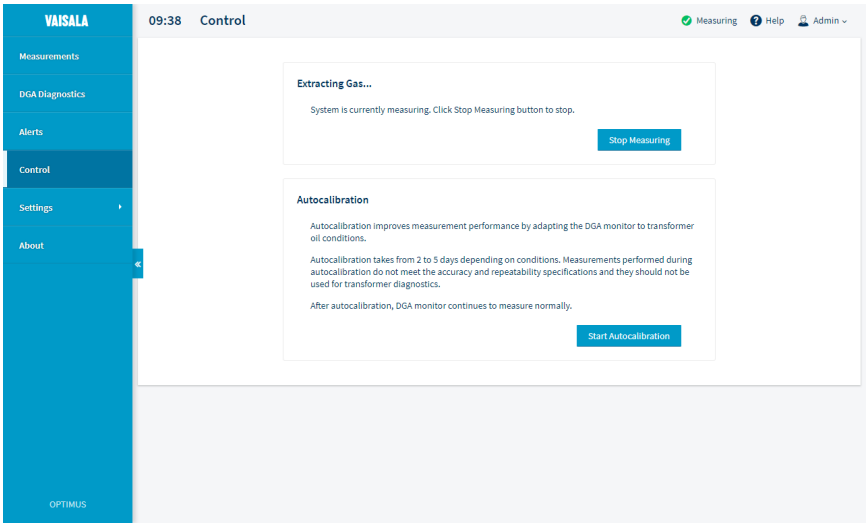


Figure 15 Control Page

3.1.6 Settings Pages

Settings pages provide access to the configuration options of the DGA monitor. Settings can only be changed by the **Admin** user.

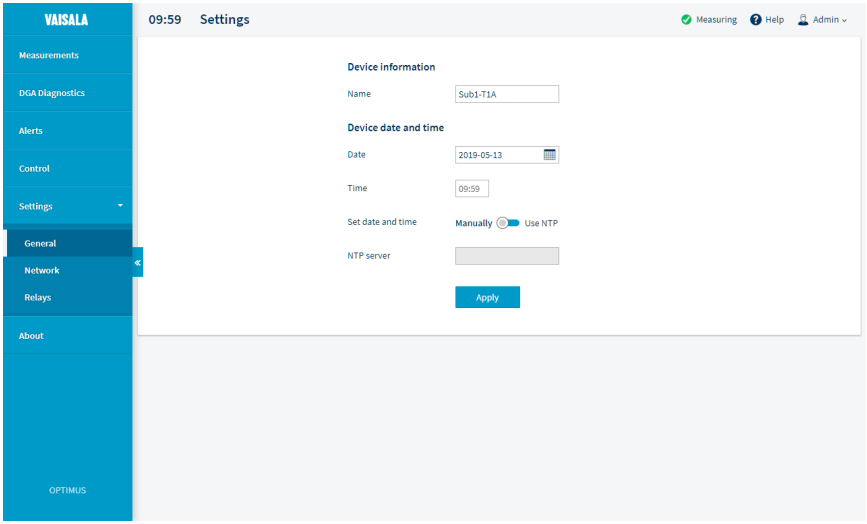


Figure 16 Settings Page

3.1.7 About Page

About page shows the serial number and software version of the DGA monitor. If you are logged in as **Admin** you can access additional features:

- Select **View** to see the software license texts of the open source components used in the DGA monitor software.
- Select **Update** to start the software update. To update the software version of the DGA monitor, you need a software update file from Vaisala.

- Select **Create** to generate a diagnostic data file from the DGA monitor. If a data file already exists, it is overwritten by the new file. Generating the file may take up to 30 minutes.
  Select **Download Data** to retrieve the file. The diagnostic data in the file is intended for use only by Vaisala.

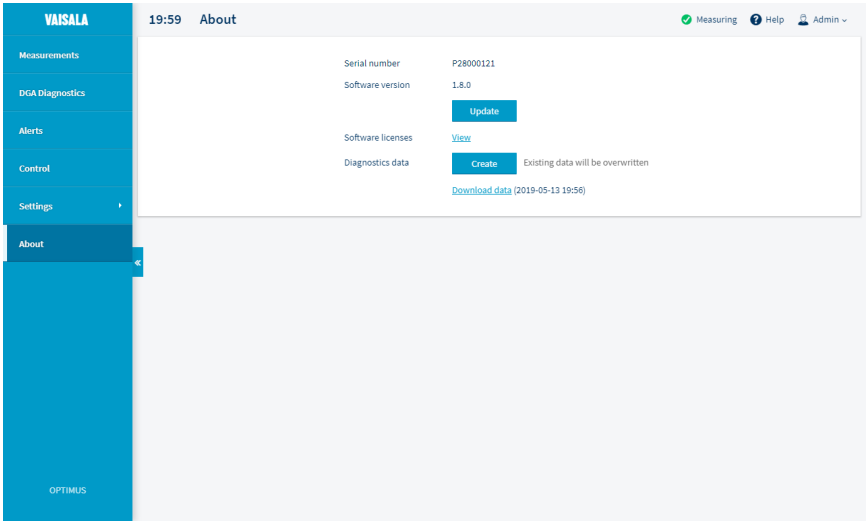


Figure 17 About Page

3.1.8 Messages

User interface of the DGA monitor will display important information as messages at the top of the user interface.

- **Gas level alerts**: Shown until acknowledged, until the gas level is no longer above the limit, or until the alert is disabled. Flashing yellow or red status LED on the DGA monitor door means that one or more gas level alert (and the corresponding message) is active.
- **Errors**: Software or device errors. For example, accidentally closing the oil valves on the transformer while the DGA monitor is measuring will cause a device error as it cannot circulate oil. If the red LED on the DGA monitor door is lit but not flashing, a device error is active and requires user actions.
- **Other notifications**: Any other messages from the DGA monitor. For example, a message will be shown when a new measurement cycle has been completed.

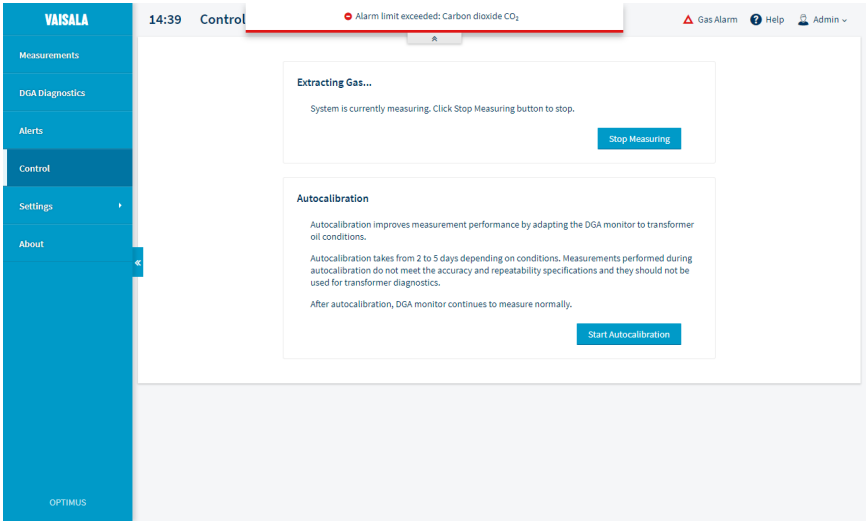


Figure 18 Gas Level Alert Message Active

3.1.9 Status Indicator

Current status of the DGA monitor is shown on top of the user interface.

Table 9 System Statuses

Status Text	Meaning
Initializing	DGA monitor is being initialized. Initialization is a part of installation and requires physical access inside the DGA monitor enclosure.
Autocalibrating	DGA monitor is performing autocalibration cycles. Autocalibration improves measurement performance by adapting the DGA monitor to transformer oil conditions. Autocalibration takes from 2 to 5 days depending on conditions. After autocalibration is completed successfully, DGA monitor automatically starts normal measurement operation.
Standby	DGA monitor is idle and waiting for commands from the administrator. Measurement cycles are not being performed.
Measuring	Normal operation; DGA monitor is performing measurement cycles.

Status Text	Meaning
Stopping	Normal measurement is being stopped. When complete, the DGA monitor will remain in the standby state.
Caution	Gas alert caution limit exceeded.
Gas Alarm	Gas alert alarm limit exceeded.
Error	Device error has been detected. Measurement cycles are not being performed.
Updating	Software update is in progress.
Connecting	System state is being determined. This state is shown after a software update has been performed.
Uninstalling	DGA monitor is being uninstalled. Uninstallation empties the DGA monitor of oil and prepares the measurement system for transportation.

3.2 Starting Measurement

In normal operation DGA monitor repeats the measurement cycle continuously. You can only start the measurement if DGA monitor is currently in standby.

1. Connect to the DGA monitor user interface and log in as an **Admin** user.
2. Start measurement from **Control > Start Measuring**.

DGA monitor warms up during the first three measurement cycles. Measurements made during the warm-up cycles are not guaranteed to be within the accuracy specification.

3.3 Configuring Gas Level Alerts

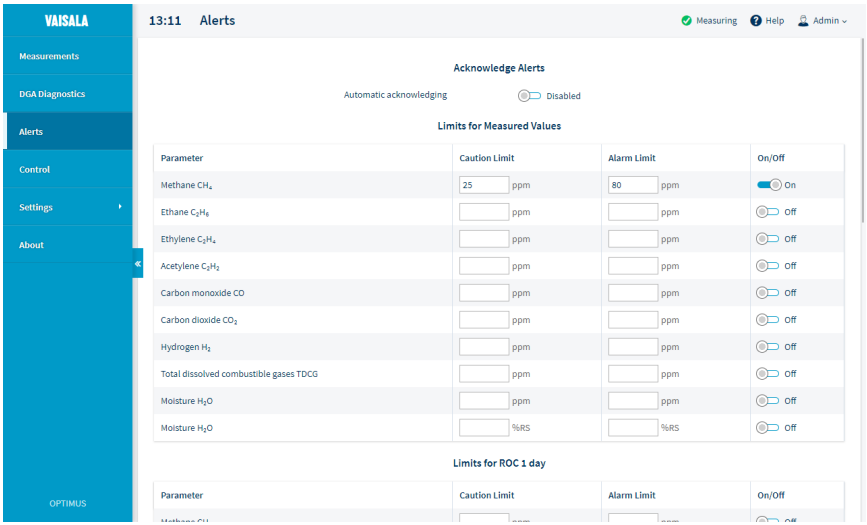


Figure 19 Alerts Page

You can configure gas level alerts on the **Alerts** page. There are separate rows for each individual alert that you can configure. By default, all alerts are off, and automatic acknowledgement is off.

1. Connect to the user interface as the **Admin** user. See Connecting to User Interface (page 19).
2. In the user interface, select **Alerts**.
3. Configure **Automatic acknowledging** as desired:
   - If you want to manually acknowledge all alerts, leave it **Disabled**.
   - If you want the DGA monitor to automatically acknowledge alerts if the criteria are met, set it to **Enabled**.

4. For each alert you want to configure, enter the
   a. Enter the **Caution Limit** in ppm. This is the lower limit that triggers an alert with caution severity.
   b. Enter the **Alarm Limit**. Alarm limit should be higher than the caution limit.
   c. Set the alert to **On** to enable it.

   Settings are applied immediately.

> It is possible to have only caution or alarm severity active. If you leave a limit value empty or enter a zero, the corresponding severity will not be active for that alert.

3.4 Acknowledging Gas Level Alerts

Acknowledging a gas level alert disables all indications of the alert:

- User interface messages for that alert are hidden
- If one or more relays have been activated by the alert, they are inactivated
- Status LEDs do not indicate the alert
- Output protocols do not communicate the alert as active

Admin user can acknowledge alarms or enable automatic acknowledging from the **Alerts** page in the user interface:

- Select **Acknowledge alerts > OK** to immediately acknowledge all active alerts.
- Enable **Automatic acknowledging** to automatically acknowledge individual alerts when the criteria below are fulfilled:
  - Alerts for measured values are cleared when there have been 20 consecutive reliable measurement cycles with result below the alert limit.
  - Rate of change (ROC) alerts are acknowledged immediately when the ROC value is below alert limit by at least 10%.

> If alert activation criteria are met again, it will be activated even if previously acknowledged. Turning an alert off will prevent it from activating again, and will also acknowledge it if currently activated. Changing the alert limit will not acknowledge a currently active alert.

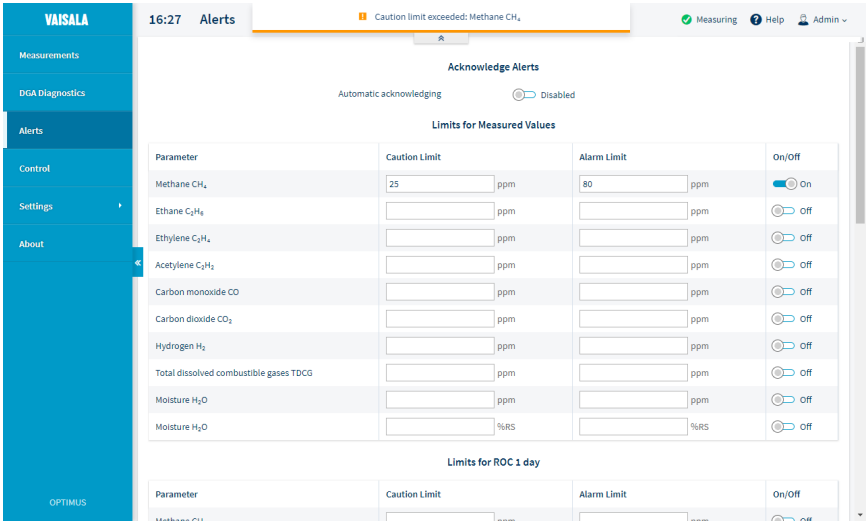


Figure 20 Alert Screen with Methane Caution Alert Visible

3.5 Setting Device Name

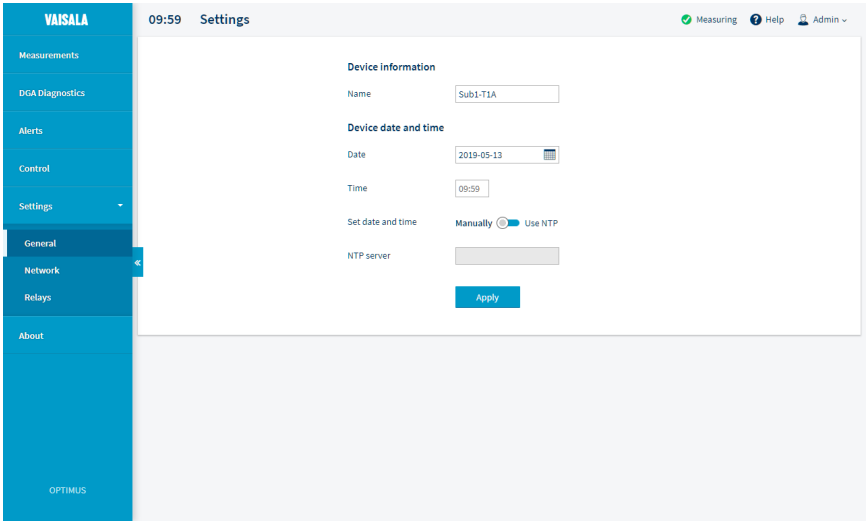


Figure 21 General Settings Page

You can give a name to the DGA monitor to help identify it. If the name is set, it is shown in:

- Login page
- Above the Optimus text in the navigation menu
- Names of files downloaded from the user interface

1. Connect to the user interface as the **Admin** user. See Connecting to User Interface (page 19).
2. In the user interface, select **Settings > General**.
3. Enter a name for the device in the **Name** field. Maximum length is 64 characters. You can use alphanumerical characters, space, hyphen "-", and underscore "_".
4. Select **Apply** to save the name.

3.6 Setting Date and Time

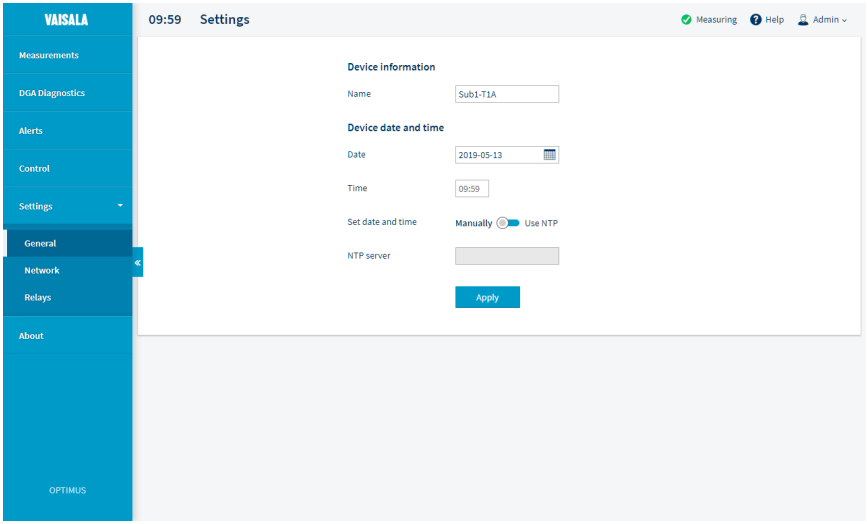


Figure 22 Date and Time Settings Page

DGA monitor uses UTC (Coordinated Universal Time) internally. Time and time stamps in the user interface are shown according to the time zone of the connecting web browser.

1. Connect to the user interface as the **Admin** user. See Connecting to User Interface (page 19).
2. Verify the current time zone of the computer you are connected with.

3. In the user interface, select **Settings > General**.
4. To set the time manually:
   a. Change **Set date and time** to **Manually**.
   b. Select or enter the current date in the **Date** field. The format is yyyy-mm-dd.
   c. Enter the current time in the **Time** field. The field is in 24-hour clock notation in the form hh:mm.
   d. Select **Apply** to save the manually set time.
5. To set up time synchronization with a Network Time Protocol (NTP) server:

   NTP synchronization requires that the network connection is configured and the IP address of the NTP server is reachable.

   a. Change **Set date and time** to **Use NTP**.
   b. Enter the IP address of the NTP server in the **NTP server** field.
   c. Select **Apply** to start time synchronization. Status of time synchronization is shown below the **NTP server** field. If the status shows **Connecting...** and does not progress to **Synchronizing time...** even after waiting for a minute, verify that the network connection is working and configured, and the IP address of the NTP server is correctly entered.
   d. Wait for the message **Time successfully synchronized** to appear.

3.7 Changing Administrator Password

CAUTION! If you forget your administrator password, you need to contact Vaisala Support to reset it for you.

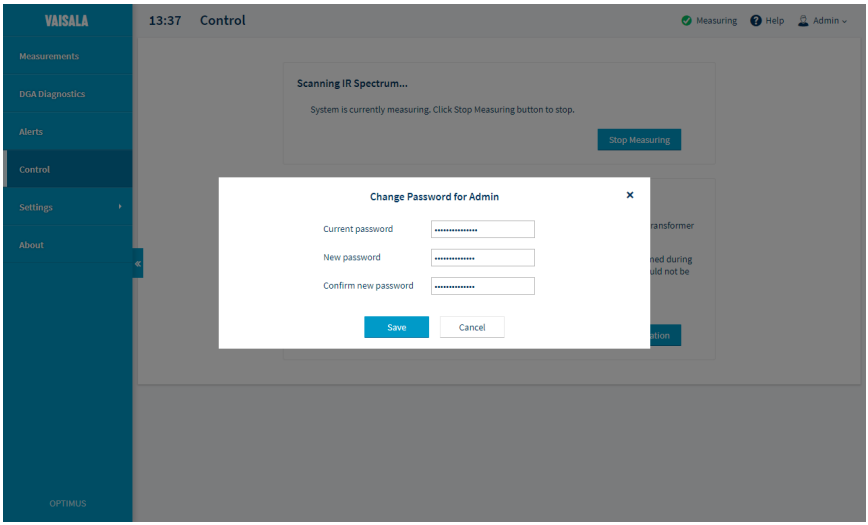
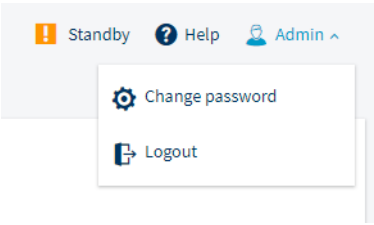


Figure 23 Changing Administrator Password

1. Connect to the user interface as the **Admin** user. See Connecting to User Interface (page 19).
2. In the top right corner of the user interface, select **Admin > Change password**.



3. Enter the current password in the **Current password** field.
4. Enter the new password in the **New password** and **Confirm new password** fields. The new password must be at least 8 characters long.
5. Select **Save** to commit the password change.

3.8 Configuring Serial Line and Modbus RTU

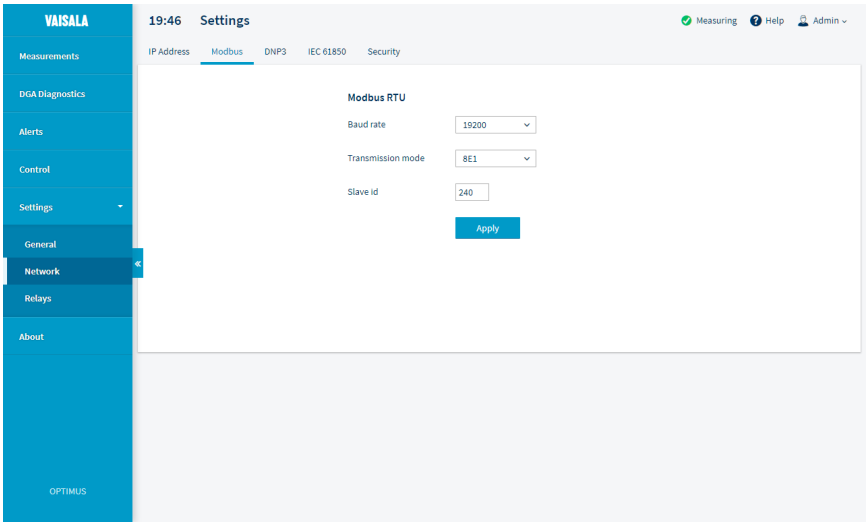


Figure 24 Modbus RTU Settings Page

This procedure configures the settings of the RS-485 line and the Modbus RTU protocol.

1. Connect to the user interface as the **Admin** user. See Connecting to User Interface (page 19).
2. In the user interface, select **Settings > Network > Modbus**.
3. Select **Baud Rate** for the connection. Available options are:
   - 4800
   - 9600
   - 19200
   - 38400
   - 57600
   - 115200
4. Select **Transmission Mode**, 8E1 or 8N2.
5. Enter the Modbus **Slave ID** for the DGA monitor. Range 1 ... 247.
6. Click **Apply** to save your changes.

3.9 Configuring Network Connection

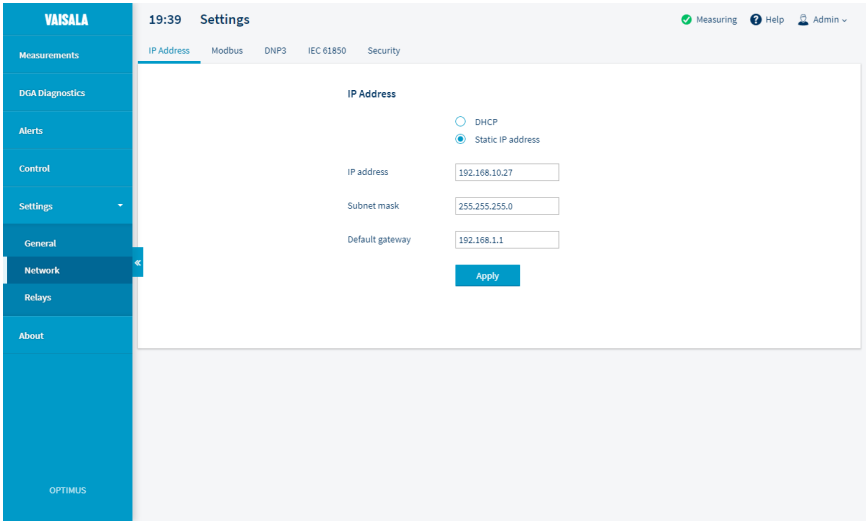


Figure 25 IP Address Settings Page

This procedure configures the network settings of the external Ethernet connection.

1. Connect to the user interface as the **Admin** user. See Connecting to User Interface (page 19).
2. In the user interface, select **Settings > Network > IP Address**.
3. Select how the IP address of the external Ethernet connection is assigned: **DHCP** for automatic assignment, and **Static IP Address** to enter the values manually.
4. If you selected **Static IP Address**, enter the following values:
   - **IP Address**
   - **Subnet Mask**
   - **Default Gateway**
5. Select **Apply** to save your changes.

3.10 Configuring User Interface Security

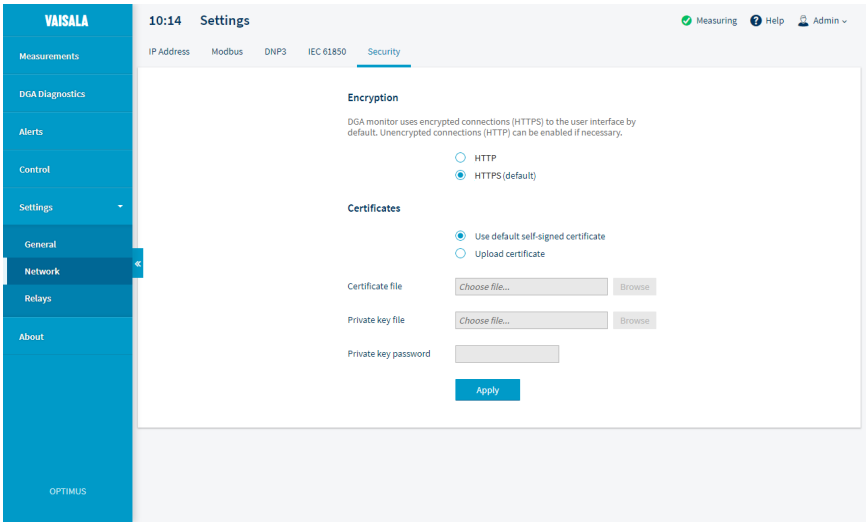


Figure 26 Network Security Settings Page

This procedure configures HTTPS encryption for the user interface connection. By default, DGA monitor only allows encrypted connections to the user interface (HTTPS) using a self-signed certificate. Any connections that request unencrypted communication (HTTP) are redirected to the encrypted interface (HTTPS).

The default self-signed certificate is not trusted by connecting web browsers, so they will notify the user that the connection is not secure. To remove the notification, you need to install a trusted TLS certificate (TLS 1.1 or 1.2) on the DGA monitor. However, note that HTTPS traffic is always encrypted even if the cerficate is not trusted. Vaisala recommends using encrypted connections (HTTPS).

1. Connect to the user interface as the **Admin** user. See Connecting to User Interface (page 19).
2. In the user interface, select **Settings > Network > Security**.
3. Select **HTTP** to use unencrypted user interface connections, or **HTTPS (default)** to secure the interface using encryption.

4. To use your own certificate with HTTPS connections:
   a. Select **Upload certificate**.
   b. Select **Certificate file > Browse** and locate the certificate file.
   c. Select **Private key file > Browse** and locate the private key file.
   d. Enter the **Private key password** if your private key requires it.
5. Select **Apply** to save your changes.

If you change the security settings, the user interface will restart and you have to log in again.

3.11 Configuring DNP3 Protocol

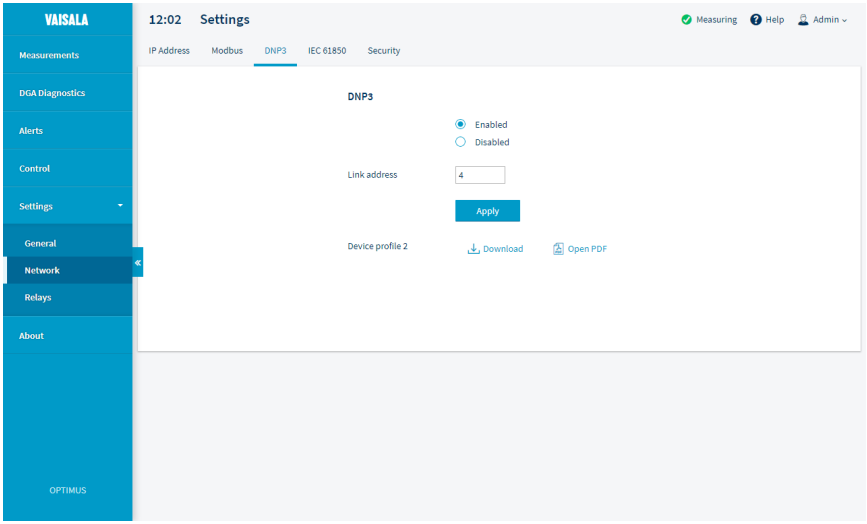


Figure 27 DNP3 Settings Page

DNP3 protocol is an optional feature and requires a license. If a license is not installed on the DGA monitor, you cannot enable the protocol. Contact Vaisala for acquiring the license.

1. Connect to the user interface as the **Admin** user. See Connecting to User Interface (page 19).

2. In the user interface, select **Settings > Network > DNP3**.
3. Select if the DNP3 protocol should be **Enabled** or **Disabled**.
4. If you enabled the DNP3 protocol, set the DNP3 **Link Address** you want to use on this DGA monitor.
5. Select **Apply** to save your changes.

Select **Download** to download the DGA monitor device profile in XML format. It is needed to configure your DNP3 master system.

3.12 Configuring IEC 61850 Protocol

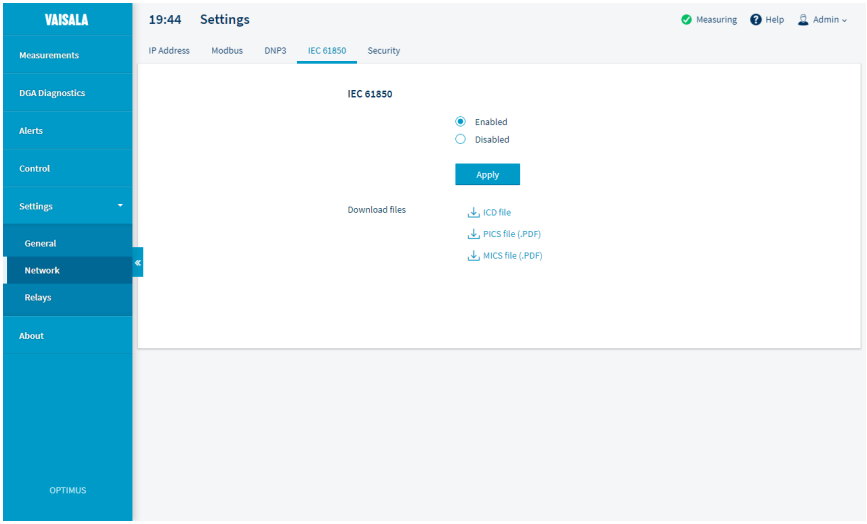


Figure 28 IEC 61850 Settings Page

IEC 61850 protocol is an optional feature and requires a license. If a license is not installed on the DGA monitor, you cannot enable the protocol. Contact Vaisala for acquiring the license.

1. Connect to the user interface as the **Admin** user. See Connecting to User Interface (page 19).
2. In the user interface, select **Settings > Network > IEC 61850**.
3. Select if the IEC 61850 protocol should be **Enabled** or **Disabled**.

4. Select **Apply** to save your changes.

You can download the following supporting documents from this page:

- IED Capability Description (ICD) file
- Protocol Implementation Conformance Statement (PICS)
- Model Implementation Conformance Statement (MICS)

3.13 Configuring Relays

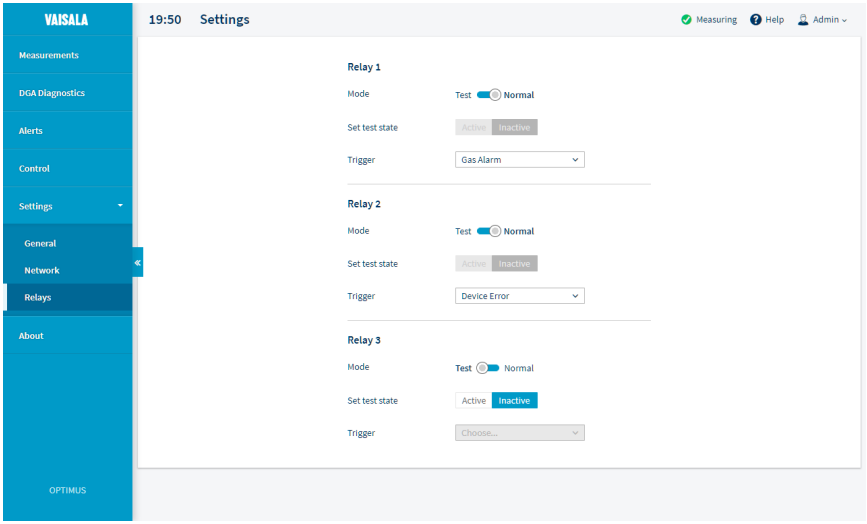


Figure 29 Relay Settings Page

1. Connect to the user interface as the **Admin** user. See Connecting to User Interface (page 19).
2. In the user interface, select **Settings > Relays**.

3. Each of the three relays is configured individually. For each relay:
   a. Select relay **Mode**:
      - In **Normal** mode, the relay is activated by the selected **Trigger**.
      - In **Test** mode, the relay activation is controlled manually from the **Set test state** buttons.

      If the relay is not used, select the **Test** mode. You can also use it to test that wiring has been connected correctly.
   b. Select relay **Trigger**:
      - **Gas Caution** activates the relay if any gas level alert of **caution** severity is active.
      - **Gas Alarm** activates the relay if any gas level alert of **alarm** severity is active.
      - **Device Error** activates the relay if a device error is active.

   Settings are applied immediately.

4. Maintenance

4.1 Maintenance Safety

WARNING! Keep away from live circuits. Operating personnel must observe safety regulations at all times.

WARNING! Ground the DGA monitor enclosures as instructed in the wiring instructions. Verify the grounding before and after performing maintenance on the unit.

CAUTION! Do not modify the DGA monitor or use it in ways not described in the documentation. Modifications may lead to safety hazards, equipment damage, failure to perform according to specification, or decreased equipment lifetime.

CAUTION! Surfaces inside DGA monitor that are marked with the symbol below heat up during normal operation. Avoid touching hot surfaces and wear protective gloves when working inside the enclosure. Whenever possible, allow the DGA monitor to cool down before starting the work.

Wear protective eyewear and gloves.

4.2 Cleaning DGA Monitor

OPT100 DGA Monitor does not need to be cleaned to maintain its normal operation. The enclosures are IP66 rated and measurement system is hermetically sealed. If a significant amount of contamination is present inside the enclosures, verify that:

- All cable glands fit tightly around cables, or are plugged if unused.
- Doors of the enclosures close properly.
- There are no oil leaks inside the DGA monitor.

4.3 Maintenance

OPT100 DGA Monitor does not require visits to the installation site for preventive maintenance. There are no consumables or components that must be replaced according to a fixed schedule. You can check the status of the DGA monitor and update its configuration remotely through the browser-based user interface. Software of the DGA monitor can be updated remotely as well.

Indications of the DGA monitor's status are also available to your SCADA system through the communication interfaces (for example, Modbus). If a problem with the DGA monitor is indicated, check the user interface.

4.4 Updating DGA Monitor Software

- Software update file for DGA monitor

Software update does not delete the data stored on the DGA monitor. Configuration settings are also retained where possible, but you should check them after the update.

Updated software may include improvements to the measurement algorithm. These updates are only applied to new measurement cycles after the update, which may cause some discontinuity in the measured gas levels even if the concentration of gases in the measured oil has not changed. Vaisala recommends starting autocalibration manually after a software update.

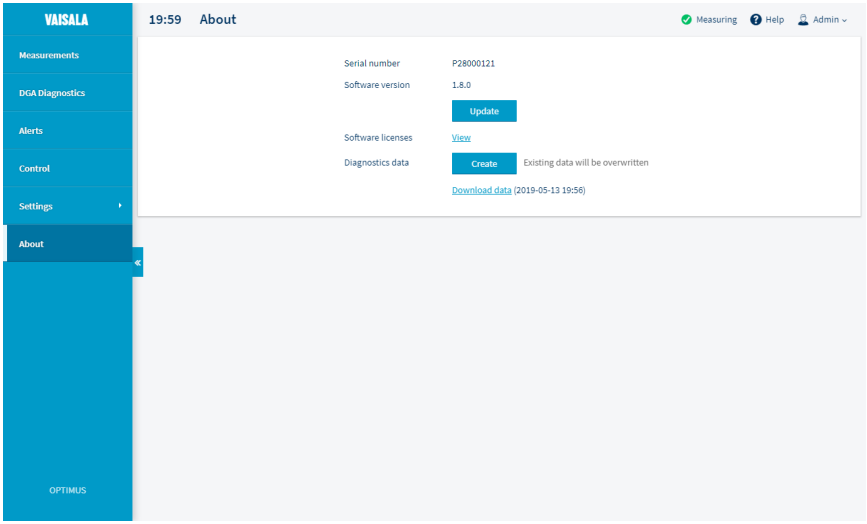
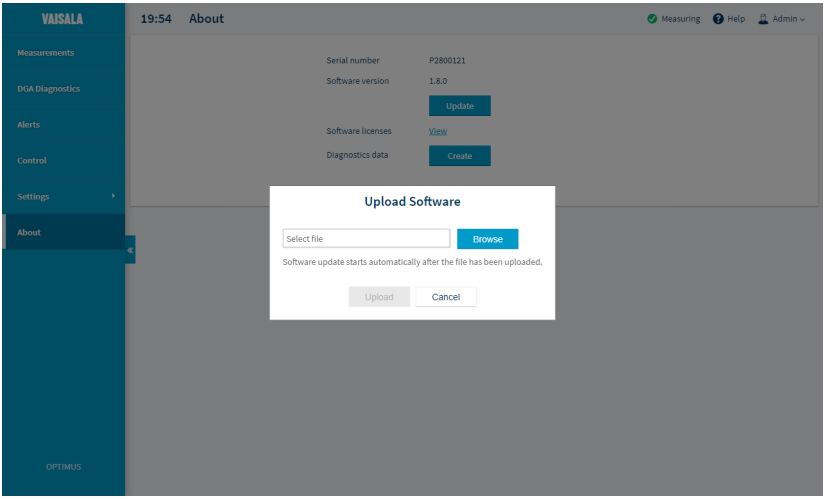


Figure 30 About Screen with Current Software Version and Update Button

1. Connect to the user interface as the **Admin** user. See Connecting to User Interface (page 19).
2. Switch the DGA monitor to **Standby** mode. See Stopping Measurement (page 48).
3. Verify that date and time on the DGA monitor are set correctly. See Setting Date and Time (page 34).
4. Wait for DGA monitor to finish stopping and enter the **Standby** mode. Depending on the stage in the measurement cycle, stopping may take up to 30 minutes.
5. Select **About > Update > Browse** and locate the firmware update file.

6. Select **Upload** to send the file to the DGA monitor.



7. DGA monitor will verify that the file was received successfully, and start the update. The update may take up to 30 minutes. Do not power off or attempt to operate the DGA monitor during the update.
8. After the update is complete, verify that the DGA monitor reports the new software version on the **About** page.
9. Verify the current **Settings** of the DGA monitor. The software update may have added new settings or changed existing ones.
10. Switch the DGA monitor back to **Measuring** mode to continue normal measurement. See Starting Measurement (page 30).
11. Optional: Start autocalibration manually to make sure any updates to the autocalibration mechanism are applied right away. See Starting Autocalibration Manually (page 47).

> Autocalibration takes from 2 to 5 days depending on conditions. Measurements performed during autocalibration do not meet the accuracy and repeatability specifications and they should not be used for transformer diagnostics.

4.5 Starting Autocalibration Manually

Autocalibration improves measurement performance by adapting the DGA monitor to transformer oil conditions. Autocalibration takes from 2 to 5 days depending on conditions. You can only start autocalibration when DGA monitor is in **Measuring** state.

It is not normally necessary to start autocalibration manually, and autocalibration always runs automatically after a DGA monitor is commissioned. However, it is recommended to start autocalibration after the software of the DGA monitor has been updated.

1. Connect to the user interface as the **Admin** user. See Connecting to User Interface (page 19).
2. Select **Control** and verify that the system is measuring and the **Start Autocalibration** button is available.
3. Select **Start Autocalibration**. DGA monitor will perform autocalibration and continue with normal measurement cycles after it is completed.

4.6 Repair

If your OPT100 DGA monitor needs repair, note the following:

- Make sure you have the latest product documentation before taking any actions. Check the OPT100 product page http://www.vaisala.com/opt100 for updates.
- If a repair procedure you need is not available in the documentation, contact Vaisala for assistance.
- Some repairs can only be performed by a Vaisala representative.
- For any components included inside the OPT100 DGA Monitor or the OPTPSU1 power supply unit, use only spare parts supplied by Vaisala.

4.6.1 Stopping Measurement

1. Connect to the DGA monitor user interface and log in as an **Admin** user.
2. Stop the measurement mode by selecting **Control > Stop Measuring**.
3. Wait for DGA monitor to enter **Standby** mode. Depending on the stage in the measurement cycle, stopping may take up to 60 minutes.

4.6.2 Turning Off the DGA Monitor for Maintenance

1. Switch the DGA monitor to standby mode.
2. Turn off AC power to the DGA monitor:
   a. Turn off AC power from the external disconnection device.
   b. Lock the disconnection device in the off position, if possible.
   c. Attach a warning label to the disconnection device that clearly states why the power is turned off.
3. Turn off DC power inside the power supply unit:
   a. Open the power supply unit enclosure.
   b. Turn off switch **S1**.
   c. Turn off circuit breaker **F1**.

4.6.3 Verifying Safety After Repair

Go through the following verification steps after performing repairs on the DGA monitor.

1. If you have replaced or altered any mechanical parts of the DGA monitor enclosure or mounting accessories, verify that:
   - Enclosure can be opened and closed normally.
   - Enclosure tightness is maintained.
   - All attachment points are intact.
2. If you have replaced any electrical components or wiring, verify that:
   - All components that are secured to a DIN rail are firmly in place.
   - There are no disconnected cables or loose wires.
   - All grounding wires are attached.
   - Wiring is done according to the wiring instructions in the *OPT100 Installation Guide (M211857EN)*, unless intentionally altered by the repair procedure.
3. If you have replaced any of the oil handling components (pipes, valves, pump, oil block, etc.) or opened any of the oil connections, verify that:
   - There are no open oil connections.
   - All oil handling components are securely attached.
   - All oil leaks have been cleaned and wiped clean. No oil is visible on the parts or oil connections.

4.6.4 Turning On DGA Monitor After Maintenance

CAUTION! If the circuit breakers will not stay in the ON position, turn off AC power to the DGA monitor immediately and inspect the AC and DC power wiring. The circuit breakers may be tripping because of a loose wire or incorrect connection.

1. Verify that the circuit breakers **Main** and **Heat** inside the DGA monitor are turned on.
2. Turn on DC power inside the power supply unit:
   a. Open the power supply unit enclosure.
   b. Turn on circuit breaker **F1**.
   c. Turn on switch **S1**.
3. Turn on AC power to the DGA monitor:
   a. Check if there are any warning labels attached to the disconnection device. If there are, make sure it is safe to turn on the AC power. Remove any labels that are now unnecessary.
   b. If the external disconnection device is locked in the off position, unlock it.
   c. Turn on AC power from the external disconnection device.

4.6.5 Starting Measurement

In normal operation DGA monitor repeats the measurement cycle continuously. You can only start the measurement if DGA monitor is currently in standby.

1. Connect to the DGA monitor user interface and log in as an **Admin** user.
2. Start measurement from **Control > Start Measuring**.

DGA monitor warms up during the first three measurement cycles. Measurements made during the warm-up cycles are not guaranteed to be within the accuracy specification.

4.7 Uninstalling DGA Monitor

- Adjustable wrench
- Screwdriver with 3 mm (0.12 in) wide slotted head
- 5 mm hex key
- Container for waste oil with at least 5 liter (1.32 gal) capacity
- Oil absorption material for controlling possible leaks
- Rags for wiping off oil

Wear protective eyewear and gloves.

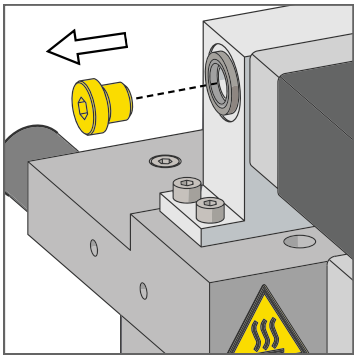
Follow this procedure to uninstall the DGA monitor. Uninstallation empties the DGA monitor of oil and allows it to be safely stored and transported. When you start the uninstallation, oil lines between DGA monitor and transformer must be intact, and oil intake and return valves on the transformer side must be open.

The procedure assumes that the DGA monitor is completely installed and currently measuring when the uninstallation is started. If the DGA monitor is already in standby mode, you can skip step 2 and step 3.

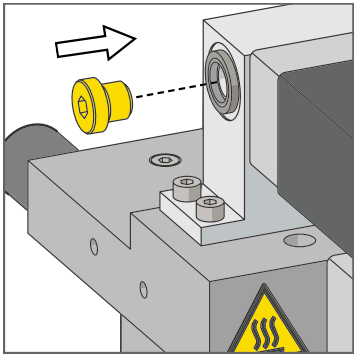
1. Connect to the DGA monitor user interface and log in as an **Admin** user.
2. Stop the measurement mode by selecting **Control > Stop Measuring**.
3. Wait for DGA monitor to enter **Standby** mode. Depending on the stage in the measurement cycle, stopping may take up to 60 minutes.
4. Select **Control > Uninstall**. The uninstallation sequence starts when you confirm that you really want to start the uninstallation.

   It will take approximately 30 minutes before the DGA monitor prompts you to perform the next step.

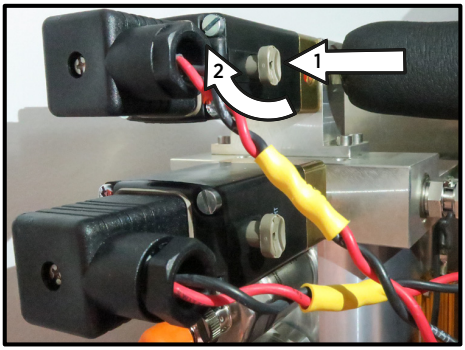
5. When instructed to do so, remove the pipe plug from the bleed valve. Select **Continue** when done.



6. When instructed to do so, close the oil intake and return valves on the transformer.
7. Disconnect oil pipes from the **Oil In** and **Oil Out** connections on the outside of the DGA monitor. Place the ends of the pipes in the waste oil container to collect the oil that drains out.
8. Select **Continue** from the user interface.
9. When instructed to do so, reattach the pipe plug to the bleed valve.



10. Push in the gray knob on the side of the bleed valve, and turn it 90° clockwise to lock the valve manually. Select **Continue** when done.



11. Select **OK** when the uninstallation sequence has completed.
12. DGA monitor is now almost empty of oil but less than one deciliter (3.4 fl. oz.) will remain in the system. Plug the **Oil In** and **Oil Out** connectors to prevent the oil from draining out during transport.
13. Turn off AC power to the DGA monitor:
    a. Turn off AC power from the external disconnection device.
    b. Lock the disconnection device in the off position, if possible.
    c. Attach a warning label to the disconnection device that clearly states why the power is turned off.
14. Disconnect the cables between the power supply unit and the DGA monitor.
15. Plug and tighten the cable glands to maintain enclosure tightness during storage.
16. Uninstall the equipment in reverse order of installation. See *OPT100 Installation Guide (M211857EN)*.
17. Place the equipment in the original packaging, if available.

5. Troubleshooting

5.1 Problem Situations

Table 10 Troubleshooting Table

Problem	Possible Cause	Solution
Green status LED is flashing.	DGA monitor is in standby mode.	Start the measurement mode. See Starting Measurement (page 30).
Yellow status LED is lit.	DGA monitor has been installed but not initialized.	Perform commissioning and initialization according to the *OPT100 Installation Guide (M211857EN)*.
	DGA monitor has been uninstalled.	Confirm the cause from the user interface.
Yellow status LED is flashing.	Gas level alert is active, caution limit exceeded.	Log in to the user interface. Check gas levels and active messages.
Red status LED is lit.	DGA monitor is in error state.	See Resolving a Device Error (page 54).
Red status LED is flashing.	Gas level alert is active, alarm limit exceeded.	Log in to the user interface. Check gas levels and active messages.
Data missing in measurement view (gaps in graphs)	Measurement cycles have not produced reliable results for some or all measurement parameters.	Can be caused by rapid temperature changes. Make sure the DGA monitor doors are closed and locked. See Notes for Normal Operation (page 9).
	DGA monitor has been in standby mode or turned off.	Keep the DGA monitor powered on and in measurement mode.

Problem	Possible Cause	Solution
My web browser warns me that the connection is not secure when connecting to the user interface.	User interface is secured using a self-signed certificate that is not trusted by your web browser.	To get rid of the warning permanently, create a trusted certificate and key and configure the user interface security to use them (recommended) or disable HTTPS security (not recommended). See Configuring User Interface Security (page 39). Alternatively, you can ignore the warning and proceed to the user interface. HTTPS traffic is always encrypted even if the certificate is not trusted.
I am unable to log in to the user interface as **Admin** user.	Forgotten password.	Contact Vaisala. See Technical Support (page 75).

5.2 Resolving a Device Error

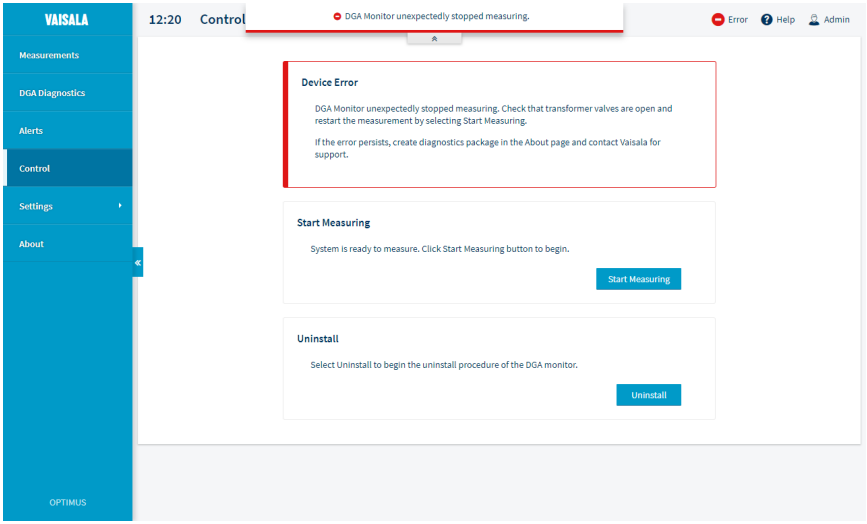


Figure 31 Device Error Active

If the DGA monitor has a serious hardware problem or cannot measure due to some external cause, it will automatically stop trying to run the measurement cycles. The red status LED on the door will be lit, and the user interface will show an appropriate message. Possible causes include hardware failure and problems with the oil connection. For example, someone may have closed the oil valve(s) on the transformer and prevented the DGA monitor from pumping oil.

If you encounter a device error, follow the steps below to resolve it.

1. Connect to the user interface as the **Admin** user. See Connecting to User Interface (page 19).
2. Check active messages and status of DGA monitor on the **Control** page.
3. Inspect the DGA monitor and oil lines to determine the cause of the error, and remove it if possible. For example, open the oil valves on the transformer if they have been closed.
4. If you have resolved the likely problem or there does not seem to be an apparent cause, select **Control > Start Measuring** to restart measurement.
5. Wait to see if the DGA monitor is able to complete a measurement cycle and keep on running normally.
6. If the DGA monitor stops measuring again and the device error returns, try to restart measurement once more.
7. If the device error is not resolved after a couple of attempts, contact Vaisala support.

From the **About** page of the user interface you can create a diagnostic data file that can help Vaisala diagnose the device error. It is recommended that you do this if your DGA monitor stops due to a device error, regardless of if the error was successfully resolved. See About Page (page 27).

6. Technical Data

6.1 OPT100 Technical Specification

Table 11 Measured Parameters in Oil

Parameter	Range	Accuracy [1) 2)]	Repeatability [2)]
Methane (CH_4)	0 ... 10 000 ppm_v	10 ppm or 10 % of reading	10 ppm or 5 % of reading
Ethane (C_2H_6)	0 ... 10 000 ppm_v	10 ppm or 10 % of reading	10 ppm or 5 % of reading [3)]
Ethylene (C_2H_4)	0 ... 10 000 ppm_v	10 ppm or 10 % of reading	10 ppm or 5 % of reading
Acetylene (C_2H_2)	0 ... 5000 ppm_v	2 ppm or 10 % of reading	1 ppm or 10 % of reading
Carbon monoxide (CO)	0 ... 10 000 ppm_v	10 ppm or 10 % of reading	10 ppm or 5 % of reading
Carbon dioxide (CO_2)	0 ... 10 000 ppm_v	10 ppm or 10 % of reading	10 ppm or 5 % of reading
Hydrogen (H_2)	0 ... 5000 ppm_v	25 ppm or 20 % of reading	15 ppm or 10 % of reading
Moisture [4)] (H_2O)	0 ... 100 ppm_w [5)]	±2 ppm [6)] or ±10 % of reading	Included in accuracy

1) *Accuracy specified is the accuracy of the sensors during calibration gas measurements. Accuracy of the gas-in-oil measurement may also be affected by oil properties and other chemical compounds dissolved in oil.*
2) *Whichever is greater.*
3) *Repeatability of ethane measurement is specified with averaging of five measurements.*
4) *Measured as relative saturation (%RS).*
5) *Upper range limited to saturation.*
6) *Calculated ppm value is based on average solubility of mineral oils.*

Table 12 Measurement Performance

Property	Description
Measurement cycle duration	1 ... 1.5 h (typical)
Response time (T63)	One measurement cycle [1)]
Warm-up time until first measurement data available	Two measurement cycles

Property	Description
Initialization time to full accuracy	Two days
Data storage	At least 10 years
Expected operating life	> 15 years

1) *Three cycles for ethane and hydrogen.*

Table 13 Calculated Parameters

Property	Description
Total dissolved combustible gases (TDCG)	Combined total of H_2, CO, CH_4, C_2H_6, C_2H_4, and C_2H_2
Rate of change (ROC)	Available for single gases and TDCG for 24 h, 7 d, and 30 d periods
Gas ratios [1)]	Available ratios: • CH_4/H_2 • C_2H_2/C_2H_4 • C_2H_2/CH_4 • C_2H_6/C_2H_2 • C_2H_4/C_2H_6 • CO_2/CO

1) *Calculated from 24 h average values. See standard IEC 60599.*

Table 14 Operating Environment

Property	Description
Transformer oil type	Mineral oil
Required minimum fire point [1)] of transformer oil	+125 °C (+257 °F)
Transformer oil pressure at oil inlet	Max. 2 bar_{abs} continuous Burst pressure 20 bar_{abs}
Transformer oil temperature at oil inlet	Max. +100 °C (+212 °F)
Ambient humidity range	0 ... 100 %RH, condensing
Ambient temperature range in operation	-40 ... +55 °C (-40 ... +131 °F)

Property	Description
Storage temperature range	-40 ... +60 °C (-40 ... +140 °F)

1) *The fire point [of transformer oil] is normally approximately 10 °C [18 °F] higher than the closed flash point. See, for example, Heathcote, Martin J. The J & P Transformer Book. 13th ed. Elsevier, 2007.*

Table 15 Power Supply

Property	Description
Operating voltage	100 ... 240 VAC, 50 ... 60 Hz, ±10 %
Overvoltage category	III
Maximum current consumption	10 A
Maximum power consumption	500 W
Typical power consumption at +25 °C (+77 °F)	100 W
Connector	Screw terminals (inside power supply unit) Wire size 2.5 ... 4 mm^2 (14 ... 12 AWG)

Table 16 Outputs

Property	Description
RS-485 Interface	
Connector	Screw terminals (inside OPT100 housing) Wire size 0.5 ... 4 mm^2 (20 ... 12 AWG)
Supported protocols	Modbus RTU
Galvanic isolation	2 kV RMS, 1 min
Ethernet Interface	
Connector	Industrial RJ45 connector with protective plug (outside OPT100 housing)
Supported protocols	Modbus TCP, HTTP, HTTPS, DNP3 (optional feature), IEC 61850 (optional feature)
Standard	IEEE 802.3
Physical layer	Base-T
Data rate	10/100 Mbps
Galvanic isolation	4 kV AC (50 Hz, 1 min)
Insulation voltage	250 V_{rms}

Property	Description
Relay Outputs	
Number of relays	3 pcs, normally open (NO) or normally closed (NC), user selectable
Trigger type	Gas alert with user selectable limits
Connector	Screw terminals (inside power supply unit housing) Wire size 0.5 … 4 mm^2 (20 … 12 AWG)
Max. switching current	6 A (at 250 VAC) 2 A (at 24 VDC) 0.2 A (at 250 VDC)
Min. switching voltage	12 VDC (at 10 mA)
Min. switching current	10 mA (at 12 V)
Contact type	1 PDT
User Interface	
Interface type	Web based user interface, can be operated with standard web browsers
Connector for service use	RJ45 connector, inside OPT100 housing (temporary local use only)

Table 17 Mechanical Specifications

Property	Description
Oil fitting	Stainless steel Swagelok® fitting for 10 mm (0.39 in) outer diameter tubing. See list of accessories for adapters available from Vaisala.
Max. length of oil pipe to transformer	Max. 10 m (33 ft) with 7 mm (0.28 in) inner diameter tubing Max. 5 m (16 ft) with 4 mm (0.15 in) inner diameter tubing
Recommended oil pipe properties	10 mm (0.39 in) outer diameter 1 … 1.5 mm wall thickness Material stainless steel
Dimensions (H × W × D)	
Installed with ground mounting set and weather shield	1630 × 675 × 453 mm (64 × 27 × 18 in)
Installed with wall mounting set and weather shield	1390 × 675 × 467 mm (55 × 27 × 18 in)

Property	Description
Weight	
OPT100 DGA Monitor	35 kg (77 lb)
OPTPSU1 Power Supply Unit	12 kg (27 lb)
OPTMSET1 Wall mounting set	8 kg (18 lb)
OPTMSET2 Ground mounting set	16 kg (35 lb)
OPTSHLD1 Weather shield	6 kg (13 lb)
Materials	
OPT100 DGA Monitor housing	Marine aluminum (EN AW-5754), stainless steel AISI 316
OPTPSU1 Power Supply Unit housing	Stainless steel AISI 316
OPTMSET1 Wall Mounting Set	Stainless steel AISI 316
OPTMSET2 Ground Mounting Set	Stainless steel AISI 316
OPTSHLD1 Weather Shield	Marine aluminum (EN AW-5754)
Materials in Contact with Oil	
Oil pipes, chambers, and valves	Aluminum (EN AW 6026), stainless steel AISI 316, brass
Gaskets and seals	NBR, FKM, FVMQ
Pump gears and bushing	PEEK/PTFE

Table 18 Type Tests

Category	Standard	Class/Level	Test
EMC compliance	IEC61000-6-5	Class 4 (interface type 4)	Immunity for Power Station and Substation Environments
	IEC61326-1	Industrial	Electrical equipment for measurement, control, and laboratory use - EMC requirements
	FCC 47 CFR 15, section 15.107	Class A	Limits for conducted emissions
	ISED ICES-003, section 5(a)(i)	Class A	Limits for conducted emissions
Environmental	IEC60529	IP66	Ingress protection
	IEC60068-2-1	-40 °C (-40 °F)	Cold endurance
	IEC60068-2-2	+55 °C (+131 °F)	Dry heat

Category	Standard	Class/Level	Test
	IEC60068-2-30	+40 °C (+104 °F), 85 %RH	Damp heat, cyclic
	IEC60068-2-32		Drop tolerance
	SFS-EN ISO 6270-1:2017	+40 °C / 100 %RH for 480 h	Constant humidity condensation atmosphere (C5-M class)
	SFS-ISO 9227:2017	Neutral Salt Spray (NSS), 35 °C, 5 %, PH 6-7, 1000 h	Salt fog (C5-M class)
Safety	IEC/EN61010-1, 3rd edition UL 61010-1:2012 CSA C22.2 No. 61010-1-12	Compliant	Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 1: General requirements

Table 19 Compliance

Property	Description/Value
CE marking	EMC directive, Low voltage directive, RoHS directive, WEEE directive

6.2 OPT100 Accessories and Spare Parts

Table 20 OPT100 Accessories

Description	Part Number
Wall Mounting Set	OPTMSET1
Ground Mounting Set	OPTMSET2
Weather Shield	OPTSHLD1
Tubing adapter, 10 mm to 3/8" (2 pcs)	ASM213275SP
Tubing adapter, 10 mm to 1/4" (2 pcs)	ASM213274SP

Table 21 OPT100 Spare Parts

Description	Part Number
Power Supply Unit	OPTPSU1

6.3 OPT100 Dimensions with Ground Mounting Set

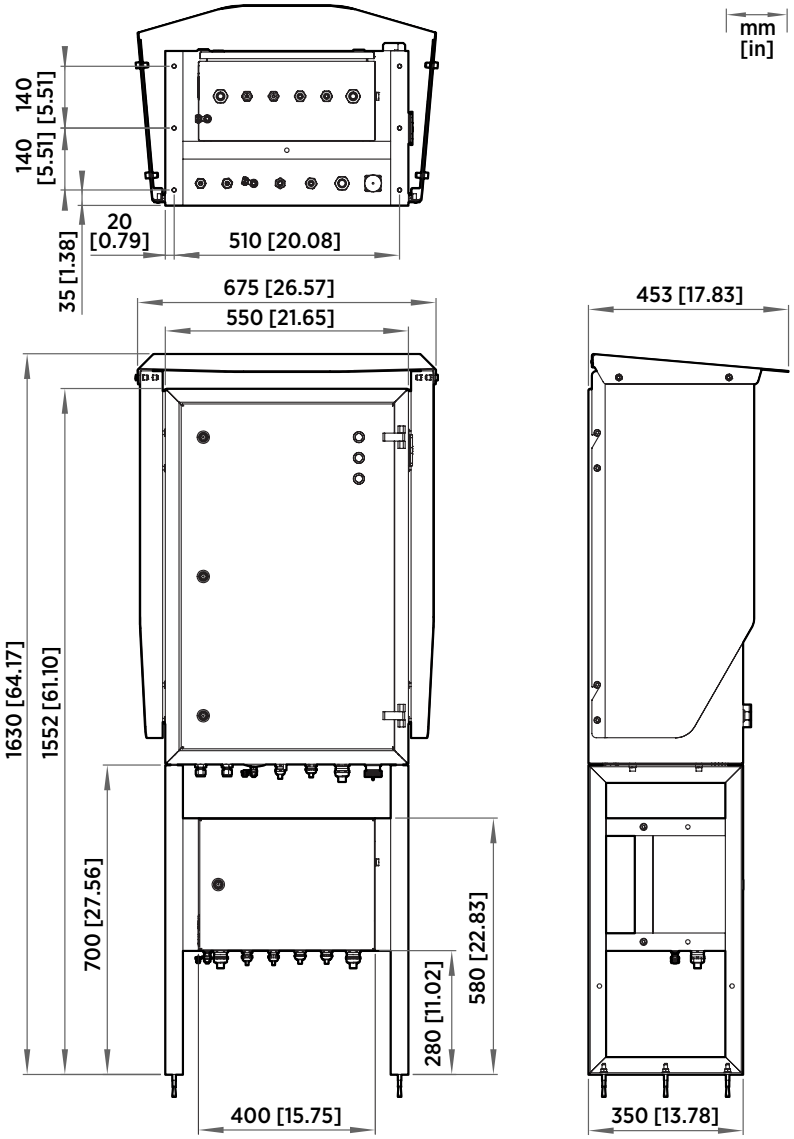


Figure 32 Dimensions with Ground Mounting Set

Appendix A. Modbus Reference

A.1 Default Communication Settings

Table 22 Default Modbus Serial Communication Settings

Description	Default Value
Serial bit rate	19200
Number of data bits	8
Parity	E
Number of stop bits	1
Modbus slave ID	240

A.2 Function Codes

Table 23 Supported Function Codes

Function Code (Decimal)	Function Code (Hexadecimal)	Name
03	03_{hex}	Read Holding Registers

A.3 Modbus Registers

CAUTION! Registers are numbered in decimal, starting from one. Register addresses in actual Modbus messages (Modbus Protocol Data Unit (PDU) are in hexadecimal and start from zero. Subtract 1 from the register number presented in this manual to get the address used in the Modbus message. For example, the register number 23 (present value of acetylene) corresponds to address 16_{hex} in the Modbus message.

Accessing unavailable (temporarily missing) measurement data does not generate an exception. “Unavailable” value (a quiet NaN for floating point data) is returned instead. An exception is generated only for any access outside the applicable register ranges.

A.3.1 32-Bit Floating Point Format

Least-significant 16 bits of floating point or integer 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. The CDAB byte order is used. Floating point values are represented in standard IEEE 32-bit floating point format.

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 the Modbus registers of the device.

A "quiet NaN" value is returned for unavailable values. A quiet NaN is, for example, $7FC00000_{hex}$; however, the master should understand any NaN value.

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

A.3.2 Measurement Data

Table 24 Measurement Data Registers (Read-Only)

Register Number (Decimal)	Address (Hexadecimal)	Register Description	Data Format	Unit and Notes
Measurement Status				
3	0002_{hex}	Measurement reliability	16-bit field	Only last bit is currently used. It is set as follows: 0 = measurement is unreliable because of high ambient temperature 1 = Measurement is reliable
Present Values				
21	0014_{hex}	Methane	32-bit float	ppm_v
23	0016_{hex}	Acetylene	32-bit float	ppm_v
25	0018_{hex}	Ethylene	32-bit float	ppm_v
27	$001A_{hex}$	Ethane	32-bit float	ppm_v
29	$001C_{hex}$	Carbon monoxide	32-bit float	ppm_v

Register Number (Decimal)	Address (Hexadecimal)	Register Description	Data Format	Unit and Notes
31	$001E_{hex}$	Carbon dioxide	32-bit float	ppm_v
33	0020_{hex}	Total dissolved combustible gases (TDCG)	32-bit float	ppm_v
35	0022_{hex}	Hydrogen	32-bit float	ppm_v
37	0024_{hex}	Moisture in oil	32-bit float	ppm_w
39	0026_{hex}	Temperature of in-oil measurement chamber	32-bit float	°C
41	0028_{hex}	Relative moisture in oil See Calculating Relative Moisture Saturation Inside Transformer (page 8)	32-bit float	%RS
24h Average Values				
51	0032_{hex}	Methane	32-bit float	ppm_v
53	0034_{hex}	Acetylene	32-bit float	ppm_v
55	0036_{hex}	Ethylene	32-bit float	ppm_v
57	0038_{hex}	Ethane	32-bit float	ppm_v
59	$003A_{hex}$	Carbon monoxide	32-bit float	ppm_v
61	$003C_{hex}$	Carbon dioxide	32-bit float	ppm_v
63	$003E_{hex}$	Total dissolved combustible gases (TDCG)	32-bit float	ppm_v
65	0040_{hex}	Hydrogen	32-bit float	ppm_v
67	0042_{hex}	Moisture in oil	32-bit float	ppm_w
69	0044_{hex}	Temperature of in-oil measurement chamber	32-bit float	°C
Rate of Change (ROC), 24h				
81	0050_{hex}	Methane	32-bit float	ppm_v/d

Register Number (Decimal)	Address (Hexadecimal)	Register Description	Data Format	Unit and Notes
83	0052_{hex}	Acetylene	32-bit float	ppm_v/d
85	0054_{hex}	Ethylene	32-bit float	ppm_v/d
87	0056_{hex}	Ethane	32-bit float	ppm_v/d
89	0058_{hex}	Carbon monoxide	32-bit float	ppm_v/d
91	$005A_{hex}$	Carbon dioxide	32-bit float	ppm_v/d
93	$005C_{hex}$	Total dissolved combustible gases (TDCG)	32-bit float	ppm_v/d
95	$005E_{hex}$	Hydrogen	32-bit float	ppm_v/d
Rate of Change (ROC), Week				
101	0064_{hex}	Methane	32-bit float	ppm_v/w
103	0066_{hex}	Acetylene	32-bit float	ppm_v/w
105	0068_{hex}	Ethylene	32-bit float	ppm_v/w
107	$006A_{hex}$	Ethane	32-bit float	ppm_v/w
109	$006C_{hex}$	Carbon monoxide	32-bit float	ppm_v/w
111	$006E_{hex}$	Carbon dioxide	32-bit float	ppm_v/w
113	0070_{hex}	Total dissolved combustible gases (TDCG)	32-bit float	ppm_v/w
115	0072_{hex}	Hydrogen	32-bit float	ppm_v/w
Rate of Change (ROC), Month				
121	0078_{hex}	Methane	32-bit float	ppm_v/m
123	$007A_{hex}$	Acetylene	32-bit float	ppm_v/m
125	$007C_{hex}$	Ethylene	32-bit float	ppm_v/m
127	$007E_{hex}$	Ethane	32-bit float	ppm_v/m
129	0080_{hex}	Carbon monoxide	32-bit float	ppm_v/m
131	0082_{hex}	Carbon dioxide	32-bit float	ppm_v/m
133	0084_{hex}	Total dissolved combustible gases (TDCG)	32-bit float	ppm_v/m
135	0086_{hex}	Hydrogen	32-bit float	ppm_v/m

Register Number (Decimal)	Address (Hexadecimal)	Register Description	Data Format	Unit and Notes
Gas Ratios (24h Average Values)				
141	$008C_{hex}$	CH_4/H_2	32-bit float	-
143	$008E_{hex}$	C_2H_2/C_2H_4	32-bit float	-
145	0090_{hex}	C_2H_2/CH_4	32-bit float	-
147	0092_{hex}	C_2H_6/C_2H_2	32-bit float	-
149	0094_{hex}	C_2H_4/C_2H_6	32-bit float	-
151	0096_{hex}	CO_2/CO	32-bit float	-
Other				
161	$00A0_{hex}$	Time stamp of measurement result set, in seconds since start of Unix epoch	64-bit float (double)	s
165	$00A4_{hex}$	Index of measurement result set	32-bit integer	-

A.3.3 Alert Registers

Gas level alert registers are 16-bit fields. Each register communicates the status of alerts of specific severity for a particular timeframe (for example, gas level caution alerts for present values).

If an alert is active, the corresponding bit is set to 1. The bit is set to 0 when the alert is acknowledged or the alert is turned off. For more information, see Gas Level Alerts (page 17).

Table 25 Alert Registers (Read-Only)

Register Number (Decimal)	Address (Hexadecimal)	Register Description	Data Format	Bit Order
11	$000A_{hex}$	Gas level caution alerts for present values	16-bit field	0 = Methane 1 = Acetylene 2 = Ethylene 3 = Ethane 4 = Carbon monoxide 5 = Carbon dioxide 6 = TDCG 7 = Hydrogen 8 = Moisture in oil 9 = Relative moisture in oil
12	$000B_{hex}$	Gas level ROC caution alerts for 24h average values	16-bit field	0 = Methane 1 = Acetylene 2 = Ethylene 3 = Ethane 4 = Carbon monoxide 5 = Carbon dioxide 6 = TDCG 7 = Hydrogen
13	$000C_{hex}$	Gas level ROC caution alerts for one week average values	16-bit field	0 = Methane 1 = Acetylene 2 = Ethylene 3 = Ethane 4 = Carbon monoxide 5 = Carbon dioxide 6 = TDCG 7 = Hydrogen

Register Number (Decimal)	Address (Hexadecimal)	Register Description	Data Format	Bit Order
14	$000D_{hex}$	Gas level ROC caution alerts for one month average values	16-bit field	0 = Methane 1 = Acetylene 2 = Ethylene 3 = Ethane 4 = Carbon monoxide 5 = Carbon dioxide 6 = TDCG 7 = Hydrogen
15	$000E_{hex}$	Gas level alarms for present values	16-bit field	0 = Methane 1 = Acetylene 2 = Ethylene 3 = Ethane 4 = Carbon monoxide 5 = Carbon dioxide 6 = TDCG 7 = Hydrogen 8 = Moisture in oil 9 = Relative moisture in oil
16	$000F_{hex}$	Gas level ROC alarms for 24h average values	16-bit field	0 = Methane 1 = Acetylene 2 = Ethylene 3 = Ethane 4 = Carbon monoxide 5 = Carbon dioxide 6 = TDCG 7 = Hydrogen

Register Number (Decimal)	Address (Hexadecimal)	Register Description	Data Format	Bit Order
17	0010_{hex}	Gas level ROC alarms for one week average values	16-bit field	0 = Methane 1 = Acetylene 2 = Ethylene 3 = Ethane 4 = Carbon monoxide 5 = Carbon dioxide 6 = TDCG 7 = Hydrogen
18	0011_{hex}	Gas level ROC alarms for one month average values	16-bit field	0 = Methane 1 = Acetylene 2 = Ethylene 3 = Ethane 4 = Carbon monoxide 5 = Carbon dioxide 6 = TDCG 7 = Hydrogen

A.3.4 Test Value Registers

Read the known test values from the test registers to verify the functionality of your Modbus implementation.

Table 26 Test Value Registers (Read-Only)

Register Number (Decimal)	Address (Hexadecimal)	Data Format	Test value
201	$00C8_{hex}$	16-bit unsigned integer	12345
202	$00C9_{hex}$	32-bit unsigned integer	1234567890
204	$00CB_{hex}$	64-bit unsigned integer	1234567890123456789
208	$00CF_{hex}$	16-bit integer	-12345
209	$00D0_{hex}$	32-bit integer	-1234567890
211	$00D2_{hex}$	64-bit integer	-1234567890123456789

Register Number (Decimal)	Address (Hexadecimal)	Data Format	Test value
215	$00D6_{hex}$	32-bit float	1.23456
217	$00D8_{hex}$	64-bit float	1.23456789

A.4 Modbus Communication Examples

Reading Acetylene Value

Device address used in the following examples is 240 ($F0_{hex}$).
The values returned by the device differ depending on the measurement conditions. Your device may not return the same values.

Request	
Bytes on the Line (Hexadecimal)	**Description**
(silence for >3.5 bytes)	Start of Modbus RTU frame
$F0_{hex}$	OPT100 address
03_{hex}	Function (Read Holding Registers)
00_{hex}	Register address (Acetylene)
16_{hex}	
00_{hex}	Number of 16-bit registers to read (2)
02_{hex}	
30_{hex}	Modbus RTU checksum
EE_{hex}	
(silence for >3.5 bytes)	End of Modbus RTU frame

Response	
Bytes on the Line (Hexadecimal)	**Description**
(silence for >3.5 bytes)	Start of Modbus RTU frame
$F0_{hex}$	OPT100 address
03_{hex}	Function (Read Holding Registers)
04_{hex}	Number of data bytes

Response	
40_{hex}	Value of first register (least significant word)
40_{hex}	
00_{hex}	Value of second register (most significant word)
00_{hex}	
$0E_{hex}$	Modbus RTU checksum
$E8_{hex}$	
(silence for >3.5 bytes)	End of Modbus RTU frame

Communication Description	
Register address	23 (1-based Modbus documentation format) = 0016_{hex} (0-based format used in actual communication).
Data format	Two 16-bit Modbus registers interpreted as IEEE 754 binary32 floating point value, least significant word first.
Returned value	40400000_{hex}, which is binary32 representation of 3 (ppm).

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Technical Support

Contact Vaisala technical support at helpdesk@vaisala.com. Provide at least the following supporting information:

- Product name, model, and serial number
- Name and location of the installation site
- Name and contact information of a technical person who can provide further information on the problem

For more information, see www.vaisala.com/support.

Warranty

For standard warranty terms and conditions, see 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.

Recycling

Recycle all applicable material.

Follow the statutory regulations for disposing of the product and packaging.

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