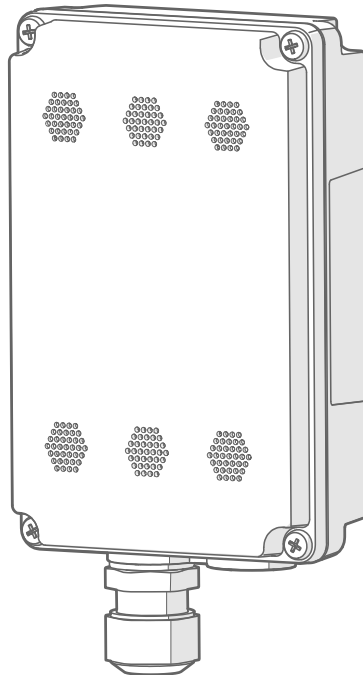


# Quick Guide

Vaisala CARBOCAP<sup>®</sup> Carbon Dioxide  
and Temperature Transmitter

**GMW87M**



**VAISALA**

PUBLISHED BY

Vaisala Oyj

Vanha Nurmijärventie 21, FI-01670 Vantaa, Finland

P.O. Box 26, FI-00421 Helsinki, Finland

+358 9 8949 1

Visit our Internet pages at [www.vaisala.com](http://www.vaisala.com).

© Vaisala 2020

No part of this document may be reproduced, published or publicly displayed in any form or by any means, electronic or mechanical (including photocopying), nor may its contents be modified, translated, adapted, sold or disclosed to a third party without prior written permission of the copyright holder. Translated documents and translated portions of multilingual documents are based on the original English versions. In ambiguous cases, the English versions are applicable, not the translations.

The contents of this document are subject to change without prior notice.

Local rules and regulations may vary and they shall take precedence over the

information contained in this document. Vaisala makes no representations on this document's compliance with the local rules and regulations applicable at any given time, and hereby disclaims any and all responsibilities related thereto.

This document does not create any legally binding obligations for Vaisala towards customers or end users. All legally binding obligations and agreements are included exclusively in the applicable supply contract or the General Conditions of Sale and General Conditions of Service of Vaisala.

**Table of contents**

**Product overview.....3**  
Transmitter parts.....3  
Safety.....4  
Regulatory compliances.....4

**Installation.....5**  
Wiring.....6

**Modbus communication.....7**  
Troubleshooting.....8

**Modbus reference.....9**  
Function codes.....9  
Data encoding.....9  
    32-bit floating point format.....9  
    16-bit integer format.....9  
Modbus registers.....10  
    Measurement data registers.....10  
    Status registers.....10  
    Test value registers.....11  
Device identification objects.....11  
Modbus communication example.....12

**Technical data.....13**

**Warranty.....15**

**Technical support.....15**

**Recycling.....15**



# Product overview

Vaisala CARBOCAP® Carbon Dioxide and Temperature Transmitter GMW87M is a wall-mount transmitter designed to fulfill the needs for CO<sub>2</sub> measurements in demanding conditions (for example, dusty or humid installation locations).

GMW87M can be accessed with the Modbus RTU protocol over an RS-485 interface. The communication settings for the protocol are entered with DIP switches on the GMW87M component board.

For information on measurement performance and technical specifications of the transmitter, see [Technical data \(page 13\)](#).

## Transmitter parts

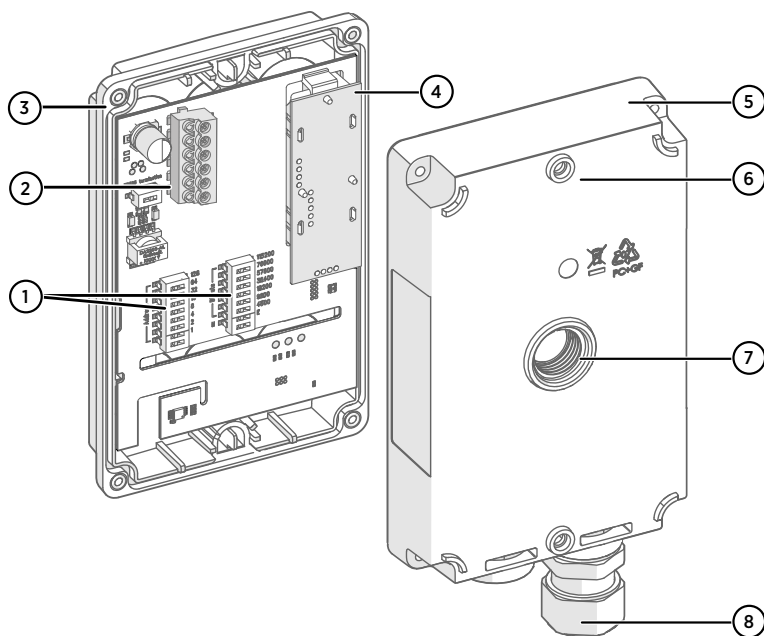


Figure 1 GMW87M transmitter parts

- 1 DIP switches for Modbus settings
- 2 Screw terminals. The screw terminal block is detachable for easy installation.
- 3 Transmitter cover with captive screws (4 pcs)
- 4 GM10 carbon dioxide measurement module
- 5 Mounting base
- 6 Screw holes for mounting on top and bottom of mounting base (2 screws, Ø 3.5 mm)
- 7 Alternative lead-through for wiring through the back
- 8 Cable gland for leading wires inside the enclosure

In GMW87M, the component board is located on the cover of the enclosure. Wires are led into the enclosure either through a cable gland on the bottom of the mounting base or a sealed lead-through at the back. The enclosure is opened and closed with 4 screws.

## Safety

The GMW87M transmitter delivered to you has been tested for safety and approved as shipped from the factory. Note the following precautions:



**WARNING!** Make sure that you prepare or connect only de-energized wires.



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



**CAUTION!** Electrostatic Discharge (ESD) can cause immediate or latent damage to electronic circuits. Avoid touching exposed component contacts during installation and maintenance.

## Regulatory compliances

Vaisala GMW80 series transmitters are in conformity with the provisions of the following EU directives:

- RoHS Directive
- EMC Directive

The conformity is declared with using the following standards:

- EN 50581: Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances.
- EN 61326-1: Electrical equipment for measurement, control, and laboratory use – EMC requirements – Immunity test requirements for equipment intended to be used in an industrial electromagnetic environment.
- EN 55032: Information technology equipment – Radio disturbance characteristics – Limits and methods of measurement.



# Installation

The GMW87 transmitter is designed to be installed on a mounting box or directly to a wall surface. For transmitter dimensions, see [Figure 3 \(page 6\)](#).

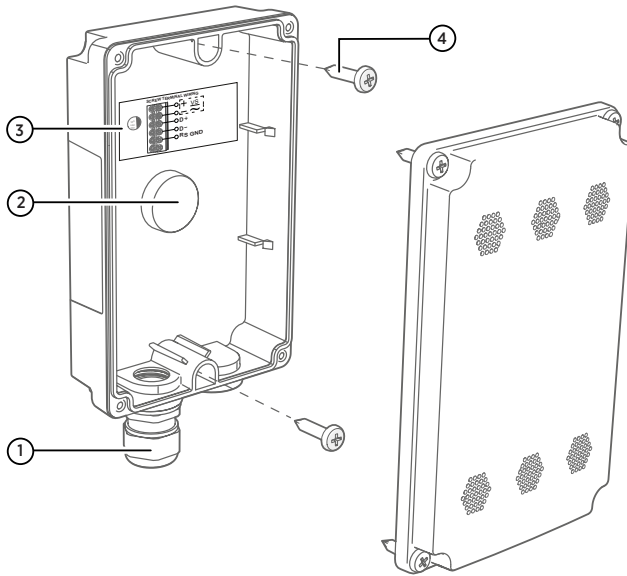


Figure 2 Mounting GMW87M

- 1 Cable gland for leading the input/output cable ( $\varnothing 4 \dots 8$  mm) inside the enclosure
- 2 Alternative lead-through for wiring through the back (break seal and transfer cable gland to the threads on this lead-through)
- 3 Wiring instructions label
- 4 Mounting screws (2 pcs,  $\varnothing 3.5$  mm, head  $\varnothing \leq 8$  mm)

- 1. Open the transmitter cover (4 screws) and use 2 mounting screws ( $\varnothing 3.5$  mm) to attach the mounting base to the installation surface. Point the cable gland straight down.
2. Route the input/output cable through the cable gland.



If you use the alternative lead-through on the back of the transmitter, seal the hole on the bottom of the transmitter after removing the cable gland.

3. For ease of installation, you can disconnect the screw terminal block by pulling it out from the component board.
4. Attach wiring to the screw terminals as shown on the wiring instructions label. See also [Wiring \(page 6\)](#).
5. If you disconnected the screw terminal block, plug it back in. Make sure it is positioned correctly.

6. Push down gently on the GM10 module. The module should be straight and firmly connected.
7. Tighten the cable gland and close the transmitter cover (4 screws).



**CAUTION!** Mounting bases are tailored to the individual transmitter at the factory. If you attach several mounting bases before connecting the transmitters, store the transmitters in their original shipping boxes, so that you can match the serial number on the mounting base to the serial number on the shipping box.

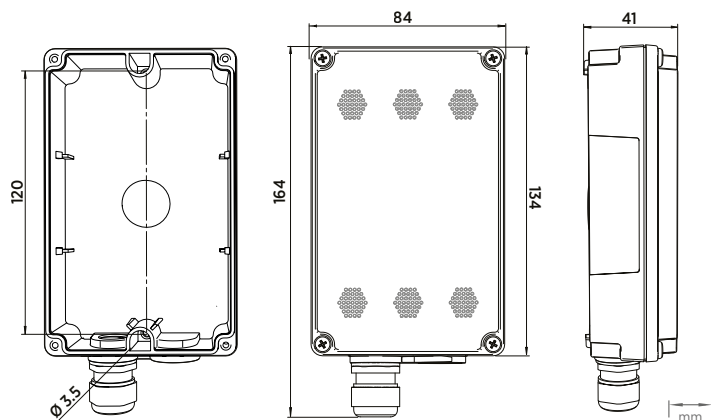


Figure 3 GMW87M dimensions

## Wiring

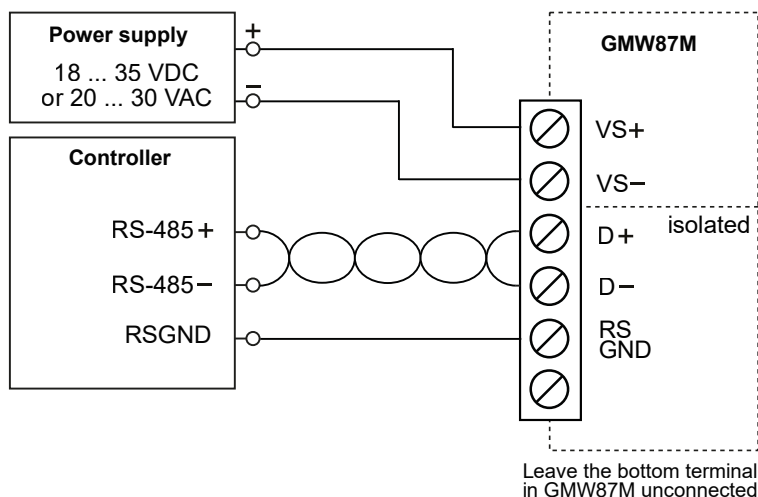


Figure 4 GMW87M wiring diagram

# Modbus communication

The Modbus variant used in GMW87M is Modbus RTU. For a list of the Modbus registers available in GMW87M, see [Modbus registers \(page 10\)](#).

You can use up to 8 transmitters on the same RS-485 line. You must configure each transmitter on the line to have a different Modbus address.



Before taking the transmitter into use, check that the Modbus device address, bit rate setting, and parity setting match the settings in your system. The number of stop bits is not significant. The device supports automatically both 1 and 2 stop bits.

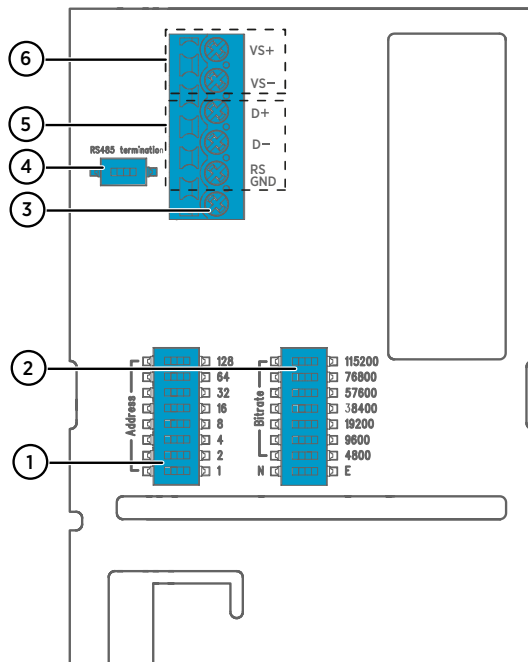


Figure 5 GMW87M component board with DIP switches and screw terminals

- 1 DIP switches for setting the GMW87M Modbus device address
- 2 DIP switches for selecting Modbus communication bit rate and parity (N/E)
- 3 Screw terminal not used in GMW87M
- 4 Switch for 120  $\Omega$  RS-485 bus termination. Switch RS-485 bus termination **ON** only on the last device of the wiring if there is no separate terminator on the bus.
- 5 RS-485 (Modbus) screw terminals
- 6 Power supply input (18 ... 35 VDC or 20 ... 30 VAC) screw terminals

Make selections with the DIP switches by sliding the DIP switch to the right (**ON**). Keep the other DIP switches on the left position (**OFF**).

# Setting Modbus device address with DIP switches



Figure 6 Modbus device address DIP switch example

DIP switches 32, 8, and 1 set to ON

The Modbus device address is encoded in eight bit binary form, with each numbered switch representing a single bit. This example shows address 41 selected: DIP switches 32, 8, and 1 (decimal: 41, binary: 00101001) are set to ON.

## Modbus device address ranges

The Modbus device address range for the transmitter is 1 ... 247. Up to 255 is possible, but non-standard.

If no address is selected (0), the device is off-line and will not respond to any Modbus requests.

## Troubleshooting

If you experience problems with GMW87M, first see the following table concerning the behavior and error indications of the transmitter.

Table 1 Troubleshooting table

| Problem                                                    | Solution                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| The device is not responding                               | <ul style="list-style-type: none"><li>• Power-cycle the transmitter by disconnecting the screw terminal block</li><li>• Check power supply voltage</li><li>• Check wiring, including RS-485 bus polarity</li><li>• Check that RS GND is connected between the transmitter and the receiver</li><li>• Compare the DIP switch settings to your Modbus host settings</li><li>• Check that RS-485 termination is enabled only on the last device of the wiring</li><li>• Alternatively, try operation without RS-485 termination at all</li></ul> |
| Unexpected value in Modbus response                        | <ul style="list-style-type: none"><li>• Change register number and/or data encoding settings in your Modbus host system</li></ul>                                                                                                                                                                                                                                                                                                                                                                                                             |
| No measurement result and/or non-zero status code returned | <ul style="list-style-type: none"><li>• Device is warming up, try again after 20 seconds</li><li>• Power-cycle the transmitter by disconnecting the screw terminal block</li><li>• Check that the GM10 module is properly attached</li><li>• Contact Vaisala for a replacement GM10 module</li></ul>                                                                                                                                                                                                                                          |

If you cannot locate the source of the error and return the transmitter to operational state, contact Vaisala technical support. See [Technical support \(page 15\)](#).

# Modbus reference

## Function codes

Table 2 Modbus function codes

| Function code (decimal) | Function code (hexadecimal)           | Name                       |
|-------------------------|---------------------------------------|----------------------------|
| 03                      | 03 <sub>hex</sub>                     | Read Holding Registers     |
| 43/14                   | 2B <sub>hex</sub> / 0E <sub>hex</sub> | Read Device Identification |

## Data encoding

In the data registers, the numeric values are available in one or two formats with separate register addresses: 32-bit IEEE floating point format and/or 16-bit signed integer format.

### 32-bit floating point format

Registers using **32-bit float** data format are encoded using the **binary32** encoding defined in IEEE 754. The format is also known as "single-precision floating point format".

The least significant 16 bits of a floating point number are placed at the Modbus register listed in the table, while the most significant 16 bits are placed in the register with number/ address + 1, as specified in Open Modbus TCP Specification, Release 1.0. This is also known as "little-endian" or "Modicon" word order.

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



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



Reading the measurement data registers with incorrect floating point format setting may occasionally result in correct-looking values. It is highly recommended to verify that you have configured the floating point format correctly on your Modbus host system by reading a floating point value from a test value register.

### 16-bit integer format

Table 3 Interpretation of 16-bit signed integer values

| Value                                       | Description                |
|---------------------------------------------|----------------------------|
| 0000 <sub>hex</sub> ... 7FFE <sub>hex</sub> | Value in range 0 ... 32766 |

| Value                                       | Description                                   |
|---------------------------------------------|-----------------------------------------------|
| 8002 <sub>hex</sub> ... FFFF <sub>hex</sub> | Value in range -32766 ... -1 (2's complement) |
| 8000 <sub>hex</sub>                         | Value is not available                        |

The 16-bit integer value for measured temperature in [Table 4 \(page 10\)](#) is scaled to include the necessary decimals.

## Modbus registers



**CAUTION!** Registers are numbered in decimal, starting from 1. Register addresses in actual Modbus messages (Modbus Protocol Data Unit (PDU)) are in hexadecimal and start from zero. Subtract 1 from the register number presented in this manual to get the address used in the Modbus message (for example, register number 1 corresponds to address 0<sub>hex</sub> in the actual Modbus message).

Accessing unavailable (temporarily missing) measurement data does not generate a Modbus exception. “Unavailable” value (a quiet NaN for floating point data or 8000<sub>hex</sub> for integer data) is returned instead. An exception is generated only for any access outside the applicable register ranges.

### Measurement data registers

Table 4 Modbus measurement data registers (read-only)

| Register number | Address             | Register description           | Data format    | Unit |
|-----------------|---------------------|--------------------------------|----------------|------|
| 1               | 0000 <sub>hex</sub> | Measured CO <sub>2</sub> value | 32-bit float   | ppm  |
| 5               | 0004 <sub>hex</sub> | Measured temperature           | 32-bit float   | °C   |
| 257             | 0100 <sub>hex</sub> | Measured CO <sub>2</sub> value | 16-bit integer | ppm  |
| 259             | 0102 <sub>hex</sub> | Measured temperature (T * 10)  | 16-bit integer | °C   |

### Status registers

Table 5 Modbus status registers (read-only)

| Register number | Address             | Register description | Data format    | Notes                                                                                                         |
|-----------------|---------------------|----------------------|----------------|---------------------------------------------------------------------------------------------------------------|
| 513             | 0200 <sub>hex</sub> | Device status        | 16-bit integer | 0000 <sub>hex</sub> : Status OK; if other values are returned, see <a href="#">Troubleshooting (page 8)</a> . |
| 514             | 0201 <sub>hex</sub> | Error code           | 32-bit integer | Used by Vaisala Technical Support when solving device problems                                                |

| Register number | Address             | Register description               | Data format    | Notes                                                                                                                                                                                                  |
|-----------------|---------------------|------------------------------------|----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 519             | 0206 <sub>hex</sub> | Temperature measurement status     | 16-bit integer | <b>0000</b> <sub>hex</sub> : Status OK                                                                                                                                                                 |
| 520             | 0207 <sub>hex</sub> | CO <sub>2</sub> measurement status |                | <b>0004</b> <sub>hex</sub> : Under range<br><b>0008</b> <sub>hex</sub> : Over range<br><b>0080</b> <sub>hex</sub> : Sensor failure<br><b>0100</b> <sub>hex</sub> : Measurement not ready <sup>1)</sup> |

1) Applicable to CO<sub>2</sub> measurement only.

## Test value registers

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

Table 6 Modbus test registers (read-only)

| Register number | Register address    | Register description | Data format    | Test value             |
|-----------------|---------------------|----------------------|----------------|------------------------|
| 7937            | 1F00 <sub>hex</sub> | Signed integer test  | 16-bit integer | -12345                 |
| 7938            | 1F01 <sub>hex</sub> | Floating point test  | 32-bit float   | -123.45                |
| 7940            | 1F03 <sub>hex</sub> | Text string test     | text           | Text string: "-123.45" |

## Device identification objects

Table 7 Device identification objects

| Object ID | Object ID (hexadecimal) | Object name                | Example contents                                       |
|-----------|-------------------------|----------------------------|--------------------------------------------------------|
| 0         | 00 <sub>hex</sub>       | VendorName                 | "Vaisala"                                              |
| 1         | 01 <sub>hex</sub>       | ProductCode                | "GMW80"                                                |
| 2         | 02 <sub>hex</sub>       | MajorMinorVersion          | Software version (for example, "1.4.0")                |
| 3         | 03 <sub>hex</sub>       | VendorUrl                  | "https://www.vaisala.com/"                             |
| 4         | 04 <sub>hex</sub>       | ProductName                | "Vaisala CARBOCAP(R) Carbon Dioxide Transmitter GMW80" |
| 128       | 80 <sub>hex</sub>       | SerialNumber <sup>1)</sup> | Transmitter serial number, e.g. "J1140501"             |

1) Vaisala-specific device information object.

# Modbus communication example

## Reading CO<sub>2</sub> concentration value



The device address used in the following example is 240 (F0<sub>hex</sub>). The values returned by the device differ depending on the ambient conditions. Your device might not return exactly the same values.

| Request                 |                                        | Response                |                                                  |
|-------------------------|----------------------------------------|-------------------------|--------------------------------------------------|
| Bytes on the line       | Description                            | Bytes on the line       | Description                                      |
| (silence for 3.5 bytes) | Start of Modbus RTU frame              | (silence for 3.5 bytes) | Start of Modbus RTU frame                        |
| F0 <sub>hex</sub>       | Transmitter address                    | F0 <sub>hex</sub>       | Transmitter address                              |
| 03 <sub>hex</sub>       | Function (Read Holding Registers)      | 03 <sub>hex</sub>       | Function (Read Holding Registers)                |
| 00 <sub>hex</sub>       | Register address                       | 04 <sub>hex</sub>       | Number of data bytes                             |
| 00 <sub>hex</sub>       |                                        | E6 <sub>hex</sub>       | Value of first register (least significant word) |
| 00 <sub>hex</sub>       |                                        | 3A <sub>hex</sub>       |                                                  |
| 02 <sub>hex</sub>       | Number of 16-bit registers to read (2) | 44 <sub>hex</sub>       | Value of second register (most significant word) |
| D1 <sub>hex</sub>       | Modbus RTU checksum                    | 17 <sub>hex</sub>       |                                                  |
| 2A <sub>hex</sub>       |                                        | 7E <sub>hex</sub>       | Modbus RTU checksum                              |
| (silence for 3.5 bytes) | End of Modbus RTU frame                | B7 <sub>hex</sub>       |                                                  |
|                         |                                        | (silence for 3.5 bytes) | End of Modbus RTU frame                          |

| Communication description |                                                                                                                  |
|---------------------------|------------------------------------------------------------------------------------------------------------------|
| Register number           | 1 (1-based Modbus register number) = address 0000 <sub>hex</sub> (0-based address used in actual communication). |
| Data format               | Two 16-bit Modbus registers interpreted as IEEE 754 binary32 floating point value, least significant word first. |
| Returned value            | 4417E63A <sub>hex</sub> , which is binary32 representation of 607.6 (ppm CO <sub>2</sub> ).                      |

# Technical data

Table 8 Measurement performance

| Property                                                          | Specification                              |
|-------------------------------------------------------------------|--------------------------------------------|
| <b>Carbon dioxide</b>                                             |                                            |
| Measurement range                                                 | 0 ... 5000 ppm                             |
| <b>Accuracy across temperature range</b>                          |                                            |
| +20 ... +30 °C (+68 ... +86 °F)                                   | ±(30 ppm +3 % of reading)                  |
| +10 ... +20 °C (+50 ... +68 °F), +30 ... +40 °C (+86 ... +104 °F) | ±(35 ppm +3.7 % of reading)                |
| +0 ... +10 °C (+32 ... +50 °F), +40 ... +50 °C (+104 ... +122 °F) | ±(40 ppm +4.8 % of reading)                |
| Stability in typical HVAC applications                            | ±(15 ppm + 2 % of reading) over five years |
| Warm-up time                                                      | 10 min for full specification              |
| Response time (63 %)                                              | 7 min                                      |
| Carbon dioxide sensor                                             | Vaisala CARBOCAP® GM10                     |
| Product lifetime                                                  | > 15 years                                 |

Table 9 Operating environment

| Property              | Specification                              |
|-----------------------|--------------------------------------------|
| Operating temperature | 0 ... +50 °C (+32 ... +122 °F)             |
| Operating humidity    | 0 ... 95 %RH<br>Dew point < 30 °C (+86 °F) |
| Storage temperature   | −40 ... +70 °C (−40 ... +158 °F)           |
| EMC compliance        | EN61326-1, Industrial environment          |

Table 10 Inputs and outputs

| Property                           | Specification                          |
|------------------------------------|----------------------------------------|
| Supply voltage                     | 18 ... 35 VDC<br>24 VAC ±20 % 50/60 Hz |
| Max. current consumption at 18 VDC | 45 mA                                  |
| Max. power consumption at 30 VAC   | 1 W                                    |

| Property                | Specification                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|-------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Digital output (RS-485) | <p>Isolated, supports Modbus RTU protocol</p> <ul style="list-style-type: none"> <li>• Modbus RTU address range: <ul style="list-style-type: none"> <li>• 1 ... 247 (up to 255 possible, non-standard)</li> </ul> </li> <li>• Bit rates: <ul style="list-style-type: none"> <li>• 4800, 9600, 19200, 38400, 57600, 76800, 115200</li> </ul> </li> <li>• Parity: <ul style="list-style-type: none"> <li>• None or Even</li> </ul> </li> <li>• Supports automatically both 1 and 2 stop bits</li> </ul> |

Table 11 Mechanical specifications

| Property         | Specification                |
|------------------|------------------------------|
| IP rating        | IP64                         |
| Housing material | PC                           |
| Housing color    | White (RAL9003)              |
| Output connector | Screw terminal               |
| Max. wire size   | 2.5 mm <sup>2</sup> (AWG 12) |
| Weight           | 160 g (5.64 oz)              |

## Warranty

For standard warranty terms and conditions, see [www.vaisala.com/warranty](http://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.

## Technical support



Contact Vaisala technical support at [helpdesk@vaisala.com](mailto:helpdesk@vaisala.com). Provide at least the following supporting information as applicable:

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

For more information, see [www.vaisala.com/support](http://www.vaisala.com/support).

## Recycling



Recycle all applicable material.



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

# VAISALA

[www.vaisala.com](http://www.vaisala.com)

