

Technical Note

Calibrating and adjusting GMP251 and GMP252 probes using Modbus

Overview of GMP251 and GMP252 probe calibration using Modbus protocol

The recommended way to calibrate and adjust Vaisala GMP250 Series CO₂ probes is using Vaisala's calibration service, Vaisala Insight PC software, or a compatible handheld meter. However, some users may have a need to implement a solution based on the Modbus protocol. This technical note provides the necessary information to operate the calibration sequence using the Modbus protocol, as well as some additional information about matters affecting the quality of the resulting calibration.

Using the Modbus protocol, you can calibrate and adjust the CO₂ measurement in 1 or 2 points. Before carrying out calibration and adjustment with Modbus, review the adjustment requirements information in [Adjustment requirements \(page 1\)](#).

Adjustment requirements

When carrying out adjustments with the Modbus protocol, note that certain Modbus-specific adjustment requirements apply to GMP250 Series probes. Review the requirements before carrying out adjustments.

Modbus adjustment requirements

- CO₂ measurement can be calibrated and adjusted in 1 or 2 points. Note that you must write an empty (NaN) value in all fields for any unused adjustment points. This prevents any possible earlier values left in those points from affecting the adjustment you are carrying out.
- Adjustment points must be populated starting from point #1 (leaving point 1 empty is not allowed).
- All CO₂ adjustment points must contain two values: reference value (after) and measured CO₂ (before).



NOTICE! At the end of the sensor life cycle, the sensor can no longer be adjusted to the specified accuracy and must be replaced. For more information, see return code **-4** in [Table 3 \(page 4\)](#).

The probe will reject adjustments that are too large (maximum adjustment: 1000 ppm + 25 % of the probe's uncorrected reading). If the probe appears to need such a large correction, repeat the adjustment procedure and make sure the measurement has stabilized and the reference environment is reliable. If the required adjustment is still too large, the probe needs to be serviced by Vaisala.

Adjustment recommendations

For further information and instructions on probe adjustment, including general adjustment recommendations and requirements such as recommended reference flow rates, see [GMP251 and GMP80 User Guide \(M211799EN\)](#) and [GMP252 User Guide \(M211897EN\)](#). The probe documentation also describes the wiring, communication settings, and Modbus implementation of the probes.

Calibration and adjustment sequence

This section describes the calibration and adjustment sequence in more detail and describes the data the Modbus client system should exchange with the probe. Prepare a reference source such as a reference gas or reference measurement instrument (1 or 2 references depending on whether the calibration or adjustment is done in 1 or 2 points) to create suitable reference conditions. See probe documentation for more information on reference source options.



The wiring, communication settings, and Modbus implementation of GMP251 and GMP252 probes are described in [GMP251 and GMP80 User Guide \(M211799EN\)](#) and [GMP252 User Guide \(M211897EN\)](#). In addition, see [Calibration-related Modbus registers and functions \(page 2\)](#).

1. Write the calibration passcode 1300 in register 0x2000 of the probe to unlock the calibration mode.
2. Calibrate the **first** point:
 - a. Insert the probe head in the reference environment for the first calibration point.
 - b. Wait for the measurement to stabilize. Track the stabilization by reading the CO₂ measurement value register (0x0000). Note that the required stabilization time varies depending on starting conditions and calibration conditions.
 - c. After the measurement is stable, write the reference value of the environment in register 0x2100. See register descriptions for valid ranges.
 - d. When the reference value is written, the probe automatically inserts the currently measured value in the appropriate register (0x2102) for the first calibration point. Read the values written by the probe and compare with the reference to determine the calibration result for the first point.
3. Calibrate the **second** point:
 - a. Insert the probe head in the reference environment for the second calibration point.
 - b. Wait for the measurement to stabilize. Track the stabilization by reading the CO₂ measurement value.
 - c. After the measurement is stable, write the reference value of the environment in register 0x2104. See register descriptions for valid ranges.
 - d. The probe automatically inserts the currently measured value in the appropriate register (0x2106) for the second calibration point. Read the value written by the probe and compare with the reference to determine the calibration result for the second point.



Note that you must write an empty (NaN) value in all fields for any unused adjustment points. This prevents any possible earlier values left in those points from affecting the current adjustment.

4. When you have calibrated all intended points, activate the adjustment by writing 1 in the function register 0x2108.
 - If the calibration results show that no adjustment is needed, you can also exit without activating the adjustment. To exit without activating the adjustment, move directly to step 7 and close the calibration mode.
5. To verify that the adjustment was successfully activated, read the return code of the adjustment function from the same register address. See [Table 3 \(page 4\)](#).
6. Write the new calibration date and information text in the appropriate registers.
7. Write -32768 (0x8000) in register 0x2000 to close the calibration mode.

Calibration-related Modbus registers and functions

Table 1 Modbus calibration registers (writable)

Register number	Address	Register description	Data format	Unit/Valid range
8193	0x2000	Calibration mode passcode	16-bit integer	1300 = calibration mode enabled Any other value = calibration mode disabled
8194	0x2001	Calibration year	16-bit integer	These 3 registers must be written in a single transaction. It is not possible to change only year/month/day alone; such an attempt will be ignored.
8195	0x2002	Calibration month	16-bit integer	
8196	0x2003	Calibration day	16-bit integer	

Register number	Address	Register description	Data format	Unit/Valid range
8197	0x2004	Calibration text	Text	Text string in UTF-8 encoding, maximum 15 bytes. When writing a new calibration text, all Modbus registers in this range must be written, even if the text is shorter. The written text must be filled with NUL bytes so that it is exactly 8 registers long. Any write attempts not writing all these registers in one transaction will be ignored.
	0x2005			
	0x2006			
	0x2007			
	0x2008			
	0x2009			
	0x201A			
	0x201B			
8205	0x200C	Calibration interval	16-bit integer	
8206	0x200D	Calibration expiry year	16-bit integer	These 3 registers must be written in a single transaction. It is not possible to change only year/month/day alone; such an attempt will be ignored.
8207	0x200E	Calibration expiry month	16-bit integer	
8208	0x200F	Calibration expiry day	16-bit integer	
8209	0x2010	Calibration reminder on/off	Boolean	When enabled, the calibration reminder only sends a notification message when the probe is connected to Insight PC software or an Indigo transmitter or Indigo handheld. In plain Modbus use, the calibration reminder function is not active and the Modbus client needs to track the calibration expiry date by itself.
User CO₂ adjustment				
8449	0x2100	Reference CO ₂ value, point 1	32-bit float	GMP251: 0–200000 ppmCO₂ GMP252: 0–30000 ppmCO₂
	0x2101			
8451	0x2102	Measured CO ₂ value, point 1	32-bit float	Any ppmCO₂ value can be entered as the measured value (also outside of the measurement range).
	0x2103			
8453	0x2104	Reference CO ₂ value, point 2	32-bit float	GMP251: 0–200000 ppmCO₂ GMP252: 0–30000 ppmCO₂
	0x2105			
8455	0x2106	Measured CO ₂ value, point 2	32-bit float	Any ppmCO₂ value can be entered as the measured value (also outside of the measurement range).
	0x2107			

CO ₂ adjustment data				
8961	0x2300	Reference CO ₂ value, point 1	32-bit float	GMP251: 0–200000 ppmCO ₂ GMP252: 0–30000 ppmCO ₂
	0x2301			
8963	0x2302	Measured CO ₂ value, point 1	32-bit float	Any ppmCO ₂ value can be entered as the measured value (also outside of the measurement range).
	0x2303			
8965	0x2304	Reference CO ₂ value, point 2	32-bit float	GMP251: 0–200000 ppmCO ₂ GMP252: 0–30000 ppmCO ₂
	0x2105			
8967	0x2306	Measured CO ₂ value, point 2	32-bit float	Any ppmCO ₂ value can be entered as the measured value (also outside of the measurement range).
	0x2307			

Table 2 Modbus function registers (writable)

Register number	Address	Register description	Data format	Unit/Valid range
Functions				
8457	0x2108	Activate CO ₂ adjustment	16-bit integer	When writing to register: 1 = Activate CO ₂ adjustment.
8458	0x2109	Restore factory CO ₂ adjustment	16-bit integer	When writing to register: 1 = Restore factory CO ₂ adjustment.

Table 3 Adjustment function return codes

Value	Meaning
0	Adjustment successful
-1	Adjustment failed, calibration locked
-2	Adjustment failed, possible device error
-3	Adjustment failed, incomplete adjustment point data
-4	Adjustment failed, cumulative correction too large ¹⁾
-5	Adjustment failed, invalid adjustment point values

1) This code may indicate that the sensor is at the end of its life cycle and must be replaced. If adjustment attempts repeatedly produce this return code, consider replacing the sensor. Before replacing the sensor, ensure that no mistakes have been made in the adjustment (for example, rule out possible issues caused by insufficient stabilization time or quality of adjustment reference). See probe documentation for adjustment requirements.