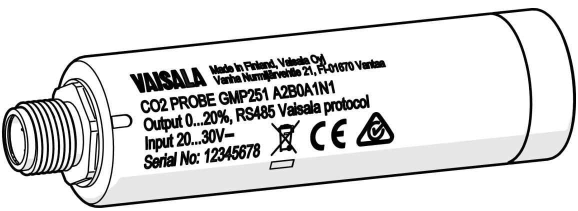
VAISALA

USER'S GUIDE

Vaisala CARBOCAP® Carbon Dioxide Probe GMP251



M211799EN-C

PUBLISHED BY

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1 GENERAL INFORMATION

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.

About this Document

Table 1 Document Revision History

Document code	Published	Description
M211799EN-C	March 2016	This version. Updated the instructions for using the `cco2` calibration command.
M211799EN-B	February 2016	Previous version. Modbus protocol and MI70 hand-held indicator support added. Measurement cuvette and probe body design updated. New installation accessories, cable and filter options, and calibration adapter. Support and instructions for switching between serial, analog and Modbus modes added. Analog output overrange clipping limit changed for 0 ... 10 V output. Performance, mechanics and operating environment specifications updated.
M211799EN-A	June 2015	The first version.

Table 2 Related Documents

Document code	Description
M211798EN	Vaisala CARBOCAP® Carbon Dioxide Probe GMP251 Quick Guide

Safety

The GMP251 probe delivered to you has been tested for safety and approved as shipped from the factory. Note the following precautions:

When returning a product for calibration or repair, make sure it has not been exposed to dangerous contamination, and is safe to handle without special precautions.

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

Do not open the probe housing. There are no user serviceable parts inside.

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. It is possible to damage the product, however, by delivering an electrostatic discharge when touching an exposed contact on the product.

To make sure you are not delivering high static voltages yourself, avoid touching the pins on the M12 connector.

Recycling

Recycle all applicable material.

Dispose of the unit according to statutory regulations. Do not dispose of with regular household refuse.

Regulatory Compliances

GMP251 is in conformity with the provisions of the following EU directives:

- EMC Directive
- RoHS Directive

Conformity is shown by compliance with the following standards:

- EN 61326-1: Electrical equipment for measurement, control, and laboratory use – EMC requirements – Generic environment.
- EN 550022: Information technology equipment – Radio disturbance characteristics – Limits and methods of measurement.

Patent Notice

GMP251 is protected by the following patents and their corresponding national rights:

Table 3 Applicable Patents

Patent Issued By	Patent Number
United States Patent and Trademark Office	US 5,827,438
	US 6,177,673
European Patent Office	EP0776023
	EP0922972
German Patent and Trade Mark Office	69615635
Japan Patent Office	4263285
Finnish Patent Office	112005
	105598

Trademarks

CARBOCAP® 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.

2 PRODUCT OVERVIEW

Introduction to GMP251

Vaisala CARBOCAP® Carbon Dioxide Probe GMP251 is designed for CO_2 measurement in demanding applications that require reliable and accurate performance. The measurement range is 0 ... 20 %CO_2.

The probe is based on Vaisala's patented 2nd generation CARBOCAP® technology and equipped with Vaisala's Microglow infrared light source. The probe is easy to install with a plug-in/plug-out M12 connection.

Sensor performance is optimized at 5 %CO_2 measurement. For compensation purposes, the probe also includes an internal temperature sensor that allows measurement compensation according to ambient temperature. As dust and most chemicals do not affect the measurement, and the effect of temperature, pressure and background gas can be compensated for, the probe can provide accurate and stable measurements in a wide range of applications.

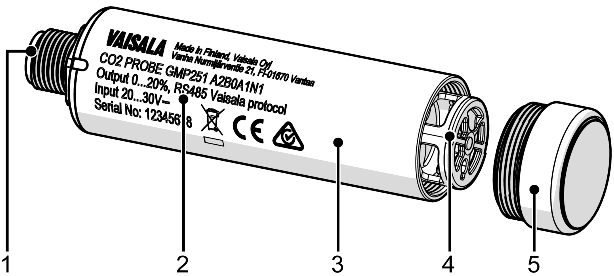


Figure 1 GMP251 Probe Parts

1 = 5-pin M12 connector. For pinout, see Wiring on page 20.

2 = Laser-printed type label.

3 = Probe body. Contains the main component board.

4 = Measurement cuvette with optics and CARBOCAP® CO_2 sensor.

5 = Filter (see Filter Options on page 10).

Do not attempt to open the probe body. There are no user-serviceable parts inside the probe body.

Basic Features and Options

- CO_2 measurement range 0 ... 20 %
- Vaisala CARBOCAP® CO_2 sensor with excellent long-term stability. See Operating Principle of CO2 Measurement on page 11 and Specifications on page 72.
- Measurement compensated for effects of temperature, pressure, and background gas. The temperature compensation can be based on an integrated temperature sensor or use a set temperature. Pressure and background gas parameters can be set to the probe. See Environmental Compensation on page 13.
- Heating to avoid condensation on optical elements.
- Digital output with RS-485:
  - Modbus RTU
  - Vaisala Industrial Protocol

  See Vaisala Industrial Protocol on page 21 and Modbus on page 54.
- Analog output:
  - Current output (0 ... 20 mA or 4 ... 20 mA)
  - Voltage output (0 ... 5 V or 0...10 V)
- Compatible with MI70 hand-held meter. See Operating with MI70 Indicator on page 60.
- Easy plug-in, plug-out

Filter Options

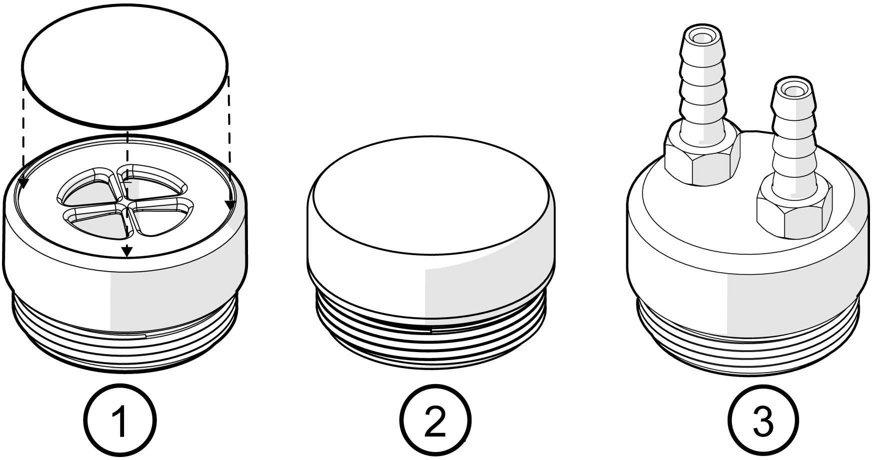


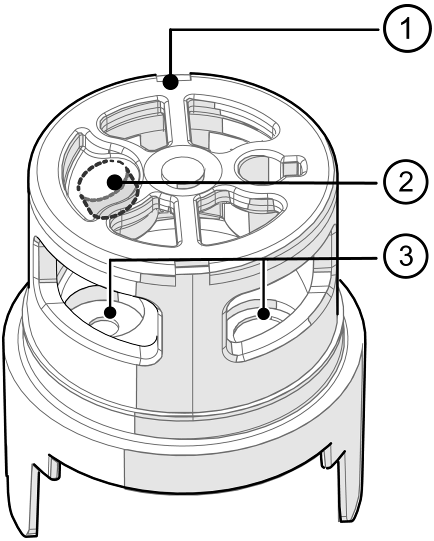
Figure 2 GMP251 Filter Options

The following filter options are available for GMP251:

1. Standard membrane filter, order code ASM211650SP. Gas can enter only through the top of the filter (plastic grid covered with membrane), the sides of the filter are solid.
2. Porous sintered PTFE filter for extra protection, order code DRW243649SP. The porous material of the filter allows gas to enter from all sides of the filter.
3. Flow-through adapter, order code ASM211697SP. Two gas ports for controlled gas feed (port outer diameter 4.6 mm, port hole inner diameter 2 mm, suitable for tubing with 4 mm inner diameter).

Operating Principle of CO_2 Measurement

The Vaisala CARBOCAP® sensor used in the probe is a silicon-based, non-dispersive infrared (NDIR) sensor for the measurement of gaseous carbon dioxide in air-like gases.



1 = Cuvette

2 = Mirror

3 = Sensor chips under TO5 package

Figure 3 CARBOCAP® Sensor of the Probe

The sensitivity to carbon dioxide is based on absorption of infrared light at a characteristic wavelength. During measurement, infrared light is routed through the cuvette that contains the gas to be measured. A mirror reflects the light from the cuvette to a thermopile detector that measures the light intensity at a wavelength determined by a Fabry–Pérot interferometer (FPI) and a band pass filter.

The carbon dioxide measurement consists of two steps: first, the FPI is electrically tuned so that its pass band coincides with the characteristic absorption wavelength of carbon dioxide and the signal is recorded. Second, the pass band is shifted to a wavelength where no absorption occurs in order to get a reference signal. The ratio of these two signals, one at the absorption wavelength and the other at the reference wavelength, gives the fraction of light absorption from which the carbon dioxide concentration is calculated. Measuring the reference signal compensates the possible effects of sensor aging and signal attenuation due to dirt on optical surfaces, making the sensor very stable over time.

TO5 packages with hermetic windows are used to protect the sensor chips from moisture and contamination. A heater chip is utilized to prevent condensation in normal operation.

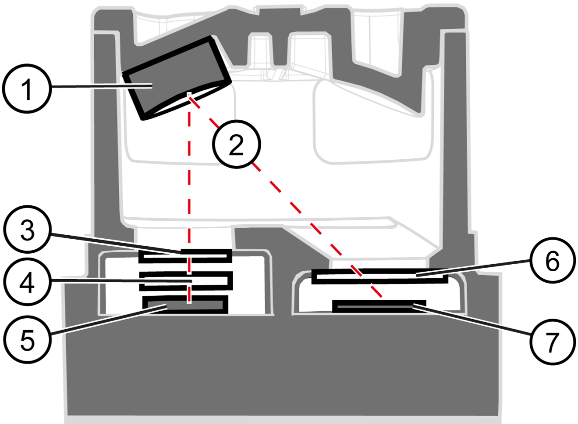


Figure 4 CO_2 Measurement in the Measurement Cuvette

1	=	Gold-plated mirror
2	=	Light absorbed by CO_2 in the measured gas
3	=	Hermetic window
4	=	Fabry-Perot interferometer
5	=	Light source (Microglow)
6	=	Hermetic window
7	=	Thermopile detector

Environmental Compensation

When necessary, various environmental compensations can be applied to improve the CO_2 measurement accuracy of the probe.

The probe can compensate for the effects of the following parameters:

- Temperature
- Pressure
- Background gas oxygen (O_2) content
- Background gas relative humidity (%RH)

The probe has an on-board temperature sensor that can be used to compensate for temperature. Additionally, if the probe is integrated in a system that measures one or more of the compensation parameters (T, P, RH, O_2), they can be updated to the probe continuously.

Compensation parameters are configured on the order form when ordering the probe, and can later be updated using Vaisala Industrial Protocol or Modbus protocol.

You can also turn off any of the compensations. In that case, the probe uses the default compensation value that is mathematically neutral for the probe's internal compensation model.

Temperature Compensation

The probe can measure the approximate temperature of the CARBOCAP® sensor for compensation, or use a fixed setpoint. The temperature measurement is accurate enough to be useful for compensation, and is recommended for use unless a dedicated temperature measurement is available and can be regularly updated to the probe. If the measurement is made in a constant temperature, this fixed temperature setpoint can be set as the compensation value.

If temperature compensation is turned off, the probe uses the default value of +25 °C (+77 °F).

> When the probe is installed through a flange (see Installation Flange on page 18), and part of the probe and the cable is left outside the measuring environment, it is possible that temperature conduction from the probe body and cable outside the measurement environment affects the temperature compensation and decreases measurement accuracy.

Pressure Compensation

The probe does not have on-board pressure measurement. However, a pressure reading from an external source can be used as a setpoint value for compensation via Vaisala Industrial Protocol (see Environmental Compensation on page 47). or Modbus (see Configuration Registers on page 84).

If pressure compensation is turned off, the probe uses the default compensation value of 1013 hPa.

Background Gas Compensation

The probe does not have on-board oxygen or relative humidity measurement. However, oxygen and relative humidity readings from an external source can be used as setpoint values for compensation via Vaisala Industrial Protocol (see Environmental Compensation on page 47). or Modbus (see Configuration Registers on page 84). The default setpoint values are as follows:

- Oxygen concentration: 19.7 $\%O_2$ or 21 $\%O_2$
- Relative humidity: 50 %RH or 93 %RH

If background gas compensations are turned off, the probe uses the value 0 % for both.

Probe Startup

When powered on, the probe starts up within 20 seconds. Measurements from the outputs (digital and analog) become available during this time but note that they will only reach specified accuracy after a 4-minute warm-up period. For this reason, you should design your system so that it does not rely on measurements from the probe during this time.

> Specifically note that the CO_2 reading will rise to the correct reading as the sensor's infrared emitter achieves operation temperature.

Analog Output Overrange Behavior

Analog output of the probe has a defined behavior when the values measured by the probe are outside the scaled analog output range. At first, the output is clipped when the measurement exceeds a set limit (the measurement continues, but the output does not change from the clipped value).

When the measurement exceeds the second limit (error limit), the analog output switches to the error state defined for the output. The table below lists the clipping and error limits and default error state outputs for the analog voltage and current outputs.

Table 4 Analog Output Overrange Clipping and Error Limits

Output voltage / current	Clipping Limit	Error Limit	Default Error State Output
0 ... 5 V	>5%	>10%	0 V
0 ... 10 V	>1%	>10%	0 V
0 ... 20 mA	>5%	>10%	23 mA
4 ... 20 mA	>5%	>10%	2 mA

The same clipping and error limits are applied when the measured value drops back to the scaled range: at first the output returns to the clipped value from the error state, and then to normal output.

Note that the clipping and error state limits differ for 0 ... 10 V and 0 ... 5 V outputs.

For 0 ... 10 V output the limits are 1% and 10%, and for 0 ... 5 V output the limits are 5% and 10%.

For example, consider a probe with 0 ... 5 V output, scaled to 0 ... 200 000 ppm (= 0 ... 20 %) CO_2.

- When the measured CO_2 rises above 20 %, the output rises above 5 V.
- The output keeps rising until the measurement is 21 %CO_2, at which point the probe outputs 5.25 V.
- If the CO_2 level rises above 21 %CO_2, the output still remains at 5.25 V.
- If the CO_2 level rises above 22 %CO_2, the output enters the error state, which is 0 V for the 0 ... 5 V output.

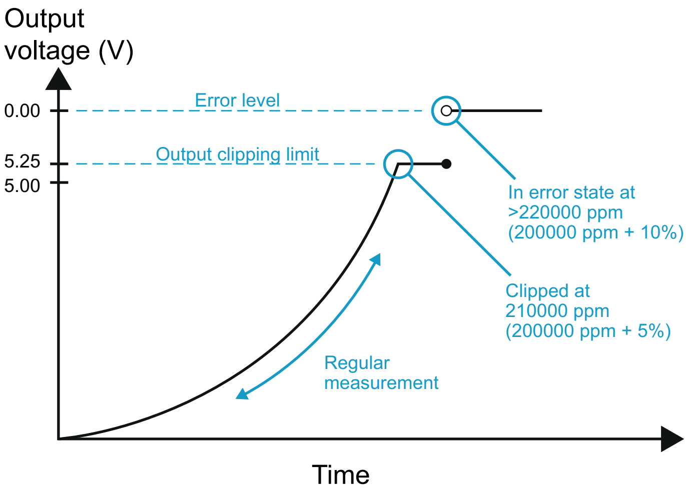


Figure 5 Example of analog output overrange behavior with output scaled to 0 … 5 V and 0 … 200000 ppm, error level set to 0 V, clipping set to 5 % overrange, and error limit set to 10 % overrange. CO_2 concentrations (ppm) are indicated for the clipping point and error limit point.

This overrange and error behavior is specific to the analog output, and does not affect the readings of the digital outputs.

You can change the analog output overrange behavior using the `aover` command. For instructions, see Aover Command on page 41.

3 INSTALLATION

Dimensions

The dimensions are given in millimeters (mm).

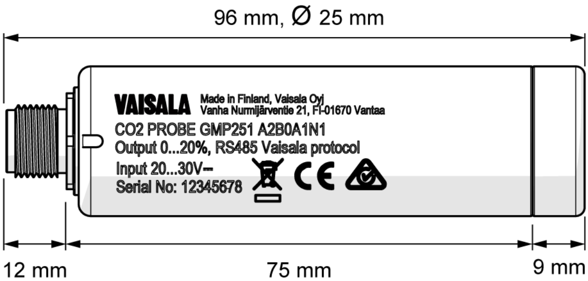


Figure 6 GMP251 Dimensions

Recommended Installation

The probe can be installed in an environment with an operating temperature range -40 ... +60 °C. Make sure the probe is in a location that represents the measurement environment properly.

The 5-pin male M12 connector on the probe provides an easy plug-in/plug-out connection to a compatible cable.

Installation Accessories

The GMP251 probe can be installed through a surface using the optional flange accessory (Vaisala product code 243261SP, see Installation Flange on the facing page), or attached for example to a wall with the optional clip accessory (two-clip set, Vaisala product code 243257SP). For ordering information, see Spare Parts and Accessories on page 75.

Installation Flange

The optional flange accessory (Vaisala order code: 243261SP) is used to install the probe body through a wall or other surface. For dimensions, see Mounting Flange Dimensions on page 76.

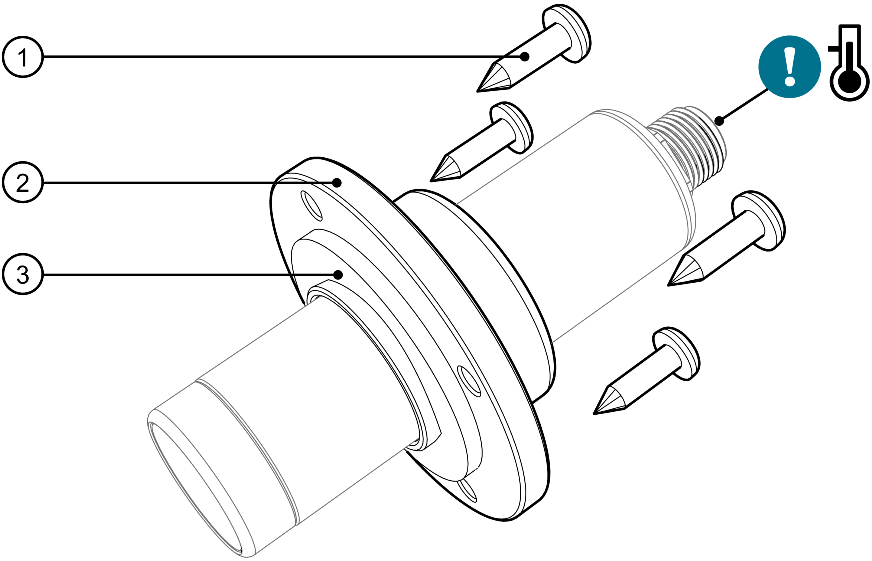


Figure 7 Probe with Installation Flange

1	=	Four Phillips head screws (included)
2	=	Installation flange (diameter 60 mm) with four Ø 4.2 mm screw holes
3	=	Gasket ring

Note that leaving part of the probe body and the cable outside the measurement environment can cause heat conduction that affects the temperature compensation and measurement accuracy.

Probe Mounting Clips

The optional mounting clips (set of two clips, Vaisala order code 243257SP) are used to hold the probe in place for example on a wall or other surface. Each clip base attaches to the installation surface with one screw (screw hole Ø 4.2 mm).

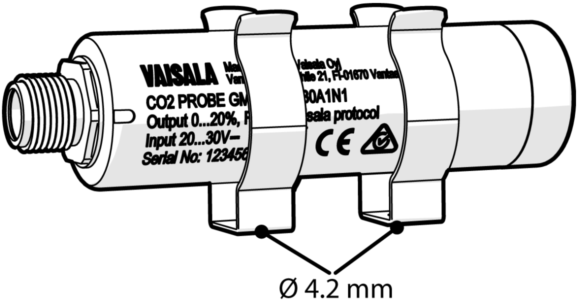


Figure 8 Optional Mounting Clips

Power Supply

The supply voltage range of the probe is 12 ... 30 VDC with the digital output option. If the analog output is used, the supply voltage range is 13 ... 30 VDC for voltage output and 20 ... 30 VDC for current output.

Typical power consumption is less than 0.4 W in continuous operation, and the maximum is 0.5 W.

Wiring

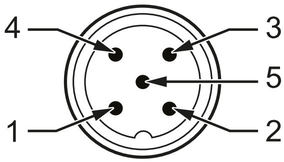


Figure 9 GMP251 M12 Male Connector Pins

Table 5 Connector Pinouts

Pin #	Function	Note	Wire Colors, Cable with Open Wires
1	Power in	With digital output: 12 ... 30 VDC With voltage output: 13 ... 30 VDC With current output: 20 ... 30 VDC Typical average power consumption <0.4 W, maximum 0.5 W	Brown
2	RS-485- or voltage output	Voltage: 0 ... 5 VDC, or 0 ... 10 VDC (default analog output mode)	White
3	GND		Blue
4	RS-485 + or current output	Current: 0 … 20 mA, or 4 ... 20 mA (default analog output mode)	Black
5	Output control	Connecting pin #5 to GND (pin #3) forces the probe to analog output mode. If analog output modes are not configured, default modes are used. Digital output is not available. If pin #5 is not connected, output operates as configured (digital or analog output).	Gray

Note that the probe always remains in analog mode when pin #5 is connected to pin #3 (see Wiring above), and cannot be switched to digital output in this wiring option.

4 VAISALA INDUSTRIAL PROTOCOL

Overview

RS-485 line of the probe 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 probe is integrated. The protocol is a plaintext protocol suitable for use both by human operators and automated systems.

Table 6 Default Serial Interface Settings

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

Physical Interface

The physical interface is a non-isolated 2-wire interface. The data lines are RS-485 D- and RS-485 D+. Ground is shared with power supply.

The connector is a 5-pin male M12. For connector pinout and wiring information, see Wiring on page 20.

Note that the probe always remains in analog mode when pin #5 is connected to pin #3 (see Wiring on page 20), and cannot be switched to digital output in this wiring option.

Connecting with a Computer

- Vaisala USB service cable (order code 242659)
- Computer with:
  - Windows operating system
  - Terminal application (e.g. PuTTy available from www.vaisala.com/software)
  - Free USB port
  - Driver for Vaisala USB service cable installed (available on the cable installation media and at www.vaisala.com/software)

Connecting with a computer allows you to configure and troubleshoot your probe using serial line commands. For a list of commands, see Serial Commands on page 28.

When connecting using a computer, use the Vaisala USB cable (Vaisala order code 242659) and a suitable terminal application:

- If you have not used the Vaisala USB cable before, install the driver before attempting to use the cable. For detailed instructions, see Installing the Driver for the USB Service Cable below.
- For more information on using a terminal application, see Terminal Application Settings on the next 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 probe using the PuTTY terminal application for Windows (available for download at www.vaisala.com/software) and a USB computer connection cable:

1. Connect the USB serial interface cable between your PC and the M12 connector of the probe.
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 press the **USB Finder** button to open the Vaisala USB Instrument Finder program.

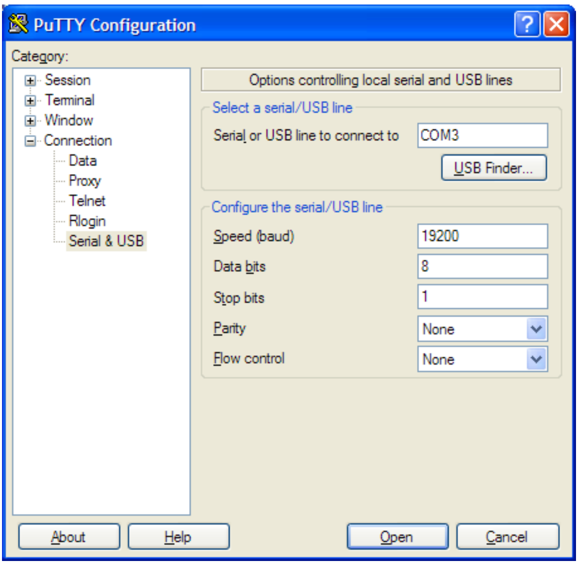


Figure 10 PuTTY Terminal Application

4. Check that the other serial settings are correct for your connection, and change if necessary. **Flow control** should be set to **None** unless you have a reason to change it. The default serial settings are listed in Table 6 on page 21

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.

Accessing Serial Commands from Modbus or Analog Mode

- Vaisala USB service cable (order code 242659)
- Computer with:
  - Windows operating system
  - Terminal application (e.g. PuTTy available from www.vaisala.com/software)
  - Free USB port
  - Driver for Vaisala USB service cable installed (available on the cable installation media and at www.vaisala.com/software)

To switch from Modbus or analog mode to using Vaisala Industrial Protocol serial commands:

1. Connect the USB cable to your PC (for USB cable installation instructions, see Connecting with a Computer on page 22).
2. Start the terminal application and open a terminal session using the default serial settings (19200/N/8/1).
3. Keep the Enter key pressed down and connect the GMP251 to the USB cable.

> When the GMP251 probe is powered on (connected to your PC with the USB cable), you must send five carriage returns (Enter key presses) within 0.7 seconds to force the probe to serial command mode.

4. The probe model information appears in the terminal application when the mode has been succesfully changed, and Vaisala Industrial Protocol commands are available for use. You can test the connection with for example the `?` command. If the mode change failed, close the terminal application, disconnect the probe from the USB cable, and repeat steps 2 and 3.
5. To keep the serial mode in use (forced serial mode access is temporary and switches off at reset), select a serial output option (stop/run/poll) with the `smode` command. For instructions on changing the serial mode, see Smode Command on page 39.

Note that the probe always remains in analog mode when pin #5 is connected to pin #3 (see Wiring on page 20), and cannot be switched to digital output in this wiring option.

Enabling Modbus Mode from Vaisala Industrial Protocol

If you need to switch from Vaisala Industrial Protocol to Modbus mode, you must configure the following settings:

- Serial line operating mode
- Modbus address
- Serial line settings (baud rate, parity, stop and data bits)

1. Set the serial mode to Modbus with the `smode` command:
   `smode modbus`
2. Set the Modbus address to 240 with the `addr` command:
   `addr 240`
3. Set the serial line settings to 19200/N/8/2 with the `seri` command:
   `seri 19200 N 8 2`
4. Power off (disconnect) the probe or reset with the `reset` command. The new configuration is available at the next restart.
5. To switch back to Vaisala Industrial Protocol, follow the instructions in Accessing Serial Commands from Modbus or Analog Mode on the previous page.

Changing From Digital Output to Analog Output

You can change the output mode from digital to analog with the `smode` serial command (see Smode Command on page 39).

To change the output mode to analog with the `smode` command:

1. Set up a terminal connection as instructed in Connecting with a Computer on page 22
2. Change the mode from digital to analog with the `smode` serial command: `smode analog`
3. Reset the probe (disconnect and reconnect the cable or use the `reset` serial command) to power on in analog output mode.
4. To switch back to serial mode, follow the instructions in Accessing Serial Commands from Modbus or Analog Mode on page 25.

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.

Table 7 below lists the basic serial commands that are available by default. To access advanced serial commands (listed in Table 8 on the next page), enter the command `pass 1300`.

Table 7 Basic Serial Commands

Command	Description	Page
Device information and status		
`?`	Show probe information.	30
`??`	Show probe information (will respond in POLL mode).	30
`errs`	Show currently active errors.	30
`help`	Show list of currently available serial commands.	31
`snum`	Show probe serial number.	31
`system`	Show probe firmware information.	31
`time`	Show probe operation hours and uptime.	32
`vers`	Show probe firmware version.	32
Serial line output and communication		
`close`	Close connection to probe (POLL mode)	32
`form [modifier string]`	Show or set output format.	33
`intv [0 ... 255 s/min/h]`	Set continuous output interval for R command.	35
`open [address]`	Open connection to probe in POLL mode.	35
`r`	Start the continuous outputting.	36
`s`	Stop the continuous outputting.	36
`sdelay [0 ... 255]`	Show or set serial line transmission delay in milliseconds.	36
`send`	Output a single measurement message.	37
`seri [baud data stop parity]`	Show or set the serial interface settings.	38

Command	Description	Page
smode [mode]	Show or set startup serial mode: RUN, STOP, or POLL.	39
Environmental compensation		
env	Show or set environmental parameters.	48
Adjustment information		
adate	Show CO_2 factory adjustment date.	45
atext	Show CO_2 factory adjustment information.	45
Other commands		
reset	Reset the probe.	53
pass [1300]	Access advanced serial commands.	53

Table 8 Advanced Serial Commands

Command	Description	Page
Serial line output and communication		
addr [0 … 254]	Show or set probe address.	32
Analog output		
amode	Show or set analog output mode (analog output limits and error level).	40
aover	Show or set analog output overrange and clipping behavior.	41
asel	Show or set analog output parameter and scaling.	44
Calibration and adjustment		
cco2	Adjust CO_2 measurement gain and offset.	46
cdate	Show or set calibration date.	45
ctext	Show or set calibration information.	45
Environmental compensation		
o2cmode	Show or set oxygen compensation mode.	50
pcmode	Show or set pressure compensation mode.	51
rhcmode	Show or set humidity compensation mode.	51
tcmode	Show or set temperature compensation mode.	52
Other commands		
frestore	Restore probe to factory settings.	52

Device Information and Status

Table 9 ? Command

Syntax	Description
`?<cr>`	Show listing of device information.
`??<cr>`	Show listing of device information even if device is in poll mode and connection has not been opened using the `open` command.

Example:

```
?
Device                  : GMP251
Copyright               : Copyright (c) Vaisala Oyj 2015. All rights
reserved.
SW Name                 : GMP251
SW version              : 1.0.0
SNUM                    : GMP233_5_18
SSNUM                   : S1234567
CBNUM                   : c1234567
Calibrated              : 20150604 @ Vaisala/R&D
Address                 : 0
Smode                   : STOP
```

Table 10 Errs Command

Syntax	Description
`errs<cr>`	Show active error(s). For a list of possible errors and their remedies, see Error Messages on page 79.

Example (no active errors):

```
errs
NO CRITICAL ERRORS
NO ERRORS
NO WARNINGS
STATUS NORMAL
```

Table 11 Help Command

<table>
<tr><th>Syntax</th><th>Description</th></tr>
<tr><td>help<cr></td><td>Show list of currently available serial commands.</td></tr>
<tr><td colspan="2">Example (showing a list of the basic commands):

help
ADATE
ADDR
ATEXT
CLOSE
ENV
ERRS
FORM
HELP
INTV
PASS
R
RESET
RX
SDELAY
SEND
SENDX
SERI
SMODE
SNUM
SYSTEM
UNIQID
TIME
VERS</td></tr>
</table>

Table 12 Snum Command

<table>
<tr><th>Syntax</th><th>Description</th></tr>
<tr><td>snum<cr></td><td>Show serial number of the probe.</td></tr>
<tr><td colspan="2">Example:

snum
SNUM : M0220028</td></tr>
</table>

Table 13 System Command

<table>
<tr><th>Syntax</th><th>Description</th></tr>
<tr><td>system<cr></td><td>Show probe firmware information.</td></tr>
<tr><td colspan="2">Example:

system
Device Name : GMP251
SW Name : GMP251
SW version : 1.0.0
Operating system : TSFOS1.0</td></tr>
</table>

Table 14 Time Command

Syntax	Description
time<cr>	Show how long the probe has been in operation since the last startup or reset. The operation counter is in format hh:mm:ss.
Example: **time** Time : 01:41:24	

Table 15 Vers Command

Syntax	Description
vers<cr>	Show firmware version of the probe.
Example: **vers** SW version : 1.0.0	

Serial Line Output and Communication

Table 16 Addr Command

Syntax	Description
addr<cr>	Show current device address. Addresses are required for POLL mode.
addr [aaa]<cr>	Set new device address. aaa = address, 0 ... 254 (default = 0)
Example (shows 0 as current address, enter 5 as the new address): **addr** Address : 0 **addr 5** Address : 5	

Table 17 Close Command

Syntax	Description
close<cr>	Close the connection that was opened with the open command.
Example: **close** line closed	

Table 18 Form Command

Syntax	Description
form<cr>	Show the currently used measurement format.
form /<cr>	Reset measurement format to default.
form [sss]<cr>	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.

Example (show currently used measurement format (default format shown here)):

```
form
6.0 "CO2=" CO2 " " U3 #r #n
```

Output example (continuous output from RUN mode):

```
CO2=   452 ppm
```

Example (set output format as $\%CO_2$):

```
form 3.1 "CO2=" CO2% " " U4 #r #n
OK
```

Output example (continuous output from RUN mode):

```
CO2=  5.1 %CO2
CO2=  5.1 %CO2
CO2=  5.0 %CO2
...
```

Example (set output format as CO_2 ppm with Modulus-65536 checksum):

```
form 6.0 "CO2=" CO2 " " U3 " " CS4 #r #n
OK
```

Output example (continuous output from RUN mode):

```
CO2= 3563 ppm 9F
CO2= 3562 ppm 9E
CO2= 3559 ppm A4
...
```

Example (set output format as CO_2 ppm, with **start of text** (ASCII character 002) and **end of text** (003) ASCII codes, and without line feed and carriage return at the end):

```
form #002 6.0 "CO2=" CO2 " " U3 #003
OK
```

Output example (continuous output from RUN mode, ASCII codes not visible here):

```
CO2= 866 ppm CO2= 866 ppm CO2= 867 ppm CO2= 867 ppm
CO2= 867 ppm CO2= 868 ppm CO2= 868 ppm CO2= 869 ppm
...
```

Table 19 Output Parameters for Form Command

Output Parameter	Abbreviation in Form Command
Carbon dioxide in ppm	`co2`
Carbon dioxide in percent	`co2%`
Currently used temperature compensation value	`tcomp`
Currently used pressure compensation value	`pcomp`
Currently used oxygen concentration compensation value	`o2comp`
Currently used relative humidity compensation value	`rhcomp`

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`	Probe address (0 ... 254).
`sn`	Probe serial number.
`time`	Cumulative operating hours of the probe.
`ux`	Name of the measurement unit using `x` number of characters. For example, `u3` shows the name of the measurement unit with three characters.
`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 Intv Command

Syntax	Description
intv<cr>	Show the output interval of the automatically repeating measurement messages (r command and run mode).
intv [iii uuu]<cr>	Set the output interval. iii = interval, range 0 ... 255. u = unit for interval setting: ■ s = seconds ■ min = minutes ■ h = hours If you set the interval to 0, the output messages are output as quickly as they are generated, without additional delay.
Example: **intv 5 s** Output interval: 5 S	

Table 22 Open Command

Syntax	Description
open [aaa]<cr>	Open a connection to a device at the specified address. Required when device is in poll mode. aaa = address, range 0 ... 254.
Example (target probe in POLL mode, with address 52): **open 52** GMP251: 52 Opened for operator commands	

Table 23 R Command

Syntax	Description
`r<cr>`	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 `intv` command until stopped with the `s` command.
Example:	

```
r
CO2= 5.1 %CO2
CO2= 5.1 %CO2
CO2= 5.1 %CO2
CO2= 5.0 %CO2
CO2= 5.0 %CO2
...
```

Table 24 S Command

Syntax	Description
`s<cr>`	Stop the continuous outputting that was started with the `r` command.
Example:	

```
...
CO2= 5.1 %CO2
CO2= 5.0 %CO2
CO2= 5.0 %CO2
s
```

Table 25 Sdelay Command

Syntax	Description
`sdelay<cr>`	Show serial line transmission delay in milliseconds.
`sdelay [delay]<cr>`	Set a new serial line transmission delay. `delay` = Serial line delay, range 0 … 255 (milliseconds).
Example (set delay to 50 milliseconds):	

```
sdelay 50
COM transmit delay  : 50
```

Table 26 Send Command

Syntax	Description
`send<cr>`	Output a single measurement message.
`send [aaa]<cr>`	Output a single measurement message from a device in poll mode. aaa = address of the probe, range range 0 ... 254
Example: **`send`** `CO2= 5.0 %CO2`	
Example (target probe in POLL mode, with address 52): **`send 52`** `CO2= 5.0 %CO2`	

Table 27 Seri Command

Syntax	Description
`seri<cr>`	Show current serial line settings.
`seri [b p d s]<cr>`	Set new serial line settings. The new settings will be taken into use when the probe is reset or powered up. `b` = baud rate (9600, 19200, or 38400) `p` = parity ■ `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 ... 38400 and parity must be none.

Example (show current settings):

```
seri
Com1 Baud rate      :   19200
Com1 Parity         :   N
Com1 Data bits      :   8
Com1 Stop bits      :   1
```

Example (set serial line to 9600 baud, even, 7 data bits, and 1 stop bit, and reset the probe to take the new settings in use):

```
seri 9600 e 7 1
OK
seri
Com1 Baud rate      :   9600
Com1 Parity         :   E
Com1 Data bits      :   7
Com1 Stop bits      :   1
reset
GMP251 1.0.0
```

Table 28 Smode Command

Syntax	Description
`smode<cr>`	Show current start-up operating mode of the serial line, and prompt to enter new mode.
`smode [mode]<cr>`	Set serial line start-up operating mode. New mode is taken into use when the device is reset or powered up. Available modes: `stop` = No automatic output. All commands available. Default mode. `run` = Automatic output of measurement messages. You can stop the output with the `s` command, and recontinue with the `r` command. `poll` = No automatic output. Will respond to addressed `send` command and `??` command. You can use other commands after opening a connection using an addressed `open` command. Use with RS-485 buses where multiple probes can share the same line. `modbus`= Serial line communication uses the Modbus protocol (see Modbus on page 54). Serial line commands (Vaisala Industrial Protocol) are not accessible in the Modbus mode. For instructions on returning to serial mode, see Accessing Serial Commands from Modbus or Analog Mode on page 25 `analog` = Switches the probe from digital output to analog output (active after probe reset). Serial line commands are not accessible in the analog mode: for instructions on returning to serial mode, see Accessing Serial Commands from Modbus or Analog Mode on page 25
Example (set serial mode to "poll"): **`smode poll`** `Serial mode : POLL`	

Analog Output

Table 29 Amode Command

Syntax	Description
amode [channel<cr>	Show currently set analog output limits and error level. channel = Analog output channel ■ 1 = voltage output (V) ■ 2 = current output (mA)
amode [channel lo_value hi_value error_value]<cr>	Set new analog output limits and error output value. channel = Analog output channel ■ 1 = voltage output (V) ■ 2 = current output (mA) lo_value = Low limit of the channel. hi_value = High limit of the channel. error_value = Error value of the channel.

Example (show current configuration):

```
pass 1300
amode 1
Aout 1 range (V)     : 0.00 ... 10.00 (error : 0.00)
amode 2
Aout 2 range (mA)    : 4.00 ... 20.00 (error : 2.00)
```

Example (set channel 1 to 0 … 5 V, and error output to 0.0 V; set channel 2 to 0 ... 20 mA, and error output to 23 mA):

```
pass 1300
amode 1 0 5 0.0
Aout 1 range (V)     : 0.00 ...  5.00 (error : 0.00)
amode 2 0 20 23
Aout 2 range (mA)    : 0.00 ... 20.00 (error : 23.00)
```

Table 30 Aover Command

Syntax	Description
`aover [channel<cr>`	Show the behavior of the analog output when the measured value is outside the scaled output range. `channel` = Analog output channel ■ 1 = voltage output (V) ■ 2 = current output (mA)
`aover [channel clipping error_ limit]<cr>`	Set the behavior of the analog output when the measured value is outside the scaled output range. `channel` = Analog output channel ■ 1 = voltage output (V) ■ 2 = current output (mA) `clipping` = Output margin (%) at which the output is clipped. `error_limit` = Measurement value margin (%) at which the output of the channel goes into the error state. The current or voltage output of the error state is defined using the `amode` command, see Table 29 on the previous page.

Example (view currently set analog output overrange behavior on channel 1):
 	
`pass 1300`
`aover 1`
`Aout 1 clipping          :5.00 %`
`Aout 1 error limit        :10.00 %`	

Syntax	Description

Example (for channel 1):

1. View currently set analog output scaling (`asel` command), limits and error level (`amode` command), and overrange behavior (`aover` command):

```
pass 1300
asel 1
Aout 1 quantity     : CO2(0 ... 200000)

amode 1
Aout 1 range (V)    : 0.00 ...  5.00 (error : 0.00)

aover 1
Aout 1 clipping     :1.00 %
Aout 1 error limit  :5.00 %
```

2. Set analog output overrange clipping to 5 % and error limit to 10 %:

```
aover 1 5 10
Aout 1 clipping     : 5.00 %
Aout 1 error limit  : 10.00 %
```

The analog output now behaves like this:

- Clipping is now set to 5.00 %, meaning the voltage output is allowed to vary between 0 ... 5.25 V. The analog channel will output the measurement for 0 ... 210 000 ppm, but range 0 ... 5 V remains scaled to 0 ... 200 000 ppm.
- Error limit is 10 %, which means the output will show the error state (0 V) when the measured CO_2 concentration is 10 % outside the scaled output range. With the settings above, this will happen if the measured CO_2 concentration is outside range 0 ... 220 000 ppm.
- The voltage output will never be above 5.25 V because of clipping: the voltage output is clipped when the output reaches 5.25 V, and if the measured CO_2 concentration keeps rising above 220 000 ppm, the output jumps directly to the error state 0 V.

Syntax	Description

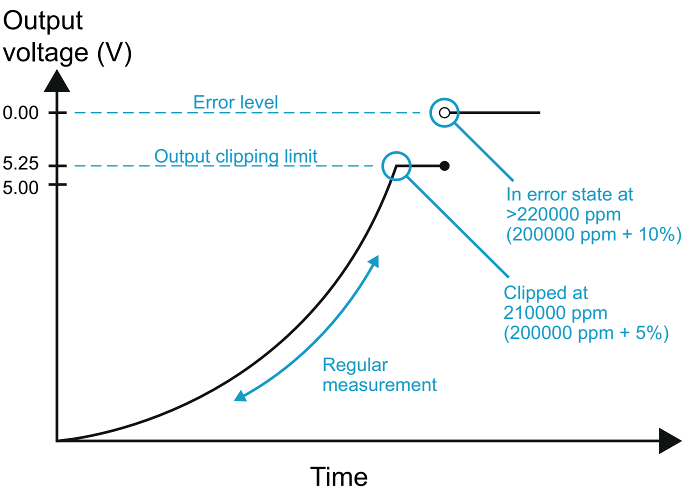


Figure 11 Example of analog output overrange behavior

The example shown above uses output scaled to 0 ... 5 V and 0 ... 200 000 ppm, has error level set to 0 V, clipping set to 5 % overrange, and error limit set to 10 % overrange. CO2 concentrations (ppm) are indicated for the clipping point and error limit point.

Table 31 Asel Command

<table>
<tr><th>Syntax</th><th>Description</th></tr>
<tr><td><code>asel [channel]<cr></code></td><td>Show the parameter and scaling of the analog output in ppm.

<code>channel</code> = Analog output channel
■ 1 = voltage output (V)
■ 2 = current output (mA)</td></tr>
<tr><td><code>asel [channel] [parameter lowlimit highlimit]<cr></code></td><td>Set the parameter and scaling of the analog output.

<code>channel</code> = Analog output channel
■ 1 = voltage output (V)
■ 2 = current output (mA)

<code>parameter</code> = Parameter that is output on analog channel. The only parameter available is CO2 (in ppm).

<code>lowlimit</code> = Lower limit of channel scaling in ppm. Minimum value is -1000000 ppm (= -100 %).

<code>highlimit</code> = High limit of channel scaling in ppm. Maximum value is 1000000 ppm (= 100 %).</td></tr>
<tr><td colspan="2">Example (for channel 1, show the currently set analog output parameter and scaling):

pass 1300
asel 1
<code>Aout 1 quantity   : CO2(0 ... 200000 ppm)</code></td></tr>
<tr><td colspan="2">Example (for channel 1, set scaling to 0 ... 10 % (= 100 000 ppm)):

pass 1300
asel 1 co2 0 100000
<code>Aout 1 quantity   : CO2(0 ... 100000 ppm)</code></td></tr>
</table>

Calibration and Adjustment

Before using the calibration and adjustment commands, read through Calibration and Adjustment on page 56.

Make sure that the environmental compensation settings of the probe are properly set for your calibration environment; see section Environmental Compensation on page 47.

Table 32 Adate Command

Syntax	Description
adate<cr>	Show CO_2 factory adjustment date.
Example: **adate** Adjustment date : 20150420	

Table 33 Atext Command

Syntax	Description
atext<cr>	Show CO_2 factory adjustment information.
Example: **atext** Adjusted at Vaisala/Helsinki	

Table 34 Cdate Command

Syntax	Description
cdate<cr>	Show calibration date.
cdate [yyyymmdd]<cr>	Set a new calibration date. yyyymmdd = Year (yyyy), month (mm) and day (dd) of calibration
Example: **pass 1300** **cdate** Calibration date : 20150220	
Example (set a new calibration date to June 30, 2015): **cdate 20150630** Calibration date : 20150630	

Table 35 Ctext Command

Syntax	Description
ctext<cr>	Show calibration information text.
ctext [text]<cr>	Set a new calibration information text to be shown after the automatic text "Calibrated at".
Example: **pass 1300** **ctext** Calibrated at 5.0% in lab	
Example (set a new information text): **ctext 0% 5% by NN** Calibrated at 0% 5% by NN	

Table 36 CCO2 Command

Syntax	Description
cco2<cr>	Show current user adjustment status.
cco2 -lo [co2]<cr> cco2 -hi [co2]<cr>	Perform a 1-point (only either low or high concentration) or 2-point (both low and high concentrations) calibration and adjustment. -lo = Adjustment at low concentration (under 2 %CO_2) -hi = Adjustment at high concentration (over 2 %CO_2) co2 = CO_2 concentration reference in ppm.
cco2 -save<cr>	Save the currently entered adjustments. Successfully saving the adjustment clears the calibration date (cdate) and calibration text (ctext) that have been stored in the probe. Use those commands to enter a new calibration date and text.
cco2 -cancel<cr>	Cancel currently entered adjustments.
cco2 -reset<cr>	Clear user adjustments.

Example (show current user adjustment status; no adjustment done):

```
pass 1300
cco2
1.Ref. point low        0
1.Meas. point low       0
2.Ref. point high   200000
2.Meas. point high  200000
Gain            : 1.0000
Offset          : 0.0000
```

Syntax	Description

Example (perform a 1-point calibration):
1. Let the probe stabilize in the desired CO_2 concentration (here: 5 %CO_2 (=50000 ppm)).
2. Enter the calibration commands:
`pass 1300`
`cco2 -hi 50000`
`OK`
`cco2 -save`
`OK`
3. Enter a new calibration date and information text:
`cdate 20150630`
`Calibration date     : 20150630`
`ctext 5% in lab`
`Calibrated at 5% in lab`	

Example (perform 2-point calibration):
1. Let the probe stabilize in the desired low CO_2 concentration (here: 0 %CO_2).
2. Enter the calibration commands:
`pass 1300`
`cco2 -lo 0`
`OK`
`cco2 -save`
`OK`
3. Let the probe stabilize in the desired high CO_2 concentration (here: 5 %CO_2 (=50000 ppm)).
4. Enter the calibration commands:
`pass 1300`
`cco2 -hi 50000`
`OK`
`cco2 -save`
`OK`
5. Enter a new calibration date and information text:
`pass 1300`
`cdate 20150430`
`Calibration date     : 20150430`
`ctext 0% 5% by NN`
`Calibrated at 0% 5% by NN`	

Environmental Compensation

For more information on environmental compensation and the default (neutral) compensation values used for disabled compensations, see Environmental Compensation on page 13

Table 37 Env Command

Syntax	Description
`env<cr>`	Show current compensation values. Before using this command, you must enable environmental compensation using the following commands: ■ `o2cmode [on]` ■ `pcmode [on]` ■ `rhcmode [on]` ■ `tcmode [on | measured]`
`env [temp | pres | oxy | hum] [value]<cr>`	Set new permanent compensation values and store them in **eeprom**. Eeprom: ■ Non-volatile memory, values retained during power off. ■ Number of writes is limited to 30000 cycles by memory implementation. ■ Must only be used for writing permanent values, to avoid wearing out the eeprom. `temp` = Compensation temperature. Range -40 ... +100 °C. `pres` = Compensation pressure. Range 500 ... 1150 hPa. `oxy` = Oxygen content of background gas. Range 0 ... 100 %. `hum` = Relative humidity of background gas. Range 0 ... 100 %.

Syntax	Description
env [xtemp | xpres | xoxy | xhum] [value]<cr>	Set new compensation values and store them in **RAM**. RAM: ▪ Volatile memory that loses the values when probe is reset, and where values are loaded from non-volatile memory at startup. ▪ Must be used for continuously updated values. xtemp = Compensation temperature stored in RAM. Range -40 ... 100 °C. xpres = Compensation pressure stored in RAM. Range 500 ... 1150 hPa. xoxy = Oxygen content of background gas stored in RAM. Range 0 ... 100 %. xhum = Relative humidity of background gas stored in RAM. Range 0 ... 100 %. Note: If temperature compensation is configured to use an internally measured value (tcmode is set to measured), it will continuously update the value in RAM, overriding any temperature value that is written to RAM with the ENV command.

Example (Show current compensation values; all compensations are enabled. Note that temperature compensation is in "measured" mode, so the value in use is constantly changing):

```
env
In eeprom:
Temperature (C)      : 25.00
Pressure (hPa)       : 1013.00
Oxygen (%O2)         : 21.00
Humidity (%RH)       : 50.00

In use:
Temperature (C)      : 36.40
Pressure (hPa)       : 1013.00
Oxygen (%O2)         : 19.70
Humidity (%RH)       : 93.00
```

Syntax	Description
Example (set temperature compensation to setpoint mode, and change temperature setpoint value to 37.2 in RAM): **pass 1300** **tcmode on** T COMP MODE : ON **env xtemp 37.2** In eeprom: Temperature (C) : 25.00 Pressure (hPa) : 1013.00 Oxygen (%O2) : 21.00 Humidity (%RH) : 50.000 In use: Temperature (C) : 37.2 Pressure (hPa) : 1013.00 Oxygen (%O2) : 19.70 Humidity (%RH) : 93.00	

Table 38 O2cmode Command

Syntax	Description
o2cmode<cr>	Check current oxygen compensation mode. Possible modes: ■ on = Compensation enabled using setpoint value. ■ off = Compensation disabled, default (neutral) value used (see Environmental Compensation on page 13.
o2cmode [on | off]<cr>	Change oxygen compensation mode (on or off).
Example (check oxygen compensation mode; oxygen compensation is disabled, a neutral value is used): **pass 1300** **o2cmode** O2 COMP MODE : OFF	
Example (enable oxygen compensation): **pass 1300** **o2cmode on** O2 COMP MODE : ON	

Table 39 Pcmode Command

Syntax	Description
`pcmode<cr>`	Check current pressure compensation mode. Possible modes: ■ `on` = Compensation enabled using setpoint value. ■ `off` = Compensation disabled, default (neutral) value used (see Environmental Compensation on page 13.
`pcmode [on | off]<cr>`	Change pressure compensation mode (`on` or `off`).
Example (check pressure compensation mode; pressure compensation is enabled using a setpoint value): **`pass 1300`** **`pcmode`** `P COMP MODE       : ON`	

Table 40 Rhcmode Command

Syntax	Description
`rhcmode<cr>`	Check current relative humidity compensation mode. Possible modes: ■ `on` = Compensation enabled using setpoint value. ■ `off` = Compensation disabled, default (neutral) value used (see Environmental Compensation on page 13.
`rhcmode [on | off]<cr>`	Change relative humidity compensation mode (`on` or `off`).
Example (check relative humidity compensation mode; relative humidity compensation is disabled, a neutral value is used): **`pass 1300`** **`rhcmode`** `RH COMP MODE       : OFF`	
Example (enable relative humidity compensation): **`pass 1300`** **`rhcmode on`** `RH COMP MODE       : ON`	

Table 41 Tcmode Command

Syntax	Description
tcmode<cr>	Check current temperature compensation mode. Possible modes: ■ on = Compensation enabled using setpoint value. ■ off = Compensation disabled, default (neutral)value used (see Environmental Compensation on page 13. ■ measured = Compensation enabled using internal measurement.
tcmode [on | off | measured]<cr>	Change temperature compensation mode (on, off or measured).

Example (check temperature compensation mode; temperature compensation is enabled using a setpoint value):

```
pass 1300
tcmode
T COMP MODE      : ON
```

Example (change temperature compensation to use internal measurement):

```
pass 1300
tcmode measured
T COMP MODE      : MEASURED
```

Other Commands

Table 42 Frestore Command

Syntax	Description
frestore<cr>	Restore the probe to its factory configuration. All user settings and user calibration parameters will be lost. Note: After using the frestore command, reset the probe using the reset command.

Example (restore the factory settings and reset the probe):

```
pass 1300
frestore
Parameters restored to factory defaults
reset
GMP251 1.0.0
```

Table 43 Pass Command

Syntax	Description
`pass [code]<cr>`	Access advanced serial commands. Advanced commands can be used until the next reset. `code` = Code for enabling advanced commands (1300).
Example: **`pass 1300`**	

Table 44 Reset Command

Syntax	Description
`reset<cr>`	Reset the probe. The probe will restart as if it had just been powered on.
Example: **`reset`** `GMP251 1.0.0`	

5 MODBUS

The probe 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 82.

For instructions on enabling the Modbus mode when you are using the probe with Vaisala Industrial Protocol, see Enabling Modbus Mode from Vaisala Industrial Protocol on page 26.

For instructions on switching to Vaisala Industrial Protocol when the probe is in Modbus mode, see Accessing Serial Commands from Modbus or Analog Mode on page 25.

The pre-configured default Modbus serial settings are presented in the following table.

Table 45 Default Modbus Serial Communication Settings

Description	Default value
Serial bit rate	19200
Parity	N
Number of data bits	8
Number of stop bits	2
Modbus device address	240

6 MAINTENANCE

Cleaning

You can clean the probe body by wiping it with a moist cloth. Standard cleaning agents can be used.

Note the following precautions when cleaning:

- Do not immerse the probe in liquid to clean it.
- Be careful not to block the filter when cleaning the probe.The optional sintered PTFE filter is especially sensitive to blockage.
- When changing the filter, you can use clean instrument air to gently blow any loose dirt and filter material from the sensor. Do not attempt to clean the optical surfaces in any other manner.

Chemical Tolerance

The following chemicals can be used to clean the probe:

- H_2O_2 (2000 ppm), non-condensing
- Alcohol-based cleaning agents such as ethanol and IPA (70 % Isopropyl Alcohol, 30 % water)
- Acetone
- Acetic acid

Avoid exposing the probe to chemicals for unnecessarily long periods of time. Do not immerse the probe in a chemical, and wipe chemicals off the probe after cleaning.

Changing the Filter

Change the filter to a new one if it shows visible signs of contamination or dirt.

When changing the filter, use clean gloves to avoid blocking the pores of the new filter.

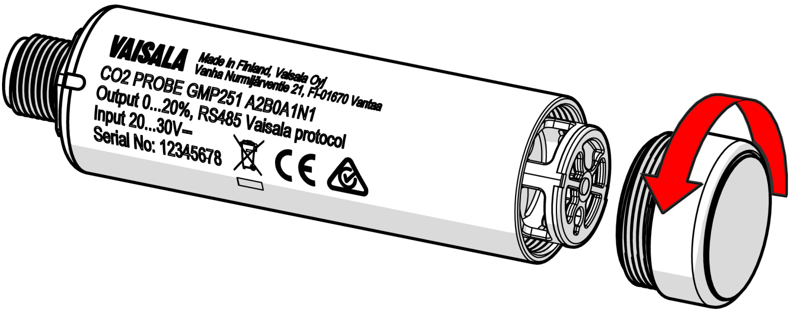


Figure 12 Replacing the Filter

When changing the filter, you can use clean instrument air to gently blow any loose dirt and filter material from the sensor. Do not attempt to clean the optical surfaces in any other manner.

Calibration and Adjustment

Calibrate and adjust the CO_2 measurement of the probe as needed. Before starting, read through this section completely so that you are aware of your options, and the main factors that affect the result.

Performing an accurate calibration and adjustment takes some time and preparation. Instead of doing it yourself, you can also have a Vaisala service center calibrate and adjust your probe. For contact information, see Technical Support on page 81

Calibration means comparing the probe's reading to a known reference, such as calibration gas or a reference instrument. Correcting the reading of the probe so that it measures accurately is referred to as **adjustment**.

Calibration Setup

Using Hand-Held Meter as Reference

You can perform a 1-point calibration using a hand-held meter as a reference. You will need a calibrated reference instrument to compare against, for example a GM70 hand-held meter with a calibrated GMP221 probe.

With the probe and the reference instrument in the same space, allow the measurement to stabilize before comparing the readings. Try to provide as stable an environment as you can during this time. Avoid working around the probe and reference instrument during this time.

Using Calibration Gas as Reference

There are two easy ways to use a calibration gas as a reference:

- You can supply the gas to the probe using the calibration adapter accessory (Vaisala order code DRW244827SP, see Field Check Adapter on page 59). Gas flow should be in the range 0.5 ... 1.1 l/min, recommendation is 1 l/min. Allow the measurement to stabilize for three minutes before starting the calibration.
- You can fill the entire incubator with the calibration gas. You can use calibration gas a reference by putting the probe in a suitable chamber (for example, an incubator) and filling that chamber with the calibration gas.

To perform a two-point adjustment, you need two calibration gases: one gas that is below 2 %CO_2 (low-end reference) and one that is above 2 %CO_2 (high-end reference).

When supplying the gas from a gas bottle, make sure the gas bottle has stabilized to room temperature before starting.

Effect of Environmental Compensations

The probe has various environmental compensations that improve its CO_2 measurement accuracy (see Environmental Compensation on page 13). As the calibration and adjustment environment may differ from the actual measurement environment, you must make sure that the compensation settings are properly set. Here are some key points to remember:

- Pressure and temperature compensations have a significant effect on accuracy. If you are using setpoint values instead of the values from the built-in temperature sensor or an integrated system, make sure to correct the setpoints so that they correspond to your calibration situation. Consider switching temperature compensation to use the internal sensor and/or integrated system when calibrating, and then switching back when calibration and adjustment is done.

- The effect of background gas compensations for humidity and oxygen may be significant when using calibration gases, since these gases are often dry and oxygen-free. For example, pure nitrogen gas is typically used as a convenient 0 ppm CO_2 reference. As it does not contain any oxygen or humidity, the compensations for them must be set to zero.
- Remember to restore the normal compensation settings after completing calibration and adjustment. If you are integrating the calibration functionality of the probe as part of a control software, also implement proper handling of the environmental compensations.

Limits of Adjustment

The probe limits the amount of adjustment that is allowed to the CO_2 measurement. The maximum correction that you can apply is 1000 ppm + 25 % of the probe's uncorrected reading. Previous user adjustments do not affect this limit (the correction is not cumulative). This feature limits the possible error introduced by incorrect adjustment.

For example, if you are adjusting using a 5 %CO_2 calibration gas (50000 ppm), the maximum correction you can apply is approximately 13500 ppm. Attempting to apply a greater adjustment will fail. Notification of failure from the probe depends on the interface you are using for adjustment.

Adjustment Types

You can adjust the CO_2 measurement of the probe in one or two points.

- One-point adjustment is recommended if you are interested in maintaining a fixed CO_2 level. For best result, use a calibration gas with a CO_2 concentration that is close to the intended level.
- Two-point adjustment is recommended if you typically measure a variable CO_2 level.

Available adjustment functions depend on the interface you use to operate the probe. If you want to integrate the functionality into a control system, the Modbus interface and the Vaisala industrial protocol are recommended. If you want to compare the reading of the probe to a reference instrument and adjust it accordingly, use an MI70 hand-held indicator and a reference probe.

Vaisala Industrial Protocol

Vaisala industrial protocol supports one and two-point adjustment with the `cco2` command. Configuration of the environmental compensation settings can be done using serial line commands.

See Calibration and Adjustment on page 44 and Environmental Compensation on page 47.

Modbus

The environmental compensation settings can be configured using Modbus registers: see Configuration Registers on page 84.

MI70 Hand-Held Indicator

MI70 hand-held indicator supports one-point adjustment, either using a calibration gas or using a reference instrument that is connected to the MI70. See Calibration and Adjustment with MI70 Indicator on page 66.

Field Check Adapter

The optional field check / calibration adapter accessory (Vaisala order code DRW244827SP) can be used to feed a reference gas to the probe through a gas port when calibrating.

Gas flow should be in the range 0.5 ... 1.1 l/min, recommendation is 1 l/min. Allow the measurement to stabilize for three minutes before starting the field check or calibration.

For more information on using a reference gas in calibration, see Calibration Setup on page 57.

For field check adapter dimensions, see Field Check Adapter Dimensions on page 77.

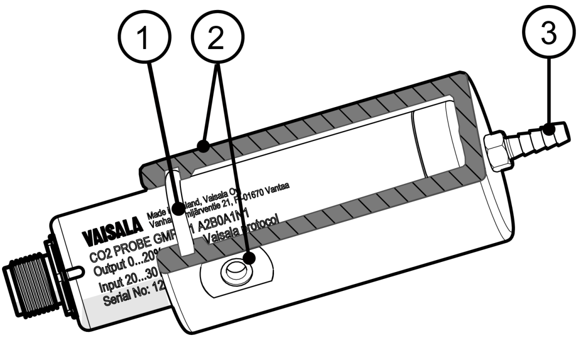


Figure 13 Optional Field Check Adapter with Probe, Cross Section View

1	=	O-ring inside the adapter
2	=	Gas outlet on each side of the adapter
3	=	Gas port (port outer diameter 4.6 mm, port hole inner diameter 2 mm, suitable for tubing with 4 mm inner diameter)

7 OPERATING WITH MI70 INDICATOR

Overview of MI70 Support

The probe is compatible with instruments that utilize the MI70 indicator, for example the GM70 Hand-Held Carbon Dioxide Meter. The MI70 indicator is a convenient service tool for viewing the measurement readings, adjusting the environmental compensation settings, and performing calibration and one-point adjustment.

Basic Display

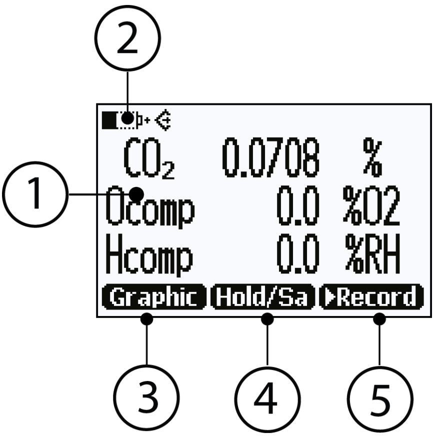


Figure 14 MI70 Basic Display

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

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:

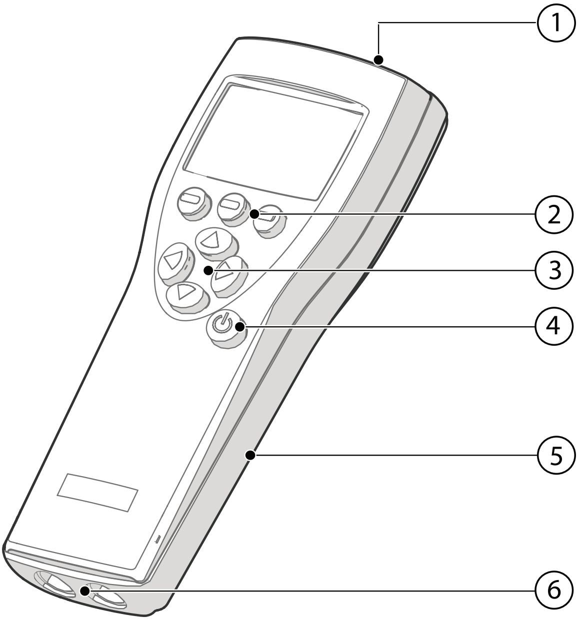
1. Go to the basic display.
2. Press any arrow key, then select **OPEN**.

In the main menu, you can configure the MI70 settings and basic display options, view information about the probe, access recordings and clear the memory, set alarms, start adjustments, and use the analog output option of the MI70 indicator.

Connecting Probe to MI70 Indicator

1. If the probe is installed permanently into a device (for example, a CO_2 incubator), disconnect the probe from the connector.
2. If the MI70 indicator is on, turn it off.
3. Connect the probe to the MI70 indicator using the MI70 connection cable (Vaisala order code: CBL210472).
4. Turn on the MI70 indicator (time and date are requested at first startup). MI70 detects the probe and proceeds to show the measurement screen. The parameters measured by probe will start to show valid measurement results after a few seconds.

Structure of the MI70 Indicator



1	=	Charger socket
2	=	Function keys. The functions change according to what you are doing with the indicator.
3	=	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**.

4	=	Power On/Off key
5	=	Battery compartment at the back of the indicator
6	=	Port I and port II for probe or hand-held instrument connection

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:

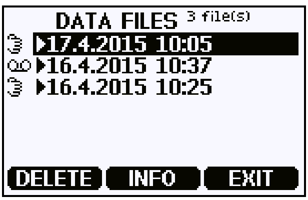
1. In the basic display, select **Record > View recorded data**. Alternatively, select **Main menu > Recording/Viewing > View recorded data**.

   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 46 below.

   If you set the duration to "Memory full", the recoding 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 46 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

Changing Environmental Compensation Settings with MI70 Indicator

You can see the compensation values that are currently used by the probe by selecting them as display quantities from **Main menu > Display > Quantities and Units**. The quantities are as follows:

- **Tcomp**: currently active temperature compensation value.
- **Pcomp**: currently active pressure compensation value.
- **Ocomp**: currently active oxygen concentration compensation value.
- **Hcomp**: currently active relative humidity compensation value.

Up to three display quantities (measurement reading and two compensations) can be shown simultaneously.

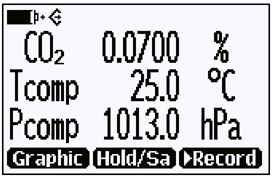


Figure 15 CO_2 Reading with Tcomp and Pcomp on MI70 Screen

You can change the compensation settings from **Main menu > Settings > Measurement settings**. For more information about the possible settings and their meaning, see Environmental Compensation on page 13.

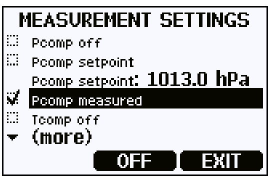


Figure 16 Probe Compensation Settings on MI70 Screen

When you turn a compensation off, the probe still shows a value for the corresponding display quantity (for example, Pcomp shows 1013.2 hPa). This is the default compensation value that is mathematically neutral for the probe's internal compensation model.

Calibration and Adjustment with MI70 Indicator

Before using the MI70 indicator for calibration and adjustment, read the instructions in Calibration and Adjustment on page 56.

Make sure that the environmental compensation settings of the probe are properly set for your calibration environment; see Changing Environmental Compensation Settings with MI70 Indicator on the previous page.

When two probes are connected to the MI70 indicator, it uses Roman numerals “I” and “II” to indicate which port the parameter or function in question is connected to.

1-Point Adjustment with an MI70-Compatible Reference Probe

1. Connect the GMP251 probe to Port I of the MI70 indicator.
2. Connect the calibrated reference probe to Port II. Make sure the reference probe is in the same environment as the GMP251’s sensor.
3. If you are using the calibration adapter to feed a calibration gas to the GMP251, you must feed the same gas to the reference probe also. Refer to the documentation of your reference probe on how to do this, and what accessories you need.
4. Turn on the MI70 indicator.
5. Start the adjustment sequence from **Main menu > Functions > Adjustments**.

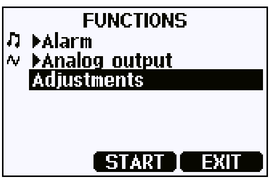


Figure 17 Functions Menu

6. MI70 notifies you that automatic power off is disabled during adjustment mode, press **OK** to acknowledge.

7. To proceed with the adjustment, select the **CO2(I)** parameter in the **Select Quantity** screen.

   In the **Select Quantity** screen you can also view the currently used compensation values, and the **Last adjustment date** information. You can update the date and text using the **CDATE** and **CTEXT** commands on the serial line.

8. You may be prompted to check the environmental settings of the reference probe before proceeding. Press **Yes** to check the settings and **Exit** when you have checked and corrected the settings.

9. The adjustment mode is now active, and you can see the measured CO_2 readings and their difference on the screen. Allow the measurement to stabilize. To proceed with the adjustment, press **Adjust**.

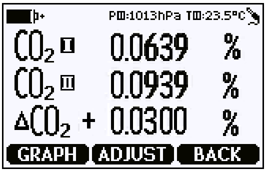


Figure 18 Comparing Readings in MI70 Adjustment Mode

10. Select **To same as CO2(II)**.

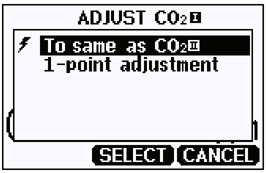


Figure 19 Selecting the Adjustment Mode

11. You will be prompted to confirm you want to adjust: select **Yes**.

12. If the adjustment is successful, MI70 will show the text **Adjustment Done**, after which you will return to the adjustment mode. At this point you can press **Back** and **Exit** to leave the adjustment mode. The adjustment is now completed.

    If the adjustment cannot be applied, the MI70 will show the text **Cannot adjust**, possibly followed by a text stating the reason. A possible reason for an adjustment failure is attempting to apply a very large correction to the reading. See Limits of Adjustment on page 58.

1-Point Adjustment with a Reference Gas

1. Connect the GMP251 to Port I of the MI70 indicator.
2. Feed a calibration gas to the GMP251 using the calibration adapter accessory (Vaisala order code: DRW244827SP). If you are using ambient air as the calibration gas, you must have a reference meter in the same environment to verify the CO_2 concentration.
3. Turn on the MI70 indicator.
4. Start the adjustment sequence from **Main menu > Functions > Adjustments**.

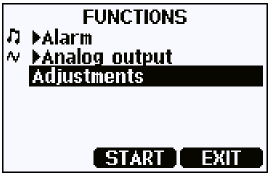


Figure 20 Functions Menu

5. MI70 notifies you that automatic power off is disabled during adjustment mode, press **OK** to acknowledge.
6. Select the CO_2 parameter when prompted.
7. You may be prompted to check the environmental settings of the reference probe before proceeding. Press **Yes** to check the settings and **Exit** when you have checked and corrected the settings.
8. The adjustment mode is now active, and you can see the measured CO_2 reading on the screen. To proceed with the adjustment, press **Adjust**.

9. Select **1-point adjustment**.

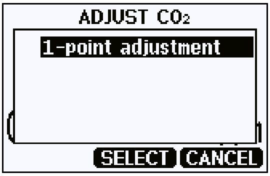


Figure 21 Selecting the Adjustment Mode

10. You will be prompted if you really want to adjust. Select **Yes**.
11. You are now in the 1-point adjustment screen. Allow the measurement to stabilize and press **Ready**.
12. Enter the CO_2 concentration of the reference gas and press **OK**.

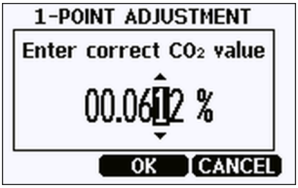


Figure 22 Entering the Reference CO_2 Concentration

13. You will be prompted if you really want to adjust. Select **Yes**.
14. If the adjustment is successful, MI70 will show the text **Adjustment Done**, after which you will return to the adjustment mode. At this point you can press **Back** and **Exit** to leave the adjustment mode. The adjustment is now completed.

    If the adjustment cannot be applied, MI70 will show the text **Cannot adjust**, possibly followed by a text stating the reason. A possible reason for an adjustment failure is attempting to apply a very large correction to the reading. See Limits of Adjustment on page 58.

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.

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 carefully 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 the following figure (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 the previous page.

In case you are installing a battery pack and you have a device with alkaline batteries, remove the metal contact from the probe port end of the battery compartment before installing the battery pack.

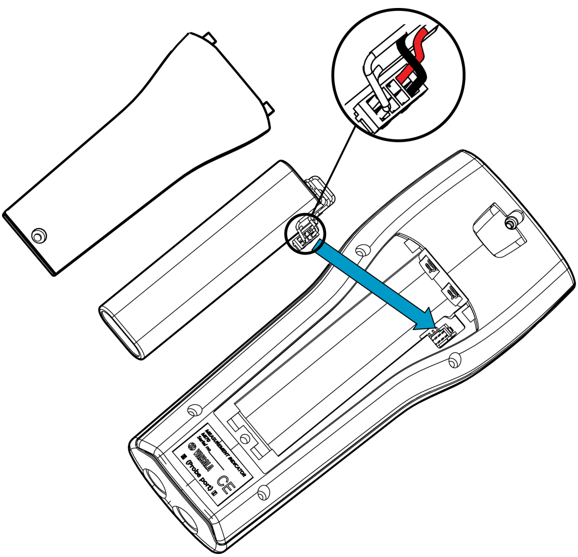


Figure 23 Installing the Battery Pack

8 TECHNICAL DATA

Specifications

Table 47 GMP251 Performance

Property	Specification
Measurement range	0...20 $\%CO_2$
Accuracy at 25 °C and 1013 hPa (incl. repeatability and nonlinearity) at 5 $\%CO_2$ 0...8 $\%CO_2$ 8...20 $\%CO_2$	 ±0.1 $\%CO_2$ ±0.2 $\%CO_2$ ±0.4 $\%CO_2$
Calibration uncertainty at 5 $\%CO_2$ at 20 $\%CO_2$	 ±0.05 $\%CO_2$ ±0.19 $\%CO_2$
Long-term stability 0...8 % $\%CO_2$ 8...12 $\%CO_2$ 12...20 $\%CO_2$	 ±0.3 $\%CO_2$/year ±0.5 $\%CO_2$/year ±1.0 $\%CO_2$/year
Temperature dependence with compensation at 5 $\%CO_2$ 0 ... 50 °C with compensation, 0…20$\%CO_2$,-40…60 °C without temperature compensation at 5 $\%CO_2$ (typical)	 <±0.05 $\%CO_2$ ±0.045 % of reading/°C -0.25 % of reading/°C
Pressure dependence with compensation at 5 $\%CO_2$ 700...1100 hPa with compensation, 0…20$\%CO_2$500...1200 hPa without compensation (typical)	 ±0.05 $\%CO_2$ ±0.015 % of reading/hPa +0.15 % of reading/hPa

Property	Specification
Humidity dependence with compensation, 0…20%CO_2, 0…100 %RH without compensation (typical)	 ±0.7 % of reading (at 25 °C) +0.05 % of reading/%RH
O_2 dependence with compensation, 0…20%CO_2, 0 ... 90 %O_2 without compensation (typical)	 ±0.6 % of reading (at 25 °C) -0.08 % of reading/%O_2
Flow rate dependence (for flow-through model option) < 1 l/min flow 1…10 l/min flow	 no effect <0.6% of reading/ l/min
Start-up time at 25 °C	< 10 s
Warm-up time for full spec.	< 4 min
Response time (T90) with standard filter flow-through model with >0.1 l/min	 < 1 min < 1 min

Table 48 Operating Environment

Property	Specification
Operating temperature of CO_2 measurement	-40 ... +60 °C
Storage temperature	-40 ... +70 °C
Pressure Compensated Operating	 500 ... 1200 hPa < 1.5 bar
Humidity	0...100 %RH, non-condensing
Gas flow (for flow-through option) Operating range Recommended range	 < 10 l/min 0.1…0.8 l min
Condensation prevention	Sensor head heating, when power on
Electromagnetic compatibility	EN61326-1, Generic Environment
Chemical tolerance (temporary exposure during cleaning)	■ H_2O_2 (2000 ppm, non-condensing) ■ Alcohol-based cleaning agents (for example ethanol and IPA) ■ Acetone ■ Acetic acid

Table 49 Inputs and Outputs

Property	Specification
Operating voltage	
With digital output in use	12...30 VDC
With voltage output in use	13...30 VDC
With current output in use	20...30 VDC
Digital output	Over RS-485: ■ Modbus ■ Vaisala Industrial Protocol
Analog outputs	0 ... 5/10 V (scalable), min load 10kΩ 0/4 ... 20 mA (scalable), max load 500Ω
Power consumption	
Typical (continuous operation)	0.4 W
Maximum	0.5 W

Table 50 Mechanics

Property	Specification
Materials	
Probe housing material	PET plastic
Filter	PTFE membrane, PET plastic grid
Connector	Nickel plated brass, M12 / 5 pin
Housing classification	
Probe body	IP65
Connector	M12 5-pin male
Weight	
Probe	45 g
Dimensions	
Probe diameter	25 mm
Probe length	96 mm

Spare Parts and Accessories

Information on spare parts, accessories and calibration products is available online at www.vaisala.com and store.vaisala.com.

Name	Order code
Cable with open wires (1.5 m)	223263SP
Probe cable with open wires and 90° plug (0.6 m)	244669SP
Probe cable with open wires (10 m)	216546SP
Standard membrane filter	ASM211650SP
Porous sintered PTFE filter (extra protection)	DRW243649SP
Flow-through adapter with gas ports	ASM211697SP
USB cable for PC connection	242659
MI70 connection cable for probe	CBL210472
Probe mounting clips (2 pcs)	243257SP
Probe mounting flange	243261SP
Calibration adapter/field check adapter	DRW244827SP

Dimensions

Mounting Flange Dimensions

The figure below shows a cross section view (dimensions in mm) of the optional mounting flange (Vaisala order code: 243261SP).

For more information on the flange, see Installation Flange on page 18.

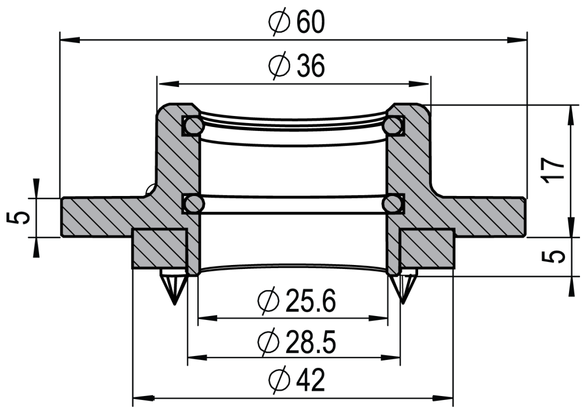


Figure 24 Optional Mounting Flange Accessory Dimensions, Cross Section

Field Check Adapter Dimensions

The figure below shows the dimensions (in mm) of the optional field check / calibration adapter (Vaisala order code: 243261SP). For more information on the adapter, see Field Check Adapter on page 59.

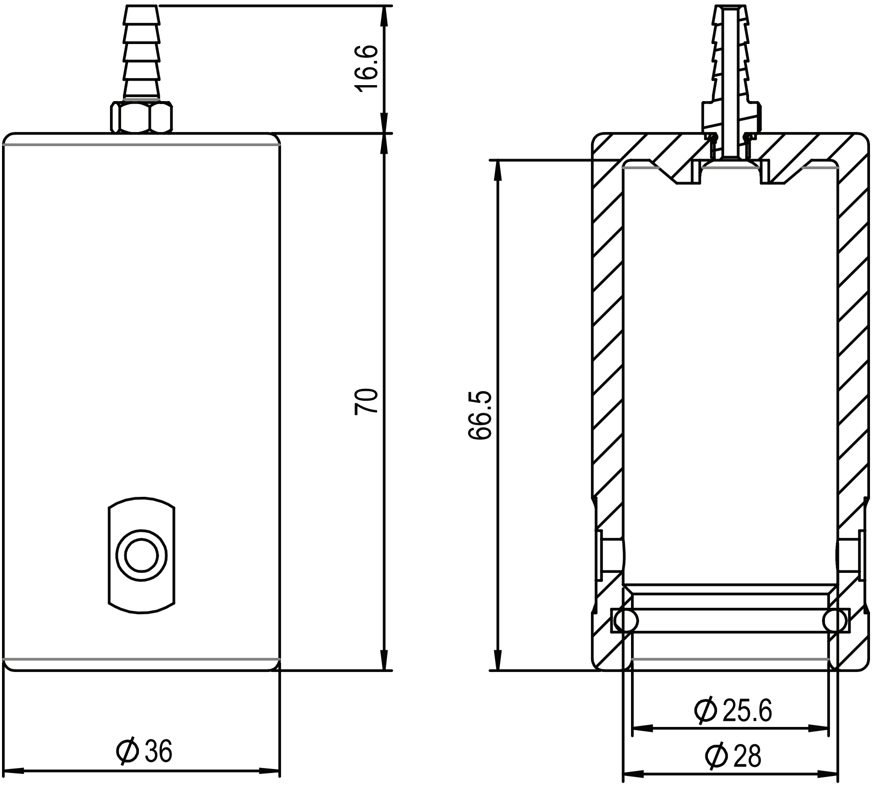


Figure 25 Optional Field Check Adapter Accessory Dimensions

9 TROUBLESHOOTING

Problem Situations

Problem	Possible Cause	Remedy
Analog output reading is unchanging and appears incorrect.	Analog output is in error state. See Analog Output Error State on page 80.	Remove the cause of the error state and the analog output will recover its normal function.
Probe outputs stars "****" on serial line instead of measurement data.	Incorrect supply voltage.	Check the power supply. Check the active errors using the ERRS command on the serial line.
	Unsuitable operating environment.	Verify that the operating environment is within specified operating limits.
Unable to access probe on the RS-485 line.	Incorrect wiring.	Check that the RS-485 connection is wired according to Wiring on page 20.
		Power cycle or reset the probe and try again.
	Probe in POLL mode with unknown address.	Issue the ?? command to make the probe output its information. The use the OPEN command to open a line to the probe's address.
CO_2 measurement not working.	Condensation on the sensor.	Remove the filter and check if condensation has formed on the sensor. If yes, dry out the condensation with instrument air and insert a new dry filter. Keep the probe powered and operating to prevent re-occurrence.

Error Messages

The error messages are categorized according to the severity of the status:

- **Critical errors** are fatal to the operation of the unit. It may not be able to respond to communication at all, and will not measure correctly.
- **Errors** prevent CO_2 measurement and cause the analog outputs to be set to the error state. Depending on the problem, errors may resolve themselves. For example, sensor heating will eventually dry out condensation on the optical surfaces.
- **Warnings** do not prevent normal operation but may indicate possible problems.
- **Status** indicates a known state of the unit.

Table 51 Error Messages in Vaisala Industrial Protocol

Error Message	Description	Recommended Action
Critical errors		
Program memory crc critical error	Program memory is corrupted.	Fatal error, contact Vaisala.
Parameter memory crc critical error	Parameter memory is corrupted.	Fatal error, contact Vaisala.
Errors		
Low supply voltage error		Check supply voltage.
Internal 30 V error	Low internal 30 V voltage.	
Low RX signal error	Low input signal. Can be caused by dirt or condensation on the optical surfaces.	Wait to see if condensation is removed by heat. For cleaning instructions, see Cleaning on page 55.
Internal 8 V error	Low internal 8 V voltage.	
RX signal cut error	Signal distortion (EMC interference)	
Out of measurement range error	CO_2 concentration is too high to measure.	Wait for CO_2 concentration to fall into the measurable range.
Sensor heater error	Sensor heater resistance is out of range.	
IR temperature error	IR source temperature error.	
FPI slope error	Signal receiver error.	Contact Vaisala.

Error Message	Description	Recommended Action
Internal 2.5 V error	Internal 2.5 V voltage is out of range.	
Internal 1.7 V error	Internal 1.7 V voltage is out of range.	
Low IR current error	IR source failure.	Contact Vaisala.
Warnings		
Signal too low warning	Low input signal. Can be caused by dirt or condensation on the optical surfaces.	Continue normally.
Cut warning	EMC interference error limit approaching.	Check for EMC interference sources.
Unexpected restart detected	Transmitter is reset by watchdog process.	Continue normally.
Status messages		
CO_2 adjustment mode active		Complete the CO_2 adjustment.

Analog Output Error State

The probe sets the analog output channel into a defined error level instead of the measured result in two situations:

- Probe detects a measurement malfunction. This means an actual measurement problem, such as sensor damage or unsuitable environmental conditions.
- Measured value(s) are significantly outside the scaled output range. For a more detailed explanation, see section Analog Output Overrange Behavior on page 14.

The default error level depends on the output type:

Output	Default Error Level
0 ... 20 mA	23 mA
4 ... 20 mA	2 mA
0 ... 5 V	0 V
0 ... 10 V	0 V

The probe resumes normal operation of the analog output when the cause of the error state is removed.

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.

A APPENDIX: MODBUS REFERENCE

Function Codes

GMP251 measurement data and configuration settings can be accessed with Modbus conformance class 0 function codes.

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

Table 52 Supported Function Codes

Function Code	Name	Class
03 (0x03)	Read Holding Registers	Class 0
16 (0x10)	Write Multiple Registers	Class 0
14 (0x0E)	Read Device Identification	

Data Encoding

16-Bit Integer Format

16-bit integer values are represented as described in the following table.

Table 53 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.

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 GMP251 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.

Modbus Registers

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

Measurement Data

The table below lists the GMP251 measurement data registers. Measurement registers are read-only.

Table 54 Modbus Measurement Data Registers

Address (decimal)	Register Description	Data Format	Unit
1	Measured CO_2 value	32-bit float	ppm
3	Measured T	32-bit float	°C
257	Measured CO_2 value	16-bit signed integer	ppm (up to 32 000 ppm)
258	Measured CO_2 value	16-bit signed integer	ppm *(*scaled)* (up to approx. 320 000 ppm)

*(*scaled) The ppm output of the second Measured CO_2 value register (address 258) is scaled and must be multiplied by 10.*

Configuration Registers

The table below lists the GMP251 configuration data registers. Configuration registers are writable.

Table 55 Modbus Configuration Data Registers

Address (decimal)	Register Description	Data Format	Unit / Valid Range
513	Persistent Compensation Pressure	32-bit float	hPa 500 ... 1100 hPa Operating <1.5 bar (Init/default: 1013.25)
515	Persistent Compensation Temperature	32-bit float	°C -40 ... +60 (Init/default: 25)
517	Persistent Compensation Humidity	32-bit float	%RH 0 ... 100 % (non-condensing) (Init/default: 0)
519	Persistent Compensation Oxygen	32-bit float	$\%O_2$ 0 ... 90 % (Init/default: 0)
521	Volatile Compensation Pressure	32-bit float	hPa (Init copied from persistent)
523	Volatile Compensation Temperature	32-bit float	°C (Init copied from persistent)
525	Volatile Compensation Humidity	32-bit float	%RH (Init copied from persistent)
527	Volatile Compensation Oxygen	32-bit float	$\%O_2$ (Init copied from persistent)
769	Modbus address	16-bit integer	Valid range 1...247 (default: 240)

Address (decimal)	Register Description	Data Format	Unit / Valid Range
770	Serial speed	enum	Valid range 4800...115200 0 = 4800 1 = 9600 2 = 19200 3 = 38400 4 = 57600 5 = 115200 (default: 2 (19200))
771	Serial parity	enum	0 = None 1 = Even 2 = Odd (default: 0 (None))
772	Serial stop bits	16-bit integer	Valid range 1...2 (default: 2)
773	Pressure compensation mode	enum	0 = Off 1 = On (default: 1 (On))
774	Temperature compensation mode	enum	0 = Off 1 = Measured 2 = Given (default: 1 (Measured))
775	Humidity compensation mode	enum	0 = Off 1 = On (default: 0 (Off))
776	Oxygen compensation mode	enum	0 = Off 1 = On (default: 0 (Off))
777	CO_2 filtering factor	16-bit integer	Valid range 0 ... 100 (default: 100 (no filtering)). For information on setting the filtering factor, see Filtering Factor on page 1.

Filtering Factor

The Modbus register CO_2 filtering factor (address 777) can be used to configure the speed at which the latest CO_2 measurement (approximately one measurement cycle per two seconds) is integrated into readings.

By default, filtering is not in use and the measurements are shown directly in the output. If the measuring environment produces occasional exceptionally high or low readings that need to be averaged out in the output, filtering can be applied.

To apply filtering, you need to set a filtering factor that determines how much the previous measurements affect the calculation of measurement output. For example, when the (default) filtering factor of 1 is used, only the latest measurement is taken into account, but with a filtering factor of 0.1, the new output is a combination of previous measurements (90%) and the latest measurement (10%).

Examples of the effect of filtering on output:

- Filtering factor 1.0 = No filtering, the latest measurement is output directly without integrating previous measurements.
- Filtering factor 0.5 = The reading output shows ~75% of the measurement change after two two-second measurement cycles and ~93% after four cycles.
- Filtering factor 0.1 = The reading output shows ~90% of the measurement change after 22 measurement cycles.

The configuration range of the filtering factor is 0 ... 100 in the 16-bit register: for example, to set the factor to 0.5, set the value of the register to 50.

The following formula is used when calculating the filtered output:

*output = [(new (unfiltered) measurement * filtering factor) + (previous output * (1.0 - filtering factor))]*

Device Identification Objects

The GMP251Modbus implementation 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 56 Device Identification Objects

Object ID (Decimal)	Object ID (Hexa-decimal)	Object Name	Example Contents
0	00	VendorName	"Vaisala"
1	01	ProductCode	"GMP25X "
2	02	MajorMinorVersion	Software version (for example "1.2.3")
3	03	VendorUrl	"http://www.vaisala.com/"
4	04	ProductName	"GMP25X"
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.

Status Registers

The table below lists the GMP251 status registers (read-only).

Table 57 Modbus Status Registers

Address (decimal)	Register Description	Data Format
2049	Device status	16-bit
2050	CO_2 status	16-bit

The device status and CO_2 status bits of the status registers are described in the following tables.

Table 58 Device status bits

Bit	Description	Comment
1	Critical error	Maintenance needed
2	Error	Device may recover automatically
3	Warning	

Table 59 CO_2 status bits

Bit	Description	Comment
1	CO_2 not reliable	Measurement is not reliable. This status also appears for a period of time during transmitter start-up.

Exception Responses

Table 60 Modbus 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 ranges applicable to GMP251.

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