VAISALA

USER'S GUIDE

Vaisala CARBOCAP® Carbon Dioxide Probe
GMP231

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CHAPTER 1
GENERAL INFORMATION

This chapter provides general notes for the manual and the GMP231 probe.

About This Manual

This manual provides information for installing, operating, and maintaining the Vaisala CARBOCAP® Carbon Dioxide Probe GMP231.

Contents of This Manual

This manual consists of the following chapters:

- Chapter 1, General Information, provides general notes for the manual and the GMP231 probe.
- Chapter 2, Product Overview, introduces the GMP231 probe and its features.
- Chapter 3, Installation, provides you with information that is intended to help you install the GMP231.
- Chapter 4, Vaisala Industrial Protocol, describes the Vaisala Industrial Protocol implementation of the GMP231.
- Chapter 5, I2C Interface, describes the I2C interface implementation of the GMP231.
- Chapter 6, Maintenance, provides information that is needed in the basic maintenance of the GMP231.
- Chapter 8, Troubleshooting, describes possible problems, their probable causes and remedies, and provides contact information for technical support.
- Chapter 9, Technical Data, provides the technical data of the GMP231.

Version Information

Table 1   Manual Revisions

Manual Code	Description
M211501EN-C	May 2014. This manual. Updated description for ENV command in section Change Compensation Setpoint Values on page 36.
M211501EN-B	Previous version. Applicable from software version 1.1.0 onward. Added instructions for operation with the MI70 hand-held indicator. Updated description of I^2C interface and Vaisala Industrial Protocol. Updated description of environmental compensations. Updated instructions for calibration and adjustment. Updated technical specification.
M211501EN-A	September 2013. First version.

Related Manuals

Table 2   Related Manuals

Manual Code	Manual Name
M211603EN	GMP231 Quick Guide

Documentation Conventions

Throughout the manual, important safety considerations are highlighted as follows:

WARNING	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	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	Note highlights important information on using the product.

Safety

The GMP231 probe delivered to you has been tested for safety and approved as shipped from the factory. Note the following precautions:

WARNING	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.

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

CAUTION	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

GMP231 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

GMP231 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 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.

CHAPTER 2
PRODUCT OVERVIEW

This chapter introduces the GMP231 probe and its features.

Introduction to GMP231

The Vaisala CARBOCAP® Carbon Dioxide Probe GMP231 is designed for incubator manufacturers requiring accurate and reliable carbon dioxide measurements and sterilization durability at high temperatures.

The GMP231 probe is based on Vaisala's patented CARBOCAP® technology and a new type of infra-red light source. The probe can remain in place during high-temperature sterilization cycles that heat the chamber interior to 180 °C. Special design of the probe enables easy installation through the incubator wall and ensures that the sensor optics and electronics are separated and thermally insulated.

Sensor performance is optimized at 5 %CO_2 measurement. GMP231 also has an internal pressure sensor, which allows compensation of the measurement according to ambient pressure. Since dust and most chemicals do not affect the measurement, and the effect of water vapor can be compensated for, GMP231 is accurate and stable at CO_2 incubator conditions.
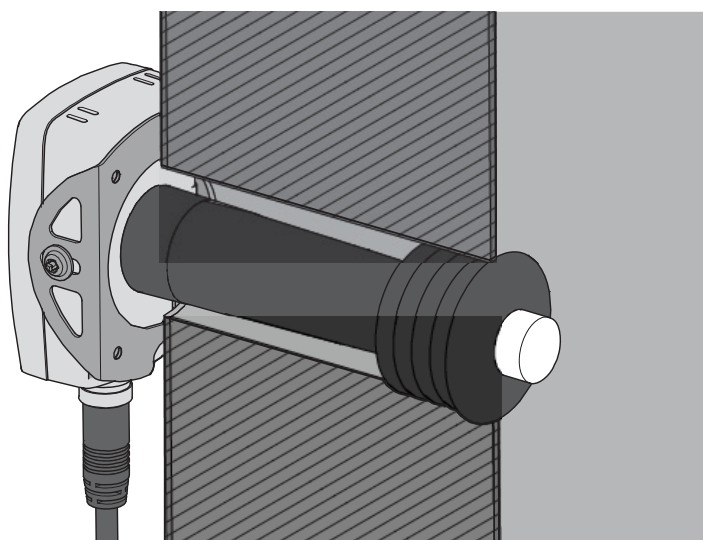
1403-144

Figure 1   GMP231 Installed Through a Chamber Wall (Example)

Basic Features and Options

- CO_2 measurement range 0 ... 20 %CO_2.
- Temperature durability in standby mode up to 195 °C (383 °F). See section Thermal Management on page 20.
- Vaisala CARBOCAP® CO_2 sensor with excellent long-term stability. See sections Operating Principle of CO_2 Measurement on page 15 and Specifications on page 85.
- Measurement compensated for effects of pressure, temperature, and background gas. Pressure compensation based on integrated pressure sensor. See section Environmental Compensation on page 17.
- Heating to avoid condensation on optical elements.
- Analog output: one current output channel (0 ... 20 mA or 4 ... 20 mA).
- Digital output:
  - I^2C.
  - RS-485 (non-isolated) with Vaisala Industrial Protocol.

GMP231 Parts
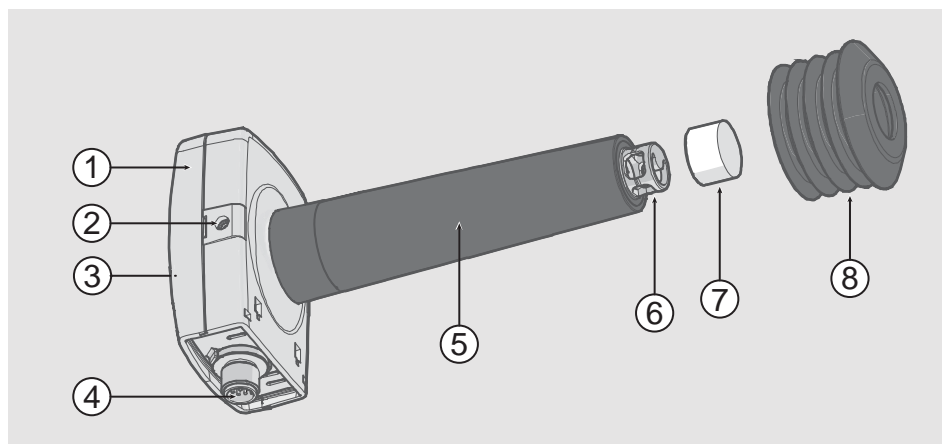
1403-153

Figure 2   GMP231 Parts

1   =   Electronics housing. Contains the main component board, including the digital pressure sensor.
2   =   Holes for M4 screws on both sides of the housing. Maximum screw depth 8 mm. Two screws included, type BN 10649 M4.
3   =   Type label on housing cover (not shown).
4   =   8-pin M12 connector. For pinout, see Table 4 on page 24.
5   =   Probe body.
6   =   Measurement cuvette with optics and CARBOCAP® CO_2 sensor.
7   =   PTFE filter.
8   =   Silicone plug for sealing the lead-through. Recommended accessory, suitable for ⌀ 44 mm lead-throughs.

CAUTION	Do not open the electronics housing; there are no user serviceable parts inside. All wiring is done through the M12 connector (4).

Operating Principle of CO$_2$ Measurement

The Vaisala CARBOCAP® sensor that is used in the GMP231 is a silicon-based, non-dispersive infrared (NDIR) sensor for the measurement of gaseous carbon dioxide. It is especially designed to tolerate high temperatures in standby mode, up to 195 °C (383 °F). This allows it to be used in applications that utilize high temperature for heat sterilization. The operating temperature range of the sensor is 0 … +70 °C (+32 ... +158 °F).

1403-160

1 = Cuvette.
2 = Mirror.
3 = Window.
4 = Sensor chips.
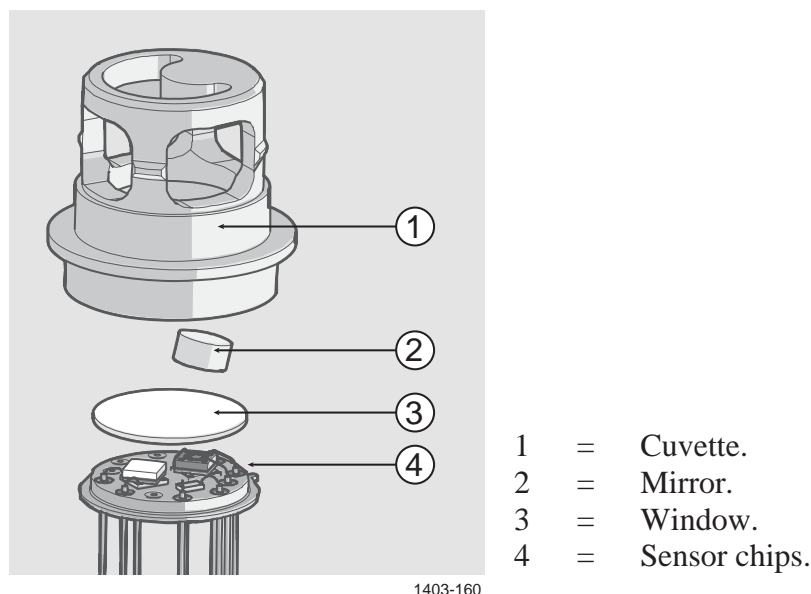
Figure 3   CARBOCAP® Sensor of the GMP231

The sensitivity to carbon dioxide is based on absorption of infrared light at a characteristic wavelength. The light is emitted by a novel, silicon-based microchip emitter into the cuvette which contains the gas to be measured. After reflection from the mirror, the light intensity is measured with a thermopile chip at a wavelength chosen by a micromechanical Fabry–Pérot interferometer (FPI) and a band pass filter. A hermetically sealed sapphire window is used to protect the sensor chips from moisture and contamination. A heater chip is utilized to prevent condensation in normal operation.

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. 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.

1403-161
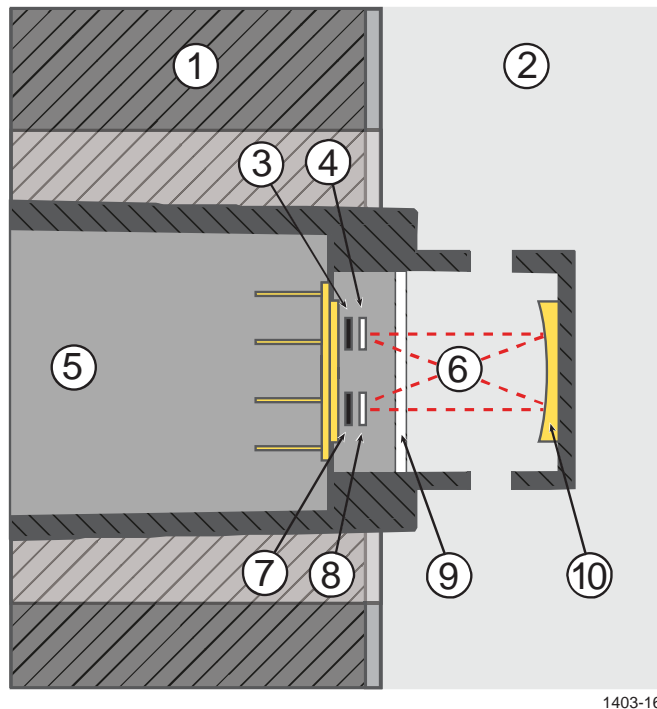
Figure 4   CO$_2$ Measurement Inside the Incubator

1   =   Chamber wall.
2   =   Chamber interior.
3   =   Light source.
4   =   Band pass filter.
5   =   Ambient air (400 ... 1000 ppm CO$_2$).
6   =   Light absorbed by CO$_2$ in the incubator gas.
7   =   Thermopile detector.
8   =   Fabry-Perot interferometer.
9   =   Sapphire window. Separates the sensor's active components
        from the measured environment.
10 =   Gold-plated mirror.

Environmental Compensation

GMP231 improves the CO_2 measurement accuracy by applying various environmental compensations. GMP231 compensates for the effects of:

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

Compensation parameters are configured on the order form when ordering the probe, and can later be updated using serial commands, MI70 Indicator, or I^2C protocol. If the probe is integrated in a system that measures one or more of the compensation parameters, they can be updated to the probe continuously.

You can also turn off any of the compensations. In that case, GMP231 uses the default compensation value that is mathematically neutral for the probe's internal compensation model.

For the effect of the compensations on measurement accuracy, refer to Table 42 on page 85.

Pressure Compensation

There is a pressure sensor on the component board of the GMP231 that provides a live measurement of ambient pressure. GMP231 can compensate the CO_2 measurement based on this pressure reading, or it can use a fixed setpoint. Using the GMP231's own sensor is recommended for most applications.

If pressure compensation is turned off, GMP231 uses the default compensation value of 1013.2 hPa.

Temperature Compensation

GMP231 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 GMP231.

If temperature compensation is turned off, GMP231 uses the default value of +37 °C (+98.6 °F).

Background Gas Compensations

Compensation for background gas parameters are based on setpoint values only, as GMP231 has no internal measurement for oxygen concentration or humidity. The default setpoint values are as follows:

- Oxygen concentration: 19.7 %O_2.
- Relative humidity: 93 %RH.

If background gas compensations are turned off, GMP231 uses the value 0% for both.

Probe Startup

When powered on, GMP231 starts up within 10 seconds. Measurements from the outputs (digital and analog) become available during this time but note that they will only reach specified accuracy after a one minute warm-up period. For this reason, you should design the incubator's control system so that it does not rely on measurements from GMP231 during this time.

NOTE	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 GMP231 has a defined behavior when the values measured by the probe are outside the scaled analog output range:

- Output is allowed to go 10% over the scaled range.
- Output is set to error state when measured value is more than 10% outside the scaled range. See section Analog Output Error State on page 84.
- Output resumes normal function when measured value returns to within 10% of the selected range.

For example, consider a GMP231 with 0 ... 20 mA analog output, scaled to 0 ... 10 %CO_2.

- When measured CO_2 rises above 10 %CO_2, the output rises above 20 mA.
- The output keeps rising until the measurement is 11 %CO_2, at which point the probe outputs 22 mA.
- If the CO_2 level rises above 11 %CO2, the output enters the error state, which is 23 mA for the 0 ... 20 mA output.

NOTE	This overrange and error state behavior is specific to the analog output, and does not affect the readings provided by the digital outputs.

You can change the analog output overrange behavior using the **AOVER** command. See section Set Analog Output Clipping and Error Limit on page 46.

CHAPTER 3

INSTALLATION

This chapter provides you with information that is intended to help you install the GMP231.

Thermal Management

GMP231 is designed to remain installed during typical heat sterilization cycles that raise the chamber temperature to 180 °C (356 °F). Since 180 °C is the target temperature for sterilization, it is likely that there will be hotspots inside the chamber that are above this temperature. Avoid installing the GMP231 near such hotspots, for example near heating elements. Do not expose the GMP231 to temperatures higher than 195 °C / 383 °F.

The following considerations are most important for achieving the specified heat durability and measurement stability:

- Only the sensor and its filter should be exposed to heat. The filter must be completely in the heated chamber. The probe body must remain inside the unheated chamber wall so that only the end of the probe body extends exactly 2.5 mm into the chamber.
- During the sterilization cycle, you must set the GMP231 to **standby mode** (turns off the CO_2 measurement), or power off the probe completely. The GMP231 will automatically stop its measurement cycle if it detects a high temperature, but it is best if the incubator's control system set the GMP231 to standby mode when the sterilization cycle is started.
- The installation tube must be sealed from the chamber side to limit heat conduction, and to prevent CO_2 in the chamber from entering the probe. Vaisala recommends a 44 mm diameter installation tube together with Vaisala's silicone plug.
- If the chamber wall contains heating elements, or has a construction where hot air is circulated inside the wall, design the installation tube so that excessive heat is not conducted to the GMP231.

Avoiding Condensation

The sensor head of the GMP231 is heated during normal operation, which prevents condensation from forming inside the filter and on the optical surfaces. The heating is not on when GMP231 is in standby mode or unpowered. For this reason, keep the probe powered and operating when the incubator is in use and humidity inside the chamber is high.

Correct installation depth of the probe is also important for preventing condensation from running to the sensor along the chamber wall. See below.

Probe Installation Depth

GMP231 must be installed so that only the sensor element and the filter are inside the chamber. If the probe is longer the installation tube, the extra length should extend to the outside of the chamber.

The installation depth must be 2.5 mm. This installation depth provides the specified heat durability of the probe, and allows the silicone plug to seal the Ø44 mm installation tube properly.
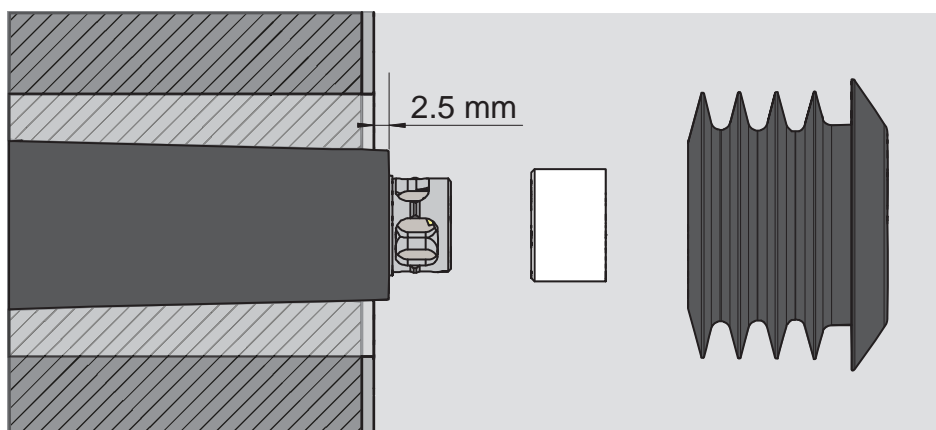
1403-154

Figure 5   Probe Installation Depth

Dimensions

1403-108
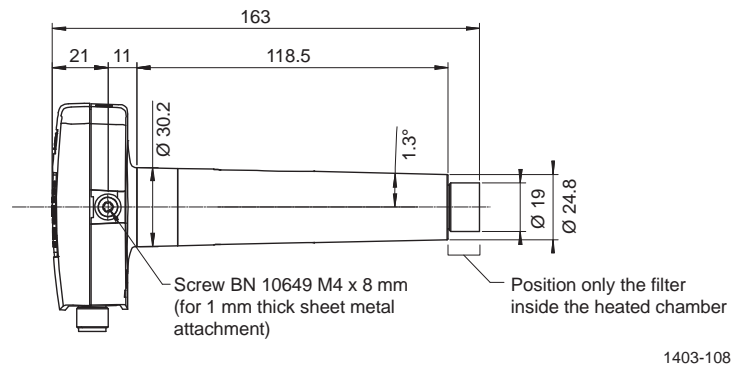
Figure 6   Probe Dimensions without Silicone Plug

1403-110
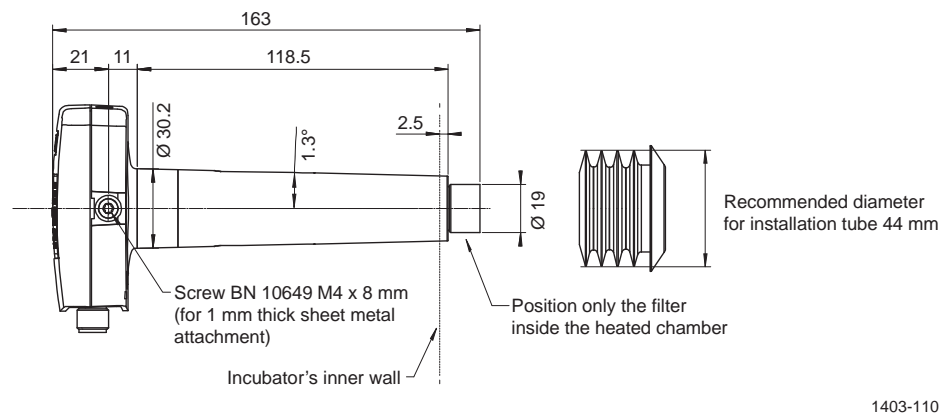
Figure 7   Probe Dimensions with Silicone Plug

1403-112
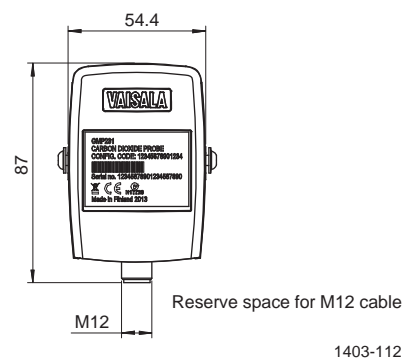
Figure 8   Electronics Housing Dimensions

1403-109
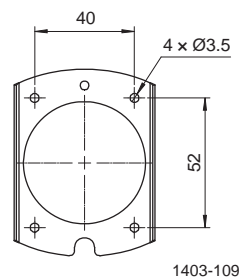
Figure 9   Attachment Bracket Dimensions

Recommended Installation

GMP231 is designed to be installed through a chamber wall, and attached to the chamber chassis using an attachment bracket and the two screw holes on the side of the probe. As the installation depth of the probe inside the chamber is critical (see section Probe Installation Depth on page 21), the mounting method must allow the probe to be positioned exactly.

NOTE	The probe and electronics housing must remain outside the heated chamber. The electronics housing should be in a ventilated space that is open to ambient air.

1403-123
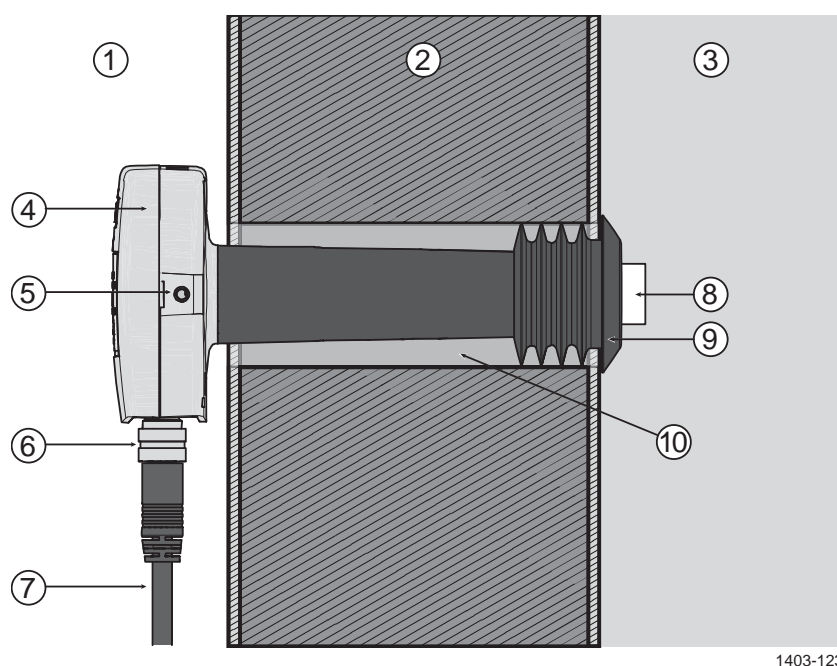
Figure 10   Recommended Installation
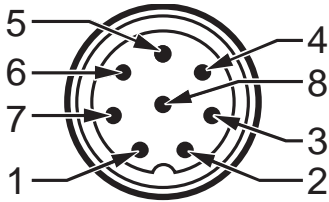
1 = Ambient air.
2 = Chamber wall.
3 = Chamber interior.
4 = GMP231 Electronics housing.
5 = M4 screw holes on both sides of the probe housing.
6 = 8-pin M12 connector. For pinout, see section Wiring on page 24.
7 = Cable.
8 = CARBOCAP® sensor under PTFE filter. The filter must be inside the chamber completely.
9 = Silicone plug. Insert the plug over the probe from inside the chamber.
10 = Ø 44 mm installation tube through the chamber wall.
       The diameter is important for proper sealing by the silicone plug.

Wiring

GMP231 provides several outputs you can use. Connect the output pins you need, and the power supply and ground pins. Use a shielded cable, and connect the shield to the chassis of the GMP231's M12 connector, and to ground on the other side.
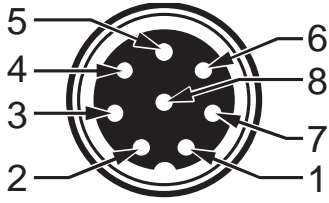
Ground pin 5 to put the probe in standby mode (stops CO_2 measurement). The probe resumes normal measurement operation when pin 5 is no longer grounded, unless its internal measurement shows the temperature is too high.

Table 4   GMP231 Connector Pinout

Male 8-pin M12	Pin #	Function
	1	I^2C SDA
	2	RS-485 D-
	3	I^2C SCL
	4	Analog output +
	5	Standby
	6	RS-485 D+
	7	Power supply +
	8	Ground
	-	Shield

Vaisala's standard connection cable for the GMP231 (order code DRW240977) is a 90 cm long cable with female 8-pin M12 connector on one end, and open ended wires on the other. It supports all outputs from the GMP231, and connects the cable shield to the connector chassis.

Table 5   Cable DRW240977

Female 8-pin M12	Pin #	Function	Wire Color
	1	I^2C SDA	White
	2	RS-485 D-	Brown
	3	I^2C SCL	Green
	4	Analog output +	Yellow
	5	Standby	Gray
	6	RS-485 D+	Pink
	7	Power supply +	Blue
	8	Ground	Red
	-	Shield	Black

Power Supply

The supply voltage range of the GMP231 is 11 ... 30 VDC.
If the analog output is used, the supply voltage range is 20 ... 30 VDC.

The maximum power consumption is 1 W.

CHAPTER 4
VAISALA INDUSTRIAL PROTOCOL

This chapter describes the Vaisala Industrial Protocol implementation of the GMP231.

Overview

RS-485 line of the GMP231 provides an implementation of the Vaisala Industrial Protocol that can be used for service and configuration use, or for interfacing with the incubator's control system. 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 3-wire interface. The data lines are RS-485 D- and RS-485 D+. Ground is shared with power supply.

The connector is an 8-pin male M12. For connector pinout and wiring information, see section Wiring on page 24.

Connecting with a Computer

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

When connecting using a computer, use the Vaisala USB cable (Vaisala order code 221040) and a suitable terminal application:

- If you have not used the Vaisala USB cable before, install the driver before attempting to use the cable. Refer to section Installing the Driver for the USB Service Cable below for detailed instructions.
- For more information on using a terminal application, see section Terminal Application Settings on page 27.

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.
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 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.

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.

5. Click the **Open** button to open the connection window and start using the serial line.

NOTE	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.

6. You may need to adjust the **Local echo** setting in the **Terminal** category to see what you are typing on the serial line. To access the configuration screen while a session is running, click the right mouse button over the session window, and select **Change Settings...** from the pop-up menu.
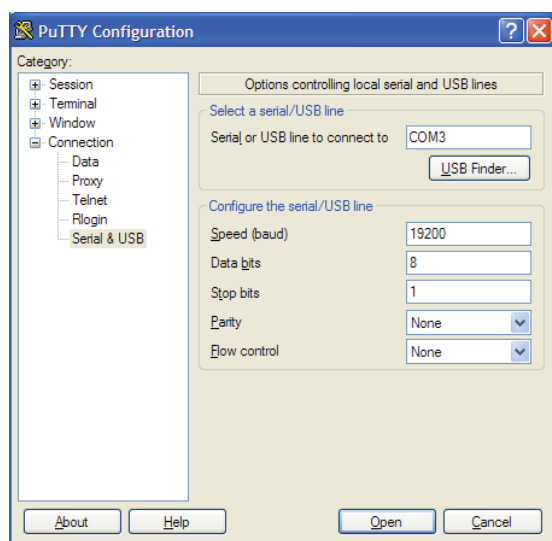
0807-004

Figure 11   PuTTY Terminal Application

Serial Commands

All commands can be issued either in uppercase or lowercase. In the command examples, the keyboard input by the user is in **bold** type.

The notation <cr> refers to pressing the carriage return (**Enter**) key on your computer keyboard. Enter a <cr> to clear the command buffer before starting to enter commands.

Table 7   Basic Serial Commands

Command	Description
?	Show probe information.
CLOSE	Close connection to probe (POLL mode)
ECHO	Show or set remote echo mode.
ENV	Show or set environmental parameters.
ERRS	Show currently active errors.
FORM [modifier string]	Show or set output format.
HELP	Show list of currently available serial commands.
INTV [0 ... 9999 s/min/h]	Set continuous output interval for R command.
OPEN [address]	Open connection to probe in POLL mode
PASS [1300]	Access advanced serial commands.
R	Start the continuous outputting.
RESET	Reset the probe.
S	Stop the continuous outputting.
SDELAY [0 ... 255]	Show or set serial line transmission delay in milliseconds.
SEND	Output measurement message once.
SERI [baud data stop parity]	Show or set the serial interface settings
SMODE [mode]	Show or set startup serial mode: RUN, STOP, or POLL.
SNUM	Show probe serial number.
STANDBY [on/off]	Standby mode on/off (turn off measurement)
SYSTEM	Show probe firmware information
TIME	Show probe operation hours and uptime
VERS	Show probe firmware version.

Table 8   Advanced Serial Commands

Command	Description
ADDR [0 … 254]	Show or set probe address.
AMODE	Show or set analog output mode.
AOVER	Show or set analog output overrange and clipping behavior.
ASEL	Show or set analog output parameter.
ATEST	Test analog putput.
CCO2	Adjust CO_2 measurement gain and offset.
CDATE	Show or set calibration date.
CP	Adjust pressure measurement offset.
CT	Adjust temperature measurement offset.
CTEXT	Show or set calibration information.
FRESTORE	Restore probe to factory settings.
O2CMODE	Show or set oxygen compensation mode.
PCMODE	Show or set pressure compensation mode.
RHCMODE	Show or set humidity compensation mode.
TCMODE	Show or set temperature compensation mode.

Showing Device Information

Show Probe Information

The **?** command outputs a listing of probe information.

?<cr>

Command **??** is a similar command that is designed to be used if the probe is in POLL mode but its address is unknown. The probe will respond to the **??** command even while in POLL mode. Do not use the **??** command if you have more than one probe on an RS-485 line.

Example:

```
?
Device              : GMP231
Copyright           : Copyright (c) Vaisala Oyj 2013. All rights reserved.
SW Name             : GMP231
SW version          : 1.0.1.1537
Snum                : J1320082
Calibrated          : 2014-03-11
Address             : 1
Smode               : STOP
```

Show Serial Number

SNUM<cr>

Example:

```
snum
Serial number      : J1320082
```

Show Firmware Version

VERS<cr>

Example:

```
vers
GMP231 / 1.1.0.1537
```

Show Firmware Information

SYSTEM<cr>

Example:

```
system
Device Name        : GMP231
SW Name            : GMP231
SW version         : 1.1.0.1537
```

Show Probe Uptime

Use the **TIME** command to show how long the probe has been in operation, and what is the current uptime since last reset (in seconds). The operation counter is in format ddddd:hh:mm:ss. Full days and hours are retained in the counter, minutes and seconds are cleared at reset.

TIME<cr>

Example (cumulative uptime 23 hours, 56 minutes, and 49 seconds, uptime since last reset 3409 seconds):

```
time
00000:23:56:49 Up time: 3409 s
```

Show Command List

Use the **HELP** command to show a list of the currently available serial commands.

HELP<cr>

Example (shows basic commands, advanced commands are not enabled):

```
CLOSE
ECHO
ENV
ERRS
FORM
HELP
INTV
PASS
R
RESET
S
SDELAY
SEND
SERI
SMODE
SNUM
STANDBY
SYSTEM
TIME
VERS
```

Serial Line Output Commands

Start Measurement Output

Use the **R** command to start the continuous outputting of measurement values as an ASCII text string to the serial line.

R<cr>

Example (measurement message in default format):

```
r
CO2=  490 ppm
CO2=  490 ppm
CO2=  491 ppm
CO2=  491 ppm
CO2=  491 ppm
...
```

The probe keeps outputting measurement messages at the interval that has been set **INTV** command until stopped.

Stop Measurement Output

You can stop the measurement output by pressing the **ESC** key or with the **S** command.

Set Output Interval

Use the **INTV** command to change the output interval of the automatically repeating measurement messages. The measurement messages are repeated in the RUN mode, or after the **R** command has been given.

INTV [*n xxx*]<cr>

where

n	=	time interval, range 0 ... 255
xxx	=	time unit = "S", "MIN", or "H"

The shortest output interval (with n = 0) outputs the measurement messages as quickly as the probe's internal measurement cycle produces them, without additional delay.

Example:

```
intv 5 s
Output interval    : 5 S
```

Output a Reading Once

Use the **SEND** command to output a single measurement message.

SEND<cr>

Example:

```
send
CO2=  1702 ppm
```

Set Measurement Output Format

Use the serial line command **FORM** to change the measurement message sent by the probe. You can freely define the output message to include the desired parameters, formatting options, text strings, and additional fields.

FORM [*modifier string*]<cr>

where

modifier string = String of parameters and modifiers that defines the output format, length 1 ... 150 characters. See Table 9 and Table 10 below. Maximum length may be shorter when text strings are used.

You can return to the default format using the "**FORM /**" command.

Table 9   FORM Command Parameters

Measured 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 10   FORM Command Modifiers

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	Shows the 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

FORM Command Examples

Example of default output (continuous output from RUN mode):

```
CO2=    860 ppm
CO2=    861 ppm
CO2=    861 ppm
...
```

Command to set output format as %CO_2:

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

Output example:

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

Command to set output format as CO_2 ppm with Modulus-65536 checksum:

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

Output example:

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

Command to 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
```

Output example (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
...
```

Changing Measurement Settings

Set Compensation Modes

You can change the mode of each environmental compensation type using a dedicated serial command. The commands are:

- **PCMODE** for pressure compensation mode.
- **TCMODE** for temperature compensation mode.
- **O2CMODE** for oxygen compensation mode.
- **RHCMODE** for relative humidity compensation.

Command syntax is as follows:

PCMODE [*on* | *off* | *measured*]<cr>

TCMODE [*on* | *off* | *measured*]<cr>

O2CMODE [*on* | *off*]<cr>

RHCMODE [*on* | *off*]<cr>

where

on	=	Compensation enabled using setpoint value.
off	=	Compensation disabled, neutral value used.
measured	=	Compensation enabled using internal measurement. Available only for pressure and temperature compensations.

Example (check temperature compensation mode):

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

Example (change temperature compensation mode to use internal measurement):

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

Change Compensation Setpoint Values

Use the **ENV** command to show or set the setpoint values of the environmental compensation parameters. To change a value, give the parameter name and value as arguments to the **ENV** command.

ENV [*temp*/*pres*/*oxy*/*hum*/*xtemp*/*xpres*/*xoxy*/*xhum*] [*value*]<cr>

There are four compensation parameters. Values of the parameters are stored in two places: eeprom (non-volatile memory, values retained during power off) and RAM (volatile memory that loses the values when probe is reset, and where values are loaded from non-volatile memory at startup). As the number of writes to eeprom is limited to 30000 cycles by memory implementation, you must write all continuously updated values to RAM to avoid wearing out the eeprom. A second set of parameters (with X prefix in the name) is provided for this purpose.

When writing permanent values to eeprom, use these parameter names. Note that updating these parameters does not update the parameters in RAM (the values that are currently used by the probe).

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%.

When writing to RAM, use the parameter names below. The ranges are the same as for the permanent parameters.

xtemp   =   Compensation temperature that is stored in RAM.
xpres   =   Compensation pressure that is stored in RAM.
xoxy   =   Oxygen content of background gas that is stored
                      in RAM.
xhum   =   Relative humidity of background gas that is stored
                      in RAM.

Example (Show current compensation values; all compensations are enabled. Note that temperature and pressure compensations use internal measurement, so the value in use is constantly changing):

```
env
Temperature (C)       : 37.00
Pressure (hPa)        : 1013.20
Oxygen (%O2)          : 19.70
Humidity (%RH)        : 93.00

In use:
Temperature (C)       : 23.10
Pressure (hPa)        : 1011.28
Oxygen (%O2)          : 19.70
Humidity (%RH)        : 93.00
```

Example below sets temperature compensation to setpoint mode, and changes temperature setpoint value to 37.2 in RAM.

```
pass 1300
tcmode on
T COMP MODE         : ON
env xtemp 37.2
In eeprom:
Temperature (C)     : 37.00
Pressure (hPa)      : 1013.20
Oxygen (%O2)        : 19.70
Humidity (%RH)      : 93.00

In use:
Temperature (C)     : 37.2
Pressure (hPa)      : 1013.20
Oxygen (%O2)        : 19.70
Humidity (%RH)      : 93.00
```

NOTE	If temperature and pressure compensations are configured to use internally measured values, they will continuously update the values in RAM, overriding any temperature and pressure values that are written to RAM with the ENV command.

Set Measurement to Standby Mode

Use the **STANDBY** command to set the probe to standby mode. In standby mode, the CO_2 measurement is disabled. Probe returns to the normal measurement when the command **STANDBY OFF** is given or the probe is reset.

STANDBY [*on* / *off*]<cr>

Example (enable standby mode):

```
standby on
Standby mode        : ON
```

Configuring Serial Line Operation

Set Serial Line Operating Mode

Use the **SMODE** command to set the start-up operating mode of the serial line.

SMODE [*mode*]<cr>

where

mode   =   STOP, RUN, or POLL.

Table 11   Selection of Output Modes

Mode	Measurement Output	Available Commands
STOP	Only with the **SEND** command.	All (default mode).
RUN	Automatic output.	Only command **S.**
POLL	Only with the **SEND** [*addr*] command.	**SEND** [*addr*] and **OPEN** [*addr*]. Other commands available after opening a line to the probe using the **OPEN** command. Use with RS-485 buses where multiple probes can share the same line.

Selected output mode will be activated at next reset or power up.

Example:

```
smode poll
Serial mode   :     POLL
```

Set Serial Line Settings

Use the **SERI** command to set the serial line settings. The new settings will be taken into use when the probe is reset or powered up.

SERI [*b p d s*]<cr>

where

b = baud rate (9600, 19200, or 19200)
p = parity (n = none, e = even, o = odd)
d = data bits (7 or 8)
s = stop bits (1 or 2)

Example (shows default 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):

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

Set Probe Address

Use the **ADDR** command to set the device address of the probe. Addresses are required for POLL mode.

ADDR [*aaa*]<cr>

where

aaa = Device address of the probe, range 0 ... 254 (default = 0)

Example (change probe address to 52):

```
pass 1300
addr 52
Address              : 52
```

Set Serial Line Response Time

With the **SDELAY** command you can set delay (response time) of the serial line, or view the currently set delay value.

SDELAY [*delay*]<cr>

where

delay   =   Serial line delay, range 0 … 255 (milliseconds).

Example (set delay to 50 milliseconds):

```
sdelay 50
Serial delay  :       50
```

Set Serial Line Echo

Use the **ECHO** command to enable or disable the echoing of characters received by the probe.

ECHO [*on/off*]<cr>

Example:

```
echo
Echo              : OFF
```

Calibration Commands

NOTE	Before calibrating GMP231 using serial line commands, read the instructions in section Calibration and Adjustment on page 73.
	Make sure that the environmental compensation settings of the GMP231 are properly set for your calibration environment; see section Changing Measurement Settings on page 35.

Adjust CO$_2$ Measurement

Use the **CCO2** command to adjust CO$_2$ measurement in one or two points. You can use either a low or high concentration reference (one-point adjustment), or both (two-point adjustment).

The idea is to let the probe stabilize in the desired CO$_2$ concentration, and then input the real CO$_2$ concentration using the **CCO2** command. If you are performing a two-point correction, repeat for the second point. Then commit the adjustment by giving the **CCO2 –SAVE** command. Note that 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 [*-lo* / *-hi*] [*co2*] <cr>

CCO2 [*-save* / *-cancel*]<cr>

CCO2 [*-reset*]<cr>

where

-lo	=	Select low concentration for adjustment. Adjusts measurement offset.
-hi	=	Select high concentration for adjustment. Adjusts measurement gain.
co2	=	CO$_2$ concentration reference in ppm.
-save	=	Save currently entered adjustments.
-cancel	=	Cancel currently entered adjustments.
-reset	=	Clear user adjustments, set Gain to 1 and offset to 0.

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 low   200000
2.Meas. point low  200000
Gain           : 1.0000
Offset         : 0.0000
```

Example (one-point adjustment in 5% concentration (50000 ppm)):

```
pass 1300
cco2 –lo 50000
OK
cco2 –save
OK
```

Set Calibration Date

Use the **CDATE** command to view the date when the probe was last calibrated, or set a new date.

CDATE [*yyyy mm dd*]<cr>

where

yyyy = Year of calibration in four digits
mm = Month of calibration in two digits
dd = Day of calibration in two digits

Example (show currently stored calibration date):

```
>pass 1300
>cdate
Calibration date   : 2013-10-03
```

Example (set calibration date to 2014-03-10):

```
>pass 1300
>cdate 2014 03 10
Calibration date   : 2014-03-10
```

Set Calibration Info Text

Use the **CTEXT** command to view or set calibration information text.

CTEXT [*text*]<cr>

where

text   =   Calibration information text string, max 19 characters. If you want to use spaces in the string, enclose the text in quotes.

Example (shows the text "Calibrated at" followed by the currently stored calibration text):

```
pass 1300
ctext
Calibrated at Vaisala
```

Example (set calibration text to "Lab_1"):

```
pass 1300
ctext Lab_1
Calibrated at Lab_1
```

Adjust Temperature Measurement

Use the **CT** command to perform an offset correction to the internal temperature measurement. The correction is done by providing the correct temperature as an argument to the **CT** command.

CT [*temp*]<cr>

CT [*-reset*]<cr>

where

temp   =   Correct temperature in degrees Celsius (°C).

Example (adjust the internal temperature measurement to 23 °C at the current conditions):

```
pass 1300
ct 23
OK
```

Example (clear the offset adjustment from internal temperature measurement):

```
pass 1300
ct -reset
OK
```

Adjust Pressure Measurement

Use the **CP** command to perform an offset correction to the internal pressure measurement. The correction is done by providing the correct pressure as an argument to the **CP** command.

CP [*pressure*]<cr>

CP [**-***reset*]<cr>

where

pressure = Correct pressure in hectopascals (hPa).

Example (adjust the internal pressure measurement to 990 hPa at the current conditions):

```
pass 1300
cp 990
OK
```

Example (clear the offset adjustment from internal pressure measurement):

```
pass 1300
cp -reset
OK
```

Configuring Analog Output

Set Analog Output Scaling

Use the **ASEL** command to show or set the scaling of the analog output.

ASEL [*channel*] [*parameter lowlimit highlimit*]<cr>

where

channel   = Analog output channel, only 1 can be selected.
parameter = Parameter that is output on analog channel.
                 Only parameter available is CO2.
lowlimit   = Lower limit of channel scaling in ppm.
highlimit = High limit of channel scaling in ppm.

Example (change channel scaling to 0 … 5%):

```
pass 1300
asel 1 co2 0 50000
Aout 1 quantity    : CO2(0 ... 50000)
```

Set Analog Output Mode

Use the **AMODE** command to set the analog output limits and error level.

AMODE [*channel lo_value hi_value error_value*]<cr>

where

channel   = Analog output channel, only 1 can be selected.
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 (mA)    :4.00 ... 20.00 (error :21.00)
```

Example (set channel to 4 … 20 mA, and error level to 3.6 mA):

```
pass 1300
amode 1 4 20 3.6
Aout 1 range (mA)    :4.00 ... 20.00 (error : 3.60)
```

Set Analog Output Clipping and Error Limit

Use the **AOVER** command to define the behavior of the analog output when the measured value is outside the scaled output range.

AOVER [*channel clip% valid%*]<cr>

where

channel = Analog output channel, only 1 can be selected.
clip% = Output margin (%) at which the output is clipped.
valid% = Output margin (%) at which the output of the channel goes into the error state. The error state is defined using the **AMODE** command, see section Set Analog Output Mode on page 45.

For example, first check the analog output settings using **ASEL**, **AMODE**, and **AOVER** commands:

```
pass 1300
asel 1
Aout 1 quantity     : CO2(0 ... 50000)

amode 1
Aout 1 range (mA)    :0.00 ... 20.00 (error : 23)

aover 1
Aout 1 clipping     :10.00 %
Aout 1 error limit  :10.00 %
```

Now give the following **AOVER** command:

```
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%, meaning the output is allowed to vary between 0 ... 21 mA. The analog channel will output the measurement for 0 ... 52500 ppm, but range 0 ... 20 mA remains scaled to 0 ... 50000 ppm.
- Error limit is 10%, which means the output will show the error state (23 mA) when the measured value is 10% outside the scaled output range. With the settings above, this will happen if the measured CO_2 concentration is outside range 0 ... 55000 ppm.
- The output will never actually be between 21 mA and 23 mA because of clipping.

Test Analog Output

You can test the operation of the analog output with the **ATEST** command by forcing the output to a given value. You can then measure the output with a calibrated multimeter. After testing the output, use the **ATEST** command again to exit the test mode.

ATEST [*channel*] [*level*]<cr>

where

channel   =   Analog output channel, only 1 can be selected.
level   =   Level for analog output channel in mA.

Example (enable analog output test mode, set level to 20 mA):

```
pass 1300
atest 1 20
Aout 1 (mA)     :20.000
```

Example (disabling analog output test mode, resuming normal output):

```
atest 1
Aout 1 test mode disabled.
```

Other Commands

Enable Advanced Commands

Use the **PASS** command to enable advanced serial commands. Advanced commands can be used until the next reset.

PASS [*code*]<cr>

where

code   =   Code for enabling advanced commands (1300).

Example:

```
pass 1300
```

Connecting to Probe in POLL Mode

Use the **OPEN** command to connect to a probe that is in POLL mode.

OPEN [*address*]<cr>

where

address = Probe address, range 0 ... 254.

Example (target probe in POLL mode, with address 52):

```
open 52
GMP231:  52 Opened for operator commands
```

Closing the Connection to a Probe in POLL Mode

The **CLOSE** command closes the connection to a probe.

CLOSE<cr>

Example:

```
close
line closed
```

Show Active Errors

Use the **ERRS** command to display probe error messages. The possible errors and their identifying numbers correspond to content of the status word of the I^2C interface. See section Status Word on page 57.

ERRS<cr>

Example (showing normal status, no active errors):

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

Example (showing probe in standby mode, no active errors):

```
errs
NO CRITICAL ERRORS
NO ERRORS
NO WARNINGS
STATUS 25              : Device in standby mode (set by user)
```

Reset Probe

Use the **RESET** command to reset the probe.

RESET<cr>

When the **RESET** command is given, the probe will restart as if it had just been powered on.

Restore Factory Settings

Use the **FRESTORE** command to restore the probe to its factory configuration. All user settings will be lost.

FRESTORE<cr>

NOTE	After using the **FRESTORE** command, reset the probe using the **RESET** command.

Example:

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

GMP231 - Version 1.1.0
Vaisala Oyj 2012 - 2014
```

CHAPTER 5
I²C INTERFACE

This chapter describes the I²C interface implementation of the GMP231.

Overview

GMP231 has an inter-integrated circuit (I²C) interface for interfacing with the incubator's control computer. GMP231 implements I²C slave functionality, with the incubator's computer acting as the master. The interface can be used to read measurement values and status information, set operation parameters, and make adjustments.

Physical Interface

The physical interface is a non-isolated 3-wire interface. Wires are SDA, SCL and ground. SDA and SCL lines are buffered. Ground is shared with power supply. There are small pull-up resistors for SCL and SDA. Connector is 8 pin male M12. Maximum cable length should not exceed 5 m and maximum capacitance between communication lines and ground should not exceed 500 pF.

For connector pinout and wiring information, see section Wiring on page 24.

1403-149
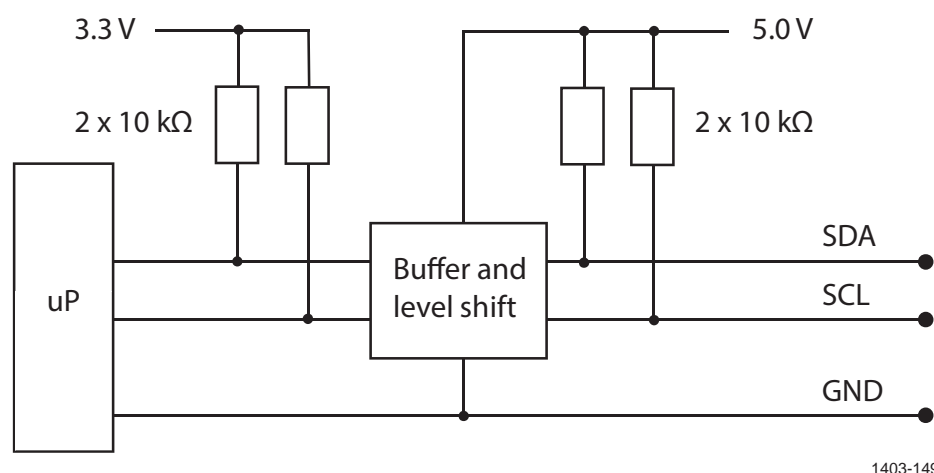
Figure 12   Hardware Schematic

Communication Parameters

GMP231 supports maximum 50 kHz clock speed. Protocol bits are sent most significant bit (MSB) first. Parameter bytes are sent using little endian order.

Addressing

GMP231 uses 7-bit addressing. The address consists of:

- 4-bit device type identifier part (default "0001" for GMP231)
- 3-bit sub address (default "001")

The full 7-bit default address is "0001001" (09h). In I^2C communication, the address should be provided by the master in the standard way after the I^2C start condition, with the read/write bit as the least significant bit (LSB).

Table 12   GMP231 I^2C Address

0	0	0	1	0	0	1	R/W
Device type				Sub-address			Read/write bit (LSB)

The I^2C implementation of the GMP231 also includes the address inside the message frame. The purpose of this is to make the I^2C implementation easier, since the I^2C address can be lost by the I^2C hardware. This address is provided without the read/write bit, with zero as the MSB.

Table 13   GMP231 Device Address

0	0	0	0	1	0	0	1
MSB	Device type				Sub-address		

NOTE	Make sure there are no addressing conflicts if other I^2C devices are put on the same bus. The GMP231 address can be changed, see Table 40 on page 67.

Communication Flow

Basic communication flow always includes I^2C write and read commands. First the master writes a command to the slave device, and then the master reads the results of that command from the slave.

When the master reads data from the slave, there is an ACK/NACK-bit in the status byte that informs the master whether or not communication was success. ACK is defined as zero and NACK is defined as one in the logical level.

NOTE	This ACK/NACK refers to the message level acknowlegdement. I^2C protocol includes a separate byte level acknowledgement.

Command messages sent by the master are called **invokes**. Replies sent by the slave are called **responses**. Note that also responses include the device address.

Table 14   Invoke Message in GMP231 I^2C Interface

Message Segment	Length	Content
Start		I^2C start condition.
I^2C address	1 byte	See Table 12 on page 51.
Command	1 byte	Identifier of command.
Device address	1 byte	See Table 13 on page 51.
Frame length	1 byte	Length of invoke message in bytes (excluding I^2C address, including CRC). Minimum invoke frame length is 5 bytes.
Data	Variable length	Content and length depending on the command. May be left out if the command contains no data in the invoke message.
Checksum	2 bytes	See section Checksum on page 56.
Stop		I^2C stop condition

Table 15   Response Message in GMP231 I^{2}C Interface

Message Segment	Length	Content
Start		I^{2}C start condition.
I^{2}C address	1 byte	See Table 12 on page 51.
Status	1 byte	See section Status Byte on page 56.
Command	1 byte	Identifier of command that was used in the invoke that the slave is responding to. If the slave is in Idle state (no valid invoke), the command code is FFh.
Device address	1 byte	See Table 13 on page 51.
Frame length	1 byte	Length of response message in bytes (excluding I^{2}C address, including CRC). Minimum response frame length is 6 bytes.
Data	Variable length	Content and length depending on the command.
Checksum	2 bytes	See section Checksum on page 56.
Stop		I^{2}C stop condition

GMP231 State Machine

The main and initial state of the GMP231 is Idle, and it will change to WaitResponse state only when a valid invoke is received. In the WaitResponse state, the GMP231 expects to see an I^{2}C read operation from the master. After seeing a read operation ,the GMP231 outputs its response with ACK/NACK and status signals.

If GMP231 is in WaitResponse state and master sends a new invoke, the GMP231's response to the previous invoke is lost. When the master sends the next I^{2}C read command, the GMP231 sends it the response to the latest invoke.

If GMP231 is in Idle state and the master sends an I^{2}C read, GMP231 responds with a NACK-signal. This tells the master that the data which the master may have received in same I^{2}C read is not valid.

If the GMP231 receives an invalid invoke, it goes to the Idle state. An invoke message can be invalid because of an unknown command, erroneous CRC, or invalid message length.
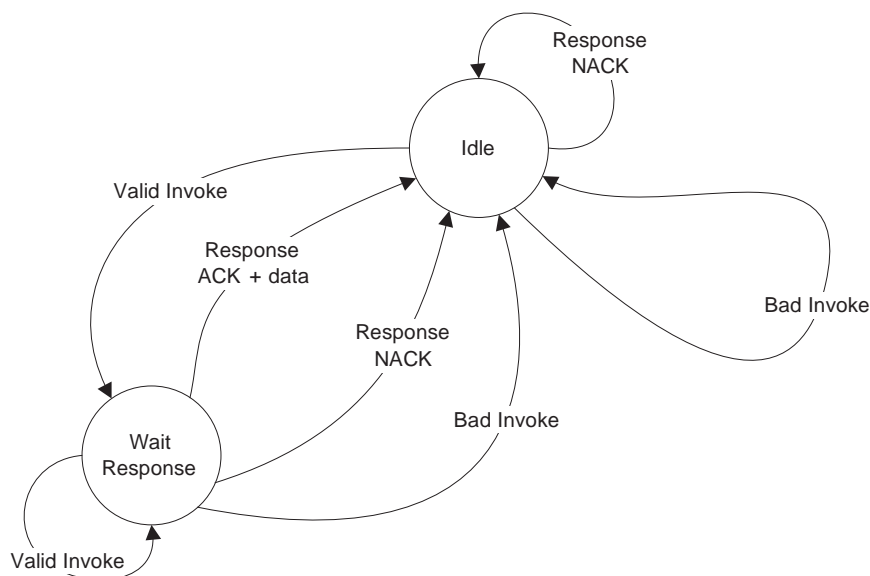
1403-146

Figure 13   GMP231 State Machine

Examples of Communication Flow

The basic data transfer communication flows are presented in the figures below. Each arrow represents an I^2C read or write operation The examples are simplified presentations. For actual message content, see section Commands on page 58.

For example, Figure 14 below shows the following message sequence:

1.   The master invokes the Get_Parameter command to read the CO_2 parameter using an I^2C write operation. This command prepares the slave to wait for a read operation from the master.

2.   The master begins an I^2C read operation to read the results of the Get_Parameter CO2 command. The slave sends the requested CO_2 result and an ACK signal to the master.
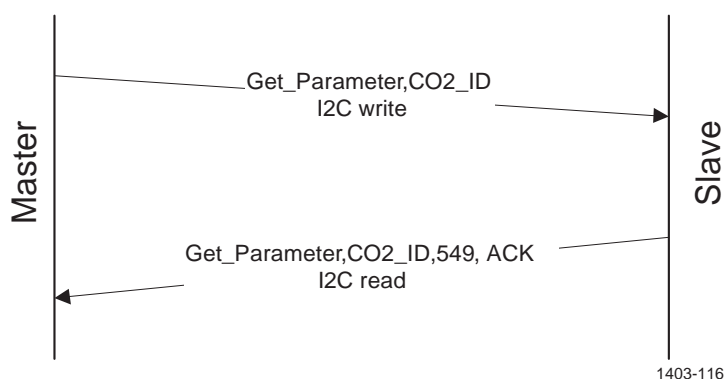
1403-116

Figure 14   Get_Parameter with ACK
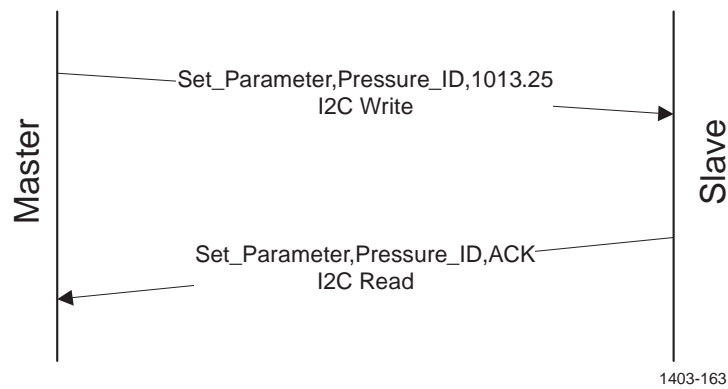
Figure 15   Set_Parameter with ACK
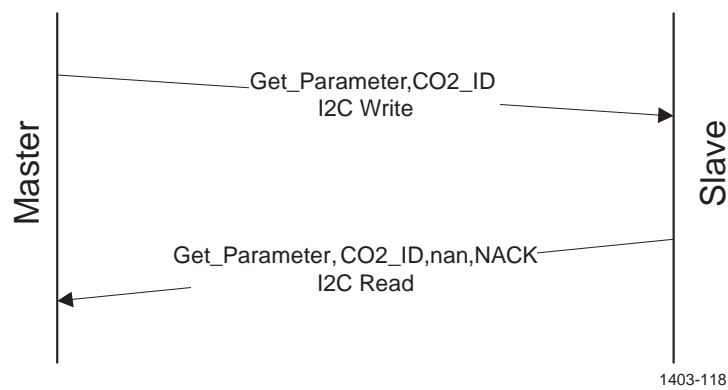
Figure 16   Get_Parameter with NACK
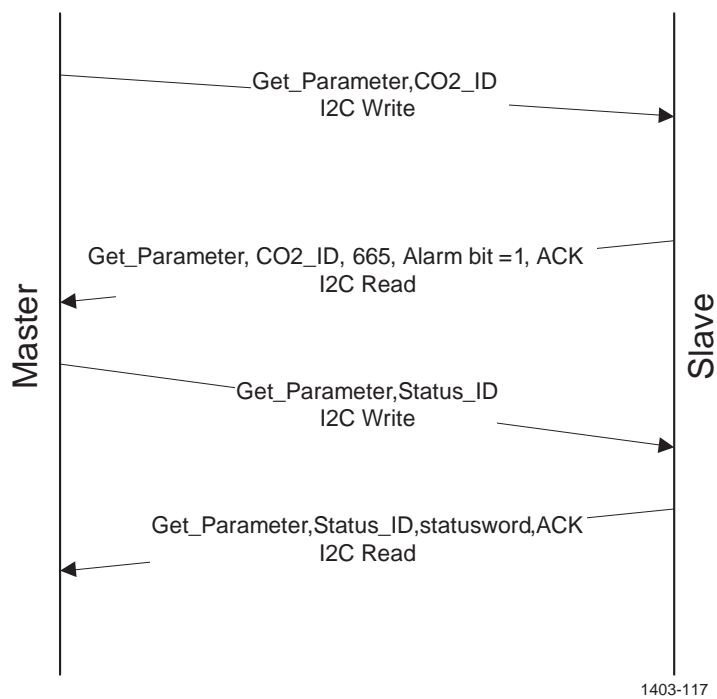
Figure 17   Get_Parameter with Alarm

NOTE	The alarm can be any of the state bits in the status byte.

Timing

The minimum time delay that the master must wait between the invoke and response messages depends on the operation. If the operation includes a write to the non-volatile memory, it takes more time than other operations.

Table 16   Timing

Operation	Minimum delay
Normal delay between invoke and response	10 ms
Delay when write to non-volatile memory	300 ms

Status Byte

The status byte gives the master device information about the slave device's state, and information about the communication status with the ACK/NACK bit.

The status byte has bits for signaling Status, Warning, Error and Critical error statuses. These bits are cleared when the status word is read. Bits are set when the corresponding status or error state changes in the slave device.

Table 17   Status Byte

Bit#	Description
0	ACK/NACK
1	Critical error
2	Error
3	Warning
4	Status
5	
6	
7	

Checksum

GMP231 uses a CRC16-CCITT checksum in its protocol frame. CCITT (x.25) polynomial is $X^{16}+X^{12}+X^5+1 = 11021h$. Initial value is 0000h and the final value is XORed with FFFFh. The checksum uses a bit reversed algorithm.

When the invoke message is received, the checksum is calculated using bytes from the command byte to the last byte of the data field. The checksum needs to be valid before data can be accepted. If the checksum is not valid, the message is rejected and the internal state of the GMP231 is set to Idle.

When the response message is transmitted, the checksum is calculated using bytes from the status byte to the last byte of the data field.

Status Word

The status word is used to monitor the status of the GMP231 device. It can be read in the same way as any other slave parameter. The status word is used as a 32-bit long bit field, where each bit represents a state of some error or other essential status.

Changes in the status word bits can be monitored by reading the status byte. See section Status Byte on page 56.

Table 18   Status Word Content

Bit#	Type	Purpose
0	Critical Error	Program memory corrupted (CRC error)
1	Critical Error	Parameter memory corrupted (CRC error)
2	Error	Low IR current
3	Error	
4	Error	Low supply voltage
5	Error	Internal 30V voltage error
6	Error	Low input (RX) signal
7	Error	Internal 8V voltage error
8	Error	Too high input (RX) signal (ADC dynamic range)
9	Error	Pressure sensor communication error
10	Error	Pressure sensor out of range
11	Error	Incubator temperature too high for operation
12	Error	CO_2 measurement out out range
13	Error	Sensor heater error
14	Error	IR source temperature error
15	Warning	
16	Warning	
17	Warning	
18	Warning	
19	Warning	
20	Warning	Low input signal
21	Status	
22	Status	
23	Status	
24	Status	
25	Status	
26	Status	
27	Status	
28	Status	
29	Status	
30	Status	
31	Status	

Commands

Get_Interface_Version

Get_Interface_Version command (ID 80h) reads the interface version information. This command is recommended for verifying version compatibility before reading or writing parameters.

Table 19   Get_Interface_Version Invoke Message

Message Segment	Length	Content
I^{2}C address	1 byte	I^{2}C address (write)
Command ID	1 byte	Always 80h
Device address	1 byte	See Table 13 on page 51
Frame length	1 byte	Always 05h
Checksum	2 bytes	See section Checksum on page 56

Table 20   Get_Interface_Version Response Message

Message Segment	Length	Content
I^{2}C address	1 byte	I^{2}C address (read)
Status	1 byte	See section Status Byte on page 56
Command ID	1 byte	Always 80h
Device address	1 byte	See Table 13 on page 51
Frame length	1 byte	Always 0Ah
Data	1 byte	Device version
	1 byte	Protocol frame version
	1 byte	Command set version
	1 byte	Parameter set version
Checksum	2 bytes	See section Checksum on page 56

Get_Parameter

Get_Parameter command (ID 81h) reads parameter values. You can use it to read both measurement results and operational parameters. If the master tries to read more bytes than message size, the slave sends FFh bytes.

Table 21   Get_Parameter Invoke Message

Message Segment	Length	Content
I^{2}C address	1 byte	I^{2}C address (write)
Command ID	1 byte	Always 81h
Device address	1 byte	See Table 13 on page 51
Frame length	1 byte	Always 06h
Data	1 byte	ID of parameter to be read
Checksum	2 bytes	See section Checksum on page 56

Table 22   Get_Parameter Response Message

Message Segment	Length	Content
I^{2}C address	1 byte	I^{2}C address (read)
Status	1 byte	See section Status Byte on page 56. If requested parameter ID was unknown, NACK bit is set in the status byte.
Command ID	1 byte	Always 81h
Device address	1 byte	See Table 13 on page 51
Frame length	1 byte	Varies according to data length, 07h ... 39h.
Data	1 byte	ID of parameter
	1 ... 50 bytes	Value of parameter. If requested parameter ID is unknown, these data bytes are left out of the response.
Checksum	2 bytes	See section Checksum on page 56

Example: Read CO₂ Measurement Result

Table 23   Get_Parameter Invoke Message Example

Message Bytes (hex)	Content
12	I²C address
81	Get_parameter command
09	Device address
06	Frame length
0A	CO2 Parameter ID
AA	CRC high
9F	CRC lo

Table 24   Get_Parameter Response Message Example

Message Bytes (hex)	Content
13	I²C address
00	Status byte (no errors, ACK)
81	Get_parameter command
09	Device address
0B	Frame length
0A	CO2 Parameter ID
69	CO2 value 653.6314 ppm
68	
23	
44	
75	CRC high
7D	CRC lo

Set_Parameter

Set_Parameter command (ID 82h) writes parameter values to non-volatile memory. You can use it to set the operational parameters of the GMP231. Depending on the change, the functionality of the GMP231 may not change immediately.

The length of the invoke message varies depending on the data length. The master must write as many bytes as indicated in the frame length of the invoke message. If the master tries to write a longer or shorter message, GMP231 rejects the message.

Table 25   Set_Parameter Invoke Message

Message Segment	Length	Content
I^{2}C address	1 byte	I^{2}C address (write)
Command ID	1 byte	Always 82h
Device address	1 byte	See Table 13 on page 51
Frame length	1 byte	Varies according to data length, 07h ... 38h.
Data	1 byte	Parameter ID
	1 ... 50 bytes	Parameter value
Checksum	2 bytes	See section Checksum on page 56

Table 26   Set_Parameter Response Message

Message Segment	Length	Content
I^{2}C address	1 byte	I^{2}C address (read)
Status	1 byte	See section Status Byte on page 56.
Command ID	1 byte	Always 82h
Device address	1 byte	See Table 13 on page 51
Frame length	1 byte	Always 08h.
Data	1 byte	Parameter ID
	1 byte	Return code. See Table 27 below.
Checksum	2 bytes	See section Checksum on page 56

Table 27   Set_Parameter Return Codes

Code	Meaning
0	Ok
1	Unknown parameter ID
2	Not writeable parameter
3	Value field too long
4	Value field too short
5	Data value not accepted

Example: Set Compensation Temperature

Table 28   Example Set_Parameter Invoke Message

Message Bytes (hex)	Content
12	I^{2}C address
82	Set_parameter command
09	Device address
0A	Frame length
10	Parameter ID of compensation temperature
00	Temperature 37C
00	
14	
42	
0C	CRC high
6E	CRC lo

Table 29   Example Set_Parameter Response Message

Message Bytes (hex)	Content
13	I^{2}C address
04	Status byte (error active, ACK)
82	Set_parameter command
09	Device address
08	Frame length
10	Parameter ID of compensation temperature
00	Return code: Ok
D1	CRC high
CE	CRC lo

Get_Parameter_Info

Get_Parameter_Info command (ID 83h) reads the properties of a single parameter from the GMP231. The command is useful for adapting to parameters that have been added in a new software version. If the requested parameter ID is not valid, data type **Unknown Parameter ID** is returned.

Table 30   Get_Parameter_Info Invoke Message

Message Segment	Length	Content
I²C address	1 byte	I²C address (write)
Command ID	1 byte	Always 83h
Device address	1 byte	See Table 13 on page 51
Frame length	1 byte	Always 06h.
Data	1 byte	Parameter ID
Checksum	2 bytes	See section Checksum on page 56

Table 31   Get_Parameter_Info Response Message

Message Segment	Length	Content
I²C address	1 byte	I²C address (read)
Status	1 byte	See section Status Byte on page 56.
Command ID	1 byte	Always 83h
Device address	1 byte	See Table 13 on page 51
Frame length	1 byte	Always 12h.
Data	1 byte	Parameter ID
	1 byte	Parameter datatype. See Table 32 below.
	1 byte	Parameter length in bytes.
	1 byte	Parameter persistence. Describes if the parameter value is volatile (lost at reset) or non-volatile (survives reset). See Table 33 below.
	8 bytes	Parameter name. If name is shorter than 8 bytes, extra bytes are filled with 00h.
Checksum	2 bytes	See section Checksum on page 56

Table 32   Parameter Data Types

Code	Meaning
0	Unknown parameter ID
1	Byte
2	Integer (16-bit)
3	Unsigned Integer (16–bit)
4	Float (32-bit)
5	String

Table 33   Parameter Persistence

Code	Meaning
0	Void
1	Volatile
2	Non volatile

Adjust

Adjust command (ID 84h) controls the user adjustment sequence of CO_2 measurement.

Table 34   Adjust Invoke Message

Message Segment	Length	Content
I^{2}C address	1 byte	I^{2}C address (write)
Command ID	1 byte	Always 84h
Device address	1 byte	See Table 13 on page 51
Frame length	1 byte	Varies according to data length, 07h ... 0Bh.
Data	1 byte	Adjustment subcommand. See Table 36 below.
	1 byte	Parameter to be adjusted. See Table 37 below.
	4 bytes	Value of parameter. Used only with subcommands 2 and 3.
Checksum	2 bytes	See section Checksum on page 56

Table 35   Adjust Response Message

Message Segment	Length	Content
I^{2}C address	1 byte	I^{2}C address (read)
Status	1 byte	See section Status Byte on page 56.
Command ID	1 byte	Always 84h
Device address	1 byte	See Table 13 on page 51
Frame length	1 byte	Always 07h.
Data	1 byte	Return code. See Table 38 on page 65.
Checksum	2 bytes	See section Checksum on page 56.

Table 36   Adjustment Subcommands

Code	Adjustment operation
0	Start 1 point adjustment
1	Start 2 point adjustment
2	Record measured point 1, reference value is given in parameter
3	Record measured point 2, reference value is given in parameter
4	Cancel adjustment (previous adjustment is reverted)
5	End (adjustment is saved and new values are taken in use)
6	Revert to factory calibration (clear user adjustment)

Table 37   Adjustment Parameters

Code	Purpose
0	All parameters (valid with revert to factory calibration)
1	CO2

Table 38   Adjustment Return Codes

Code	Meaning
0	Ok
1	Function not supported
2	Sequence error
3	Recorded-Reference difference too large
4	2-point adjustment: Points too close
5	Given reference value is invalid

Adjusting Measurement

NOTE	Before implementing an adjustment sequence using the Adjust command, read the general instructions for calibration and adjustment in section Calibration and Adjustment on page 73.

Create the reference environment inside the chamber, and use the Adjust command to perform the adjustment sequence.

Adjustment can fail for a number of reasons. Refer to the list of return codes for the Adjust command in Table 38 above.

One Point Adjustment

To perform a one point adjustment of carbon dioxide (CO_2), measurement using I^2C protocol, you must perform the following sequence:

1.   Using the **Adjust** command, start 1 point adjustment for the chosen parameter.
2.   Place the sensor in the reference environment and wait until the measurement has stabilized.
3.   Using the **Adjust** command, record the measured point and give the reference value.
4.   Use the **Adjust** command to end the adjustment.

Two Point Adjustment

To perform a two point adjustment of CO_2 measurement using I^2C protocol, you must perform the following sequence:

1. Using the **Adjust** command, start 2 point adjustment for CO_2.
2. Supply the low concentration CO_2 reference gas to the sensor and wait for three minutes until the measurement has stabilized.
3. Using the **Adjust** command, record the first measured point and give the first reference value.
4. Supply the high concentration CO_2 reference gas to the sensor and wait for three minutes until the measurement has stabilized.
5. Using the **Adjust** command, record the second measured point and give the second reference value.
6. Use the **Adjust** command to end the adjustment.

Data Registers

The register table describes all available parameters and their properties. The properties are: parameter meaning, ID, name, data type, length and persistence. Persistence defines if the parameter is saved in eeprom (non-volatile memory) or in RAM. Make sure not to write excessively to the eeprom, as it has a maximum lifetime of approximately 30000 cycles.

Data Formats

Table 39   Data Formats

Data type name	Size (Bytes)	Other
Byte	1	Value range 0...255
Integer	2	Value range -32768...32767.
Unsigned integer	2	Value range 0…65535
Long integer	4	Value range −2,147,483,648…2,147,483,647
Unsigned long integer	4	Value range 0…4,294,967,295
Float	4	According to IEEE-754. Nan (7FC00000) is returned if no value is available.
String	Max. 50	All characters accepted (00h…FFh)

NOTE	Maximum string size refers to maximum communication buffer size. The actual reserved storage space for each parameter can be seen in Table 40 on page 67.

NOTE	Integers and floating point numbers are sent LSB first.

Register Table

Table 40   GMP231 Register Table

Meaning	Name	ID	Size (bytes)	Type	Read/ Write	Persistent	Other
Factory information							
Device address	ADDR	0	1	Byte	R	Yes	Default is 09h.
Device serial number	SNUM	1	12	Str	R	Yes	Example: A1234567
Sensor number	SSNUM	2	12	Str	R	Yes	Example: B1234567
Component board number	CBNUM	3	12	Str	R	Yes	Example: C1234567
Software version number	VERS	4	12	Str	R	Yes	Example: 1.2.3.4567
Factory adjustment date Year	ADATEY	5	2	Uint	R	Yes	Example: 2014
Factory adjustment date Month	ADATEM	6	1	Byte	R	Yes	Example: 3
Factory adjustment date Day	ADATED	7	1	Byte	R	Yes	Example: 29
General parameters and variables							
Device status word	STATUS	8	4	Str	R	No	See section Status Word on page 57.
CO2 measurement mode	CO2_MODE	9	1	Byte	R/W	Yes	0 = Standby mode. Measurement and probe heating is off 1 = Measurement on Note: Internal logic can override this setting
Final CO2 result	CO2	10	4	Float	R	No	ppm CO_2
Raw CO2 (uncompensated, unfiltered)	CO2_RAW	11	4	Float	R	No	ppm CO_2
Compensated CO2 (unfiltered)	CO2_COMP	12	4	Float	R	No	ppm CO_2
CO2 measurement filtering	CO2_FILT	13	1	Byte	R/W	Yes	Range 0 … 1, 0 = no filtering 1 = filtering (default)
Sensor heating	HEAT	14	1	Byte	R/W	Yes	Range 0…1 0 = no heating 1 = heating (default)

Meaning	Name	ID	Size (bytes)	Type	Read/ Write	Persistent	Other
Compensation settings							
Temperature compensation mode	TC_MODE	15	1	Byte	R/W	Yes	0 = Compensation off 1 = Use temperature setpoint value (default) 2 = Use Internal sensor temperature
Compensation temperature	T_COMP	16	4	Float	R/W	No	Celsius
Measured temperature (internal sensor)	T	17	4	Float	R	No	Celsius
Pressure compensation mode	PC_MODE	18	1	Byte	R/W	Yes	0 = Compensation off 1 = Use pressure setpoint value 2 = Use internal pressure sensor (default)
Compensation pressure	P_COMP	19	4	Float	R/W	No	hPa
Measured pressure (internal sensor)	P	20	4	Float	R	No	hPa
Humidity compensation mode	RHC_MODE	21	1	Byte	R/W	Yes	0 = Compensation off 1 = Use RH setpoint value (default)
Compensation Humidity	RH_COMP	22	4	Float	R/W	No	%RH
Oxygen compensation mode	O2C_MODE	23	1	Byte	R/W	Yes	0 = Compensation off 1 = Use oxygen concentration setpoint value (default)
Compensation Oxygen	O2_COMP	24	4	Float	R/W	No	%02
Adjustment settings							
Reference CO2 point 1	CO2_RP1	25	4	Float	R/W	Yes	ppm CO_2 0 ppm
Measured CO2 point 1	CO2_MP1	26	4	Float	R	Yes	ppm CO_2 0 ppm
Reference CO2 point 2	CO2_RP2	27	4	Float	R/W	Yes	ppm CO_2 20%
Measured CO2 point 2	CO2_MP2	28	4	Float	R	Yes	ppm CO_2 20%
Reference temperature point 1	T_RP1	29	4	Float	R/W	Yes	Celsius 0C
Measured temperature point 1	T_MP1	30	4	Float	R	Yes	Celsius 0C
Reference pressure point 1	PRE_RP1	31	4	Float	R/W	Yes	hPa 1013.25
Measured pressure point 1	PRE_MP1	32	4	Float	R	Yes	hPa 1013.25
Analog output settings							
Analog output mode	A_MODE	33	1	Byte	R/W	No	0 = Off (0 mA) 1 = Testmode 2 = Normal (default) 3 = Locked to latest value
Analog output test current	A_TC	34	4	Float	R/W	No	0 … 25 mA
Analog output error state current	A_EC	35	4	Float	R/W	Yes	0 … 25 mA
Analog output low end current	A_LC	36	1	Byte	R/W	Yes	0 = 0 mA 1 = 4 mA
Analog output scale low (0/4 mA)	A_LOW	37	4	Float	R/W	Yes	ppm CO2
Analog output scale high (20 mA)	A_HI	38	4	Float	R/W	Yes	ppm CO2

Meaning	Name	ID	Size (bytes)	Type	Read/ Write	Persistent	Other
Other							
Persistent compensation values (used if volatile values are not given)							
Compensation temperature	T_COMP2	39	4	Float	R/W	Yes	37 °C (default)
Compensation pressure	P_COMP2	40	4	Float	R/W	Yes	1013.25 hPa (default)
Compensation Humidity	RH_COMP2	41	4	Float	R/W	Yes	90 %RH (default)
Compensation Oxygen	O2_COMP2	42	4	Float	R/W	Yes	19.7 %O_2 (default)

CHAPTER 6
MAINTENANCE

This chapter provides information that is needed in the basic maintenance of the GMP231.

Cleaning

When correctly installed, the GMP231 is minimally exposed to contaminants in the chamber. There is little reason to perform cleaning other than normal chamber sterilization, and changing the filter and/or silicone plug if they appear contaminated. See the following sections for instructions:

- Changing the Filter on page 71.
- Changing the Silicone Plug on page 72.

The CARBOCAP® sensor of the GMP231 is well protected by the PTFE filter, and it can tolerate some dirt on the optics as the measurement is compensated for the reduction of signal.

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

Chemical Tolerance

GMP231 tolerates the following sterilization chemicals:

- DMSO
- IPA (70% Isopropyl Alcohol, 30% water)
- H_2O_2 (2000 ppm), non-condensing
- Ethanol
- Acetic acid

CAUTION	The electronics housing of the GMP231 is not sealed, so do not expose it to these chemicals. If necessary, you can clean the housing by wiping with a moist cloth.

Changing the Filter

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

1.   Pull the white PTFE filter away from the sensor. Rotating the filter slightly makes it easier to detach.
2.   Use clean instrument air to gently blow any loose dirt and filter material away from the sensor.
3.   Take a new clean filter and push it onto the sensor. If you are using the Vaisala silicone plug for sealing, push and rotate the filter slightly to make sure the filter reaches below the edge of the plug.
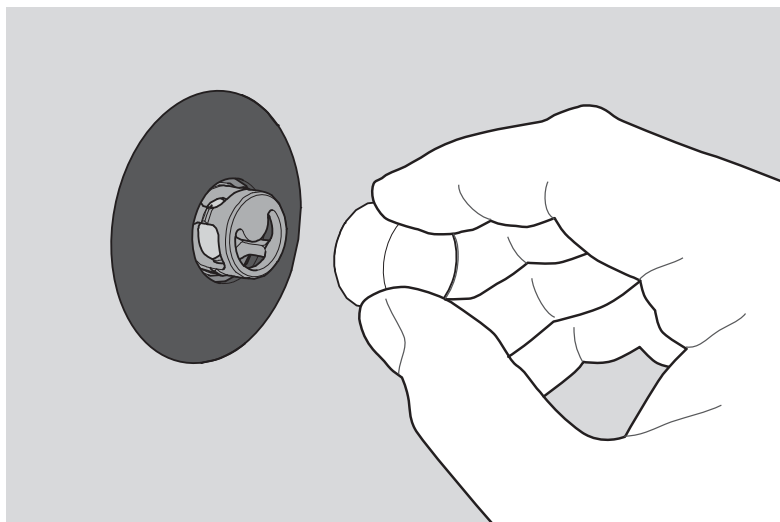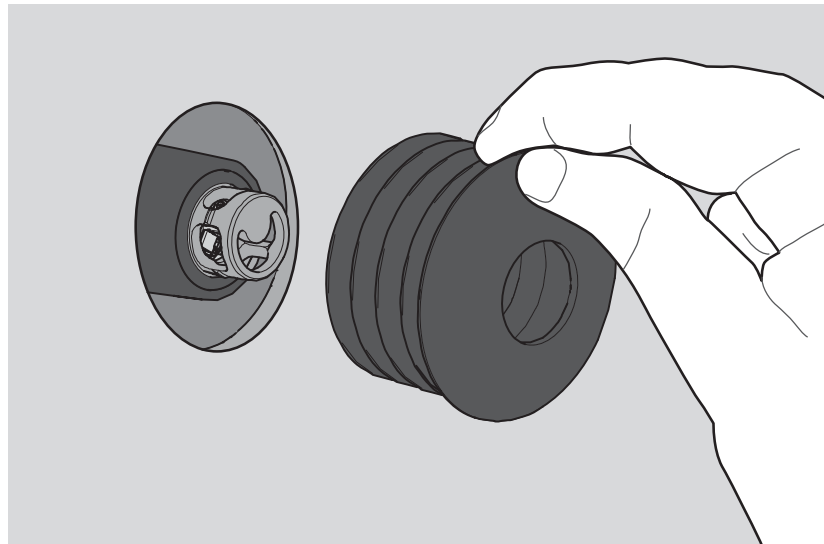

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Figure 18   Changing the Filter

Changing the Silicone Plug

Change the silicone plug if it shows visible signs of contamination. It is best to replace the filter also.

1. Pull the white PTFE filter away from the sensor. Rotating the filter slightly makes it easier to detach

2. Lift one edge of the plug and pull it away from the installation tube.

3. Use clean instrument air to gently blow any loose dirt and filter material away from the sensor.

4. Clean the installation tube and the wall around the plug.

5. Place the new silicone plug over the sensor and push it into the installation tube.

6. Take a new clean filter and push it onto the sensor. Push and rotate the filter slightly to make sure it is fully in place.

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Figure 19   Changing the Silicone Plug

Calibration and Adjustment

Calibrate and adjust the CO_2 measurement of the GMP231 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.

| NOTE	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 GMP231. For contact information, see section Product Returns on page 84.

NOTE	**Calibration** means comparing the GMP231 to a known reference, such as calibration gas or a reference instrument. Correcting the reading of the GMP231 so that is measures accurately is referred to as **adjustment**.

Calibration Setup

GMP231 is designed to be calibrated while it remains installed through an incubator wall. If you calibrate the GMP231 without it being installed, note the following:

- If you are using a calibration gas, prevent it from entering the electronics housing of the GMP231. Otherwise it will diffuse through the probe to the sensor and alter the CO_2 reading.
- Make sure the PTFE filter is in place when performing calibration.
- If you are using the calibration adapter accessory to feed the calibration gas to the sensor, note that you must have the silicone plug and the PTFE filter installed on the probe. Without both of them in place, the calibration adapter will not function properly. Vaisala recommends replacing the silicone plug and the PTFE filter before calibration.
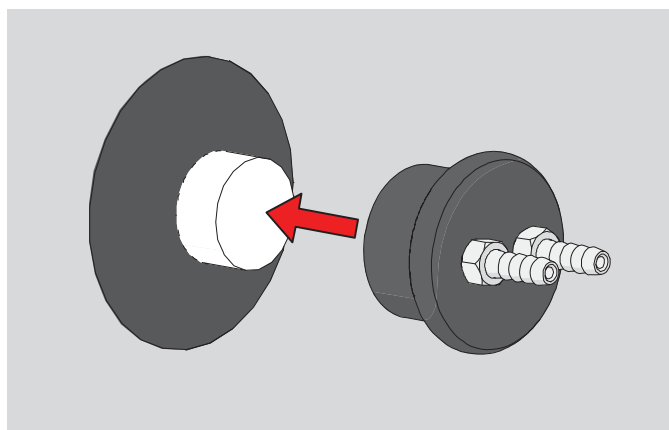
1403-147

Figure 20   **Inserting the Calibration Adapter over the Filter**

Using Ambient Air as Reference

You can use ambient air to do a 1-point calibration with the background CO_2 level as your reference. You will need a calibrated reference instrument to compare against, for example a GM70 hand-held meter with a calibrated GMP222 probe.

With the GMP231 and the reference instrument in the same space (for example, inside the incubator with the door open), allow the measurement to stabilize before comparing the readings. Try to provide as stable environment as you can during this time. Avoid working around the incubator during this time.

Using a Calibration Gas as Reference

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

- You can supply the gas to the GMP231 using the calibration adapter accessory. 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.

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

GMP231 has various environmental compensations that improve its CO_2 measurement accuracy (see section Environmental Compensation on page 17). 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 built-in pressure and temperature sensors, make sure to correct the setpoints so that they corresponds to your calibration situation. Consider switching the compensations to use the internal sensors 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 they are often dry and oxygen-free. For example, pure nitrogen gas is typically used as a convenient 0 ppm CO_2 reference.
- Remember to restore the normal compensation settings after completing calibration and adjustment. If you are integrating the calibration functionality of the GMP231 as part of the incubator's control software, also implement proper handling of the environmental compensations.

Limits of Adjustment

GMP231 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 (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 GMP231 depends on the interface you are using for adjustment.

Adjustment Types

You can adjust the CO_2 measurement of the GMP231 in one or two points.

- One-point adjustment is recommended if you are interested in maintaining a fixed CO_2 level inside the chamber. 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 GMP231. If you want to integrate the functionality into the incubator's control system, the I²C interface and the Vaisala industrial protocol are recommended. If you want to compare the reading of the GMP231 to a reference instrument as adjust it accordingly, use an MI70 hand-held indicator and a reference probe.

I²C Interface

I²C interface supports one and two-point adjustment sequences as well as configuration of the environmental compensation settings using the Get_Parameter and Set_Parameter commands. See the following sections:

Vaisala Industrial Protocol

Vaisala industrial protocol supports one and two-point adjustment with the **CCO2** command. You can also adjust the internal pressure and temperature measurements with a simple offset correction. Configuration of the environmental compensation settings can be done using serial line commands. See the following sections:

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.

CHAPTER 7
OPERATING WITH MI70 INDICATOR

Overview of MI70 Support

GMP231 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.
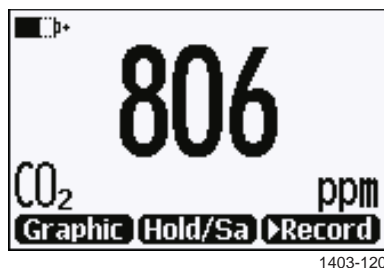
1403-120

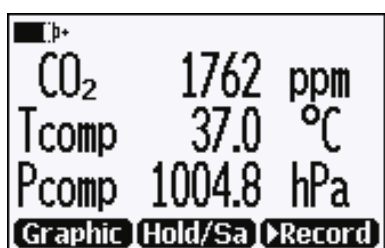**Figure 21   CO$_2$ Reading on MI70 Screen**

Connecting GMP231 to MI70 Indicator

1. If the GMP231 is installed in an incubator, disconnect the incubator's cable from the 8-pin M12 connector. Note that GMP231 can remain physically connected to the incubator.

2. If the MI70 indicator is on, turn it off.

3. Connect the GMP231 to the MI70 indicator using the GMP231 service cable for MI70. See section Spare Parts and Accessories on page 87.

4. Turn on the MI70 indicator. MI70 detects the probe and proceeds to show the measurement screen. The parameters measured by GMP231 will start to show valid measurement results after a few seconds.

Changing Environmental Compensation Settings with MI70 Indicator

You can see the compensation values that are currently used by the GMP231 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.

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Figure 22 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 17.
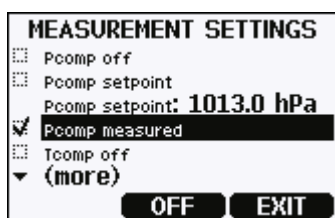
1403-137

Figure 23   GMP231 Compensation Settings on MI70 Screen

NOTE	When you turn a compensation off, GMP231 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

NOTE	Before using the MI70 indicator for calibration and adjustment, read the instructions in section Calibration and Adjustment on page 73.
	Make sure that the environmental compensation settings of the GMP231 are properly set for your calibration environment; see section Changing Environmental Compensation Settings with MI70 Indicator on page 78.

NOTE	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 GMP231 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 GMP231's sensor.
3. If you are using the calibration adapter to feed a calibration gas to the GMP231, 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**.
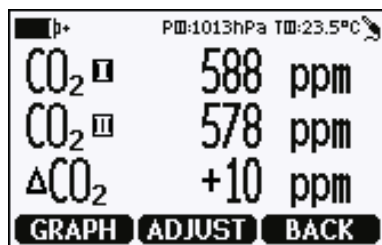

1403-131

Figure 24   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 **CO$_2$(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**.

1403-134

Figure 25   Comparing Readings in MI70 Adjustment Mode

10. Select **To same as CO$_2$(II).**
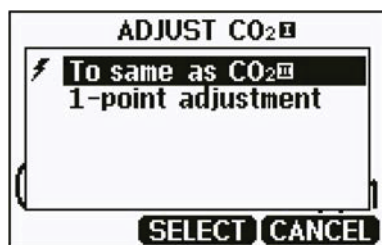
1403-142

Figure 26   Selecting the Adjustment Mode

11. You will be prompted if you really want to adjust. Select **Yes**.

12. If the adjustment is successful, the 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 section Limits of Adjustment on page 75.

1-Point Adjustment with a Reference Gas

1. Connect the GMP231 to Port I of the MI70 indicator.

2. Feed a calibration gas to the GMP231 using the calibration adapter accessory. 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**.
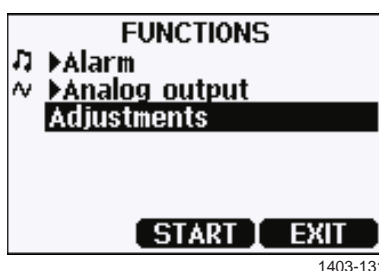

1403-131

Figure 27   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**.
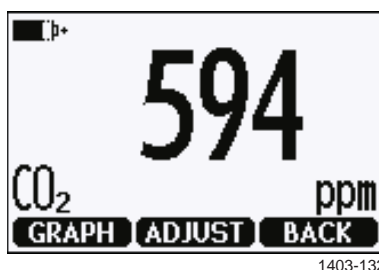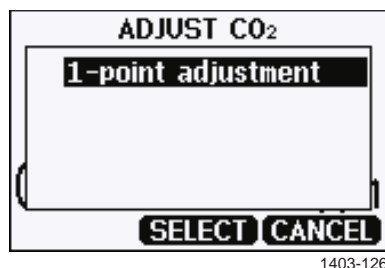

1403-132

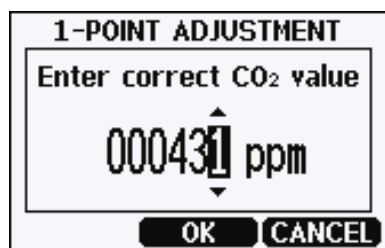**Figure 28   MI70 Adjustment Mode**

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

1403-126

Figure 29   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**.

1403-125

Figure 30   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, the 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 section Limits of Adjustment on page 75.

CHAPTER 8
TROUBLESHOOTING

This chapter describes possible problems, their probable causes and remedies, and provides contact information for technical support.

Problem Situations

Table 41   Possible Problem Situations and Their Remedies

Problem	Possible Cause	Remedy
Analog output reading is unchanging and appears incorrect.	Analog output is in error state. See section Analog Output Error State on page 84	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 section Wiring on page 24.
		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.
CO2 measurement not working.	Condensation on the sensor.	Remove the PTFE 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.

Analog Output Error State

GMP231 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 well outside the scaled output range. For a more detailed explanation, see section Analog Output Overrange Behavior on page 19.

The default error level depends on the output type:
- For 4 ... 20 mA output, the default error level is **3.6 mA**
- For 0 ... 20 mA output, the default error level is **23 mA**.

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

CHAPTER 9
TECHNICAL DATA

This chapter provides the technical data of the GMP231.

Specifications

Table 42   Performance

Property	Description / Value
Measurement range	0 ... 20 %CO_2
Accuracy at 37 °C, 1013 hPa	
Repeatability at 0 ... 8 %CO_2	±0.1 %CO_2
Repeatability at 8 ... 12 %CO_2	±0.2 %CO_2
Repeatability at 12 ... 20 %CO_2	±0.4 %CO_2
Non-linearity at 0 ... 20 %CO_2	±0.1 %CO_2
Calibration uncertainty at 5 %CO_2	±0.1 %CO_2
Temperature dependence	
with compensation at	
3 … 12 %CO_2, 20 … 60 °C	±0.1 %CO_2
0 … 16 %CO_2, 0 … 70 °C	±(0.1 %CO_2 + 0.05 % of reading / °C)
16 … 20 %CO_2, 0 … 70 °C	±1.5 %CO_2
without compensation (typical)	-0.4 % of reading / °C
Pressure dependence	
with compensation at	
3 … 12 %CO_2, 700 … 1100 hPa	±0.015 % of reading / hPa
0 … 20 %CO_2, 500 … 1100 hPa	±(10 ppm + 0.020 % of reading) / hPa
without compensation (typical)	+0.15 % of reading / hPa
Humidity dependence	
with compensation at	
0 … 20 %CO_2, 0 … 100 %RH	±0.9% of reading (37 °C)
without compensation (typical)	+0.05% of reading / %RH
O_2 dependence	
with compensation at	
0 … 20 %CO_2, 0…90 %O_2	±0.6 % of reading
without compensation (typical)	-0.08 % of reading / %O_2
Start-up time	10 s
Warm-up time for full spec.	1 min
Response time	
T63	< 30 s
T90	< 50 s
Long-term stability	
0 … 8 %CO_2	< ±0.2 %CO_2 / year
8 % ...12 %CO_2	< ±0.5 %CO_2 / year
12 % ... 20 %CO_2	< ±1.0 %CO_2 / year

Table 43   Operating Environment

Property	Description / Value
Operating temperature of CO_2 measurement	0 … 70 °C
Max. temperature durability in standby mode	up to +195 °C
Heat sterilization (+180 °C) durability	At least 120 cycles
Storage temperature	-40 … +75 °C

Pressure
   Compensated
   Operating
	
	500 … 1100 hPa
	< 1500 hPa

Humidity	0 … 100 %, non-condensing
Condensation prevention	Sensor head heating when power on
Chemical tolerance	DMSO IPA (70% Isopropyl Alcohol, 30% water) H_2O_2 (2000 ppm), non-condensing Ethanol Acetic acid
Electromagnetic compatibility	EN61326-1, Generic environment

Table 44   Inputs and Outputs

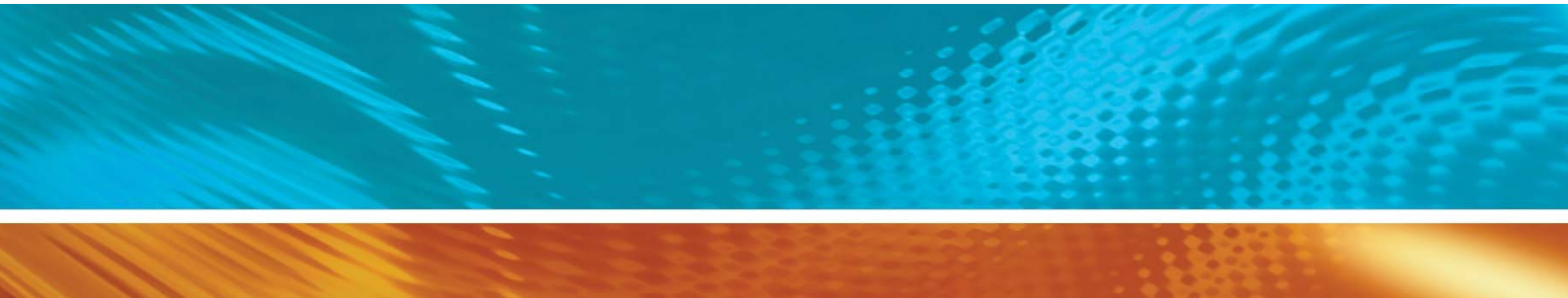| Property	Description / Value

Operating voltage
   When digital output in use
   When analog output in use
	
	11…30 VDC
	20…30 VDC

Digital outputs	I^2C 5 V RS-485 (2-wire with Vaisala Industrial Protocol)
Analog output	0 … 20 mA (scalable) max. load 600 Ω
Power consumption	< 1 W (pulsed)

Table 45   Mechanics

Property	Description / Value

Materials
   Housing
   Inner tube
   Probe tube
   Filter
	
	Metal coated plastic ABS+PC
	Aluminum
	PPSU
	PTFE

Housing classifications
   Sensor head
   Electronics housing
	
	IP54
	IP20

Connector	M12 / 8 pin

Weight
   Probe with cable
   Probe without cable
	
	200 g
	150 g

Dimensions
   Probe tube max. diameter
   Probe tube min. diameter
   Probe tube length
   Sensor filter diameter
   Sensor filter length
	
	30.2 mm
	24.8 mm
	118.5 mm
	19 mm
	12 mm

Spare Parts and Accessories

Table 46   Spare Parts and Accessories for GMP231

Description	Order Code
M12 Connection Cable 0.9 m with open ends	DRW240977SP
M12 Connection Cable 0.6 m with Milli-Grid connector	ASM210903SP
Service cable for MI70	221801
USB PC connection cable	221040
PTFE filter	DRW240494SP
Silicone plug	DRW240015SP
Attachment bracket	DRW240247SP
Calibration adapter for GMP231	239523