Technical Note | Calibrating and adjusting HMP Series and HMP110 probes using Modbus

Overview of HMP Series and HMP110 probe calibration using Modbus protocol

The recommended way to calibrate and adjust Vaisala HMP Series and HMP110 humidity and temperature probes is using Vaisala's calibration service, Vaisala Insight 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 adjust the humidity measurement in 1–5 points, and the temperature measurement in 1–2 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 HMP Series probes and HMP110 probes. Review the requirements before carrying out adjustments.

Modbus adjustment requirements

- RH can be calibrated and adjusted in 1–5 points, and temperature in 1–2 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 (no empty points are allowed in between).
- All RH adjustment points must contain three values: reference value (after), measured RH (before), and measured T.

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 **-5** in Table 3 (page 5).
The probe will reject adjustments that are too large (for example, for HMP Series probes adjustments greater than 10 %RH for humidity and 0.5 °C for temperature). If the probe appears to need such a large correction, perform a sensor purge (if available on the probe) and repeat the adjustment procedure. 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 humidity levels, see HMP Series User Guide M212022EN and HMP110 User Guide M211060EN. 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 master system should exchange with the probe. A humidity and/or temperature calibrator is needed to create suitable reference conditions.

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Wiring, communication settings, and Modbus implementation of the HMP Series probes and HMP110 probes are described in HMP Series User Guide (M212022EN) and HMP60 and HMP110 Series User Guide M211060EN. In addition, see Calibration-related Modbus registers and functions (page 3).

1. If the probe to be calibrated is capable of sensor purge, it is recommended to perform the purge before calibration and adjustment. Write 1 in register 0x0504 to start the sensor purge.

> **NOTICE!** To prevent heat conduction during sensor purge, the probe head should not be inside a calibration chamber or be attached to anything. After the sensor purge is completed, allow the probe head to cool down completely before starting the calibration sequence. Typically this takes at least 30 minutes.

2. Write the calibration passcode 1300 in register 0x2000 of the probe to unlock the calibration mode. In addition to enabling the adjustment registers and functions, this temporarily disables probe features such as condensation prevention heating that could interfere with calibration.
3. 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 values for RH (0x0000) and T (0x0002). Note that the required stabilization time varies greatly depending on probe model, starting conditions, and calibration conditions.
   c. After the measurement is stable, write the reference value of the environment (for example, 11.3 %RH or 23 °C) in the appropriate register:
      - 0x2100 if you are calibrating RH measurement
      - 0x2200 if you are calibrating T measurement
   d. When the reference value is written, the probe automatically inserts the currently measured value(s) in the appropriate register(s) 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.
4. 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 RH and T values.
   c. After the measurement is stable, write the reference value of the environment (for example, 75.1 %RH or 40 °C) in the appropriate register:
      - 0x2106 if you are calibrating RH measurement
      - 0x2204 if you are calibrating T measurement
   d. The probe automatically inserts the currently measured value(s) in the appropriate register(s) for the second calibration point. Read the values written by the probe and compare with the reference to determine the calibration result for the second point.
5. If you are performing an RH calibration, you can calibrate up to 5 points using the same method. See Calibration-related Modbus registers and functions (page 3) for the register addresses of the remaining 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 current adjustment.

6. When you have calibrated all intended points, activate the adjustment by writing 1 in the appropriate function register:
   - 0x211E to activate RH adjustment
   - 0x2208 to activate T adjustment
   - 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 9 and close the calibration mode.
7. 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 5).
8. Write new calibration date and information text in the appropriate registers.
9. Write -32768 (0x8000) in register 0x2000 to close the calibration mode.

Calibration-related Modbus registers and functions

Note that register availability varies depending on the probe model (for example, RH registers are not applicable for T-only probes).

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 attempt will be ignored.
8195	0x2002	Calibration month	16-bit integer	
8196	0x2003	Calibration day	16-bit integer	
8197	0x2004	Calibration text	text	Text string in UTF-8 encoding, maximum 24 bytes (23 bytes on HMP110). 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 exactly 12 registers (24 bytes) long. Any write attempts not writing all these registers in one transaction will be ignored.
	0x2005			
	0x2006			
	0x2007			
	0x2008			
	0x2009			
	0x2010			
	0x2011			
	0x2012			
	0x2013			
	0x2014			
	0x2015			
User RH adjustment				
8449	0x2100	Reference RH value, point 1	32-bit float	%RH
	0x2101			
8451	0x2102	Measured RH value, point 1	32-bit float	%RH
	0x2103			
8453	0x2104	Measured T value, point 1	32-bit float	°C
	0x2105			
8455	0x2106	Reference RH value, point 2	32-bit float	%RH
	0x2107			

User RH adjustment				
8457	0x2108	Measured RH value, point 2	32-bit float	%RH
	0x2109			
8459	0x210A	Measured T value, point 2	32-bit float	°C
	0x210B			
8461	0x210C	Reference RH value, point 3	32-bit float	%RH
	0x210D			
8463	0x210E	Measured RH value, point 3	32-bit float	%RH
	0x210F			
8465	0x2110	Measured T value, point 3	32-bit float	°C
	0x2111			
8467	0x2112	Reference RH value, point 4	32-bit float	%RH
	0x2113			
8469	0x2114	Measured RH value, point 4	32-bit float	%RH
	0x2115			
8471	0x2116	Measured T value, point 4	32-bit float	°C
	0x2117			
8473	0x2118	Reference RH value, point 5	32-bit float	%RH
	0x2119			
8475	0x211A	Measured RH value, point 5	32-bit float	%RH
	0x211B			
8477	0x211C	Measured T value, point 5	32-bit float	°C
	0x211D			
User T adjustment				
8705	0x2200	Reference T value, point 1	32-bit float	°C
	0x2201			
8707	0x2202	Measured T value, point 1	32-bit float	°C
	0x2203			
8709	0x2204	Reference T value, point 2	32-bit float	°C
	0x2205			
8711	0x2206	Measured T value, point 2	32-bit float	°C
	0x2207			

Table 2 Modbus function registers (writable)

Register number	Address	Register description	Data format	Unit/Valid range
Functions				
1285	0x0504	Start sensor purge	16-bit integer	When writing to register: 1 = Start sensor purge When sensor purge is in progress, the value of the register will count up from 0 to 100. When the value returns to 0, the sensor purge is complete.
8479	0x211E	Activate RH adjustment	16-bit integer	When writing to register: 1 = Activate RH adjustment
8480	0x211F	Restore factory RH adjustment	16-bit integer	When writing to register: 1 = Restore factory RH adjustment
8713	0x2208	Activate T adjustment	16-bit integer	When writing to register: 1 = Activate T adjustment
8714	0x2209	Restore factory T adjustment	16-bit integer	When writing to register: 1 = Restore factory T adjustment

Table 3 Adjustment function return codes

Value	Meaning
0	Adjustment successful
-1	Adjustment failed due to missing or incorrect calibration values
-2	Adjustment failed, calibration locked
-4	Adjustment failed, calibration points too close to each other
-5	Adjustment failed, cumulative correction too large [1)]
-6	**HMP110 only:** Adjustment failed, multipoint calibration points not compatible with each other

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.*