control solutions
TERACOM




# TSM400-4-CPTH

## CO2, humidity and temperature multi-sensor

# USER MANUAL

www.teracomsystems.com

## 1. Short description

TSM400-4-CPTH is a multi-sensor that supports MODBUS RTU protocol over the RS-485 interface. The sensor measures $CO_2$ concentration, temperature, humidity, and barometric pressure. The MODBUS device integrates an advanced non-dispersive infrared sensing element (NDIR) for $CO_2$ measurements. The measurement principle is based on the absorption of infra-red (IR) light with specific wavelengths by $CO_2$ molecules. The carbon dioxide sensing element is temperature compensated for better accuracy. Self-calibration is available for carbon dioxide measurements. It is done if the sensor is left in fresh (around 400 ppm $CO_2$ concentration) air.

The basic sensing element for barometric pressure is factory calibrated and it does not require any lifetime recalibration. A unique capacitive element is used for measuring relative Humidity while the temperature is measured by a band gap sensor. Both sensors are seamlessly coupled to a 12-bit analog to digital-converter. This results in superior signal quality.

The TSM400-4-CPTH multi-sensor is housed in a slim plastic enclosure. The bottom part of the enclosure is suitable for installation on standard flush-mounted/cavity wall boxes ø68mm, with installation openings on 61 mm.

## 2. Features

- LED indicator for status of communication;
- Long-term stability based on digital signal processing;
- Self-calibration on fresh air for $CO_2$ measurements;
- RS-485 interface carrying up to 32 nodes;
- Changeable bitrate and other communication parameters;
- Firmware update via the interface.

## 3. Applications

- Environmental quality monitoring and assessment for offices
- $CO_2$ pollution monitoring
- Server room and data centers humidity and temperature monitoring
- Smart ventilation systems
- $CO_2$, humidity, and temperature monitoring in building management systems (BMS)

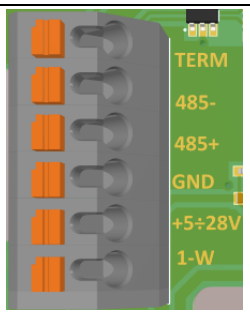
## 4. Specifications

- Physical characteristics
  Dimensions: 81 x 81 x 30mm
  Weight: 66g
- Environmental limits
  Operating temperature range: -20 to 60°C
  Operating relative humidity range: 10 to 90% (non-condensing)
  Recommended operating range is 20% to 80% RH (non-condensing) over –10 °C to 60 °C
  Prolonged operation beyond these ranges may result in a shift of sensor reading, with slow recovery time
  Long term drift typical: ±0.25%RH/year, ±0.05°C/year
  Higher drift might occur due to contaminant environments with vaporized solvents, adhesives, packaging materials, etc.
  Storage temperature range: -20 to 60°C
  Storage relative humidity range: 10 to 90% (non-condensing)
  Ingress protection: IP20

- Power requirements
  Operating voltage range (including -15/+20% according to IEC 62368-1): 4.5 to 26VDC
  Current consumption:  25 mA@5VDC (Peak: 150 mA@5VDC)
- $CO_2$ measurements
  Range: 400 to 5000ppm
  Accuracy: ± (40ppm + 5%)
  Resolution: 1ppm
  Calibration: Manual/Automatic
- Pressure measurements
  Range: 10 to 1200hPa
  Accuracy (min): ±1.5hPa (25°C, 750hPa)
  Accuracy (max): ±2.5hPa (-20°C to + 85°C, 300 to 1100hPa)
  Resolution: 1hPa
- Humidity measurements
  Accuracy (min): ±3.0 %RH (in 20 to 80 %RH range)
  Accuracy (max): ±5.0 %RH (in 10 to 90 %RH range) *
  Resolution: 0.1%RH
- Temperature measurements
  Accuracy (min): ±0.4°C (in -10 to +60°C range)
  Accuracy (max): ±0.6°C (in -20 to +60°C range)
  Resolution: 0.1°C
- Interface
  Response time ≤ 50ms

    Master response time-out ≥ Response time + Answer time
    The answer time depends on the number of bits and the baud rate

## 5. Pinout

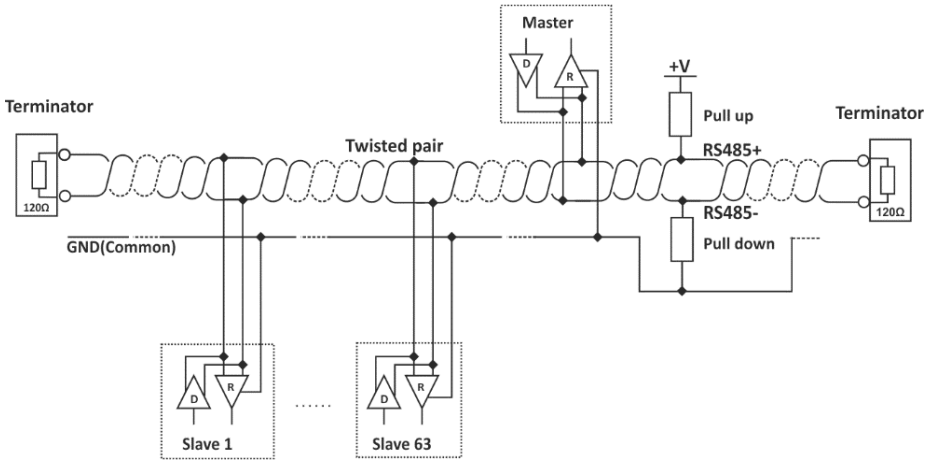



| Pin | Description | UTP wires color |
|---|---|---|
| TERM | For termination, connect to 485- | |
| 485- | RS485- | Blue |
| 485+ | RS485+ | Blue/White Tracer |
| GND | Ground (negative) supply | Brown |
| +5÷28V | Positive power supply | Brown/White Tracer |
| 1-W | Not used | |

## 6. Installation

Two-Wire MODBUS definition according to modbus.org:

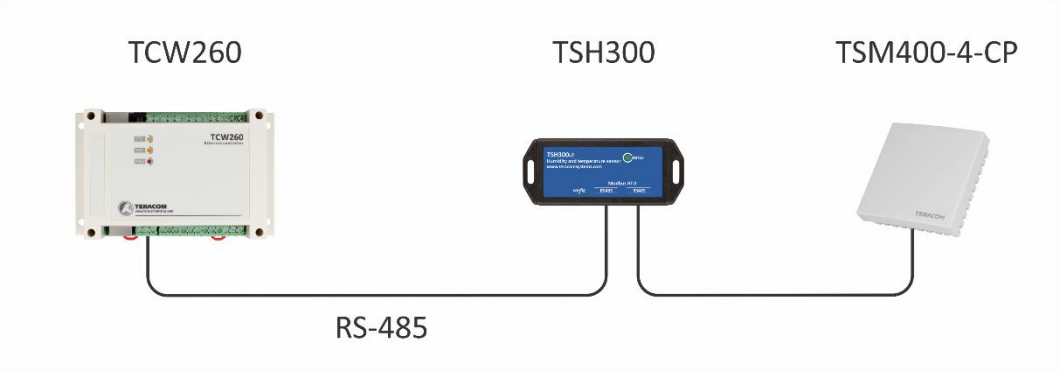
“A MODBUS solution over a serial line should implement a “Two-Wire” electrical interface in accordance with EIA/TIA-485 standard. On such a “Two-Wire” topology, at any time one driver only has the right for transmitting. In fact, a third conductor must also interconnect all the devices of the bus - the common.”




**Attention:**

For proper operation of the interface, terminators (120 ohms resistors) must be installed at both ends of the bus. The device has a built-in 120 ohm resistor and to terminate the "RS485-" and "TERM" must be shortened.

A daisy-chained (linear) topology for multiple sensors should be used. UTP/FTP cables are mandatory for interconnection.

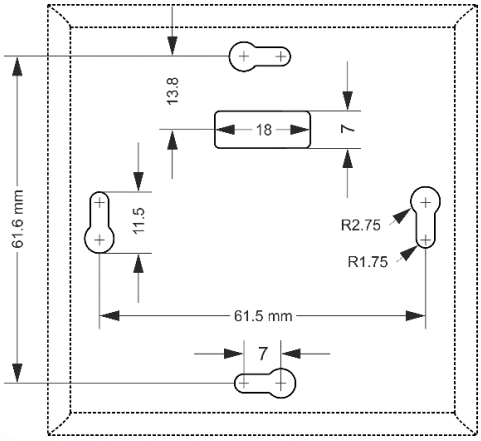



## 7. Installation tips

The location and the mounting position of the sensor have a direct effect on the accuracy of the measurement. The tips below will ensure good measuring results:

- Sensor shall be installed about 1.2-1.4 m above the floor;
- To avoid solar radiation, the sensor should not be installed next to windows or directly in the sunlight;
- Sensors shall be installed in a place with sufficient air circulation.

TSM400-4-CPTH sensor is intended for installation on a cavity wall box with 68mm diameter and 61 mm screw spacing.



## 8. Status indicator

The status of the device is shown by a single LED, located inside the box:

- If the LED blinks for a period of 1 second, the sensor works properly;
- If the LED blinks for a period of 3 seconds, there isn‘t communication with the controller;
- If LED doesn‘t blink, there isn‘t a power supply.

## 9. CO2 Calibration

The device has the capability to automatically and manually calibrate carbon dioxide measurements. It is advised by the sensor element's manufacturer to perform calibration on a weekly basis.

The determination of whether the calibration is done manually or automatically depends on the information stored in MB register with PDU address 2002.

The automatic self-calibration (ASC) feature ensures the device maintains the highest long-term stability without requiring any manual actions from the user.

The algorithm for automatic self-calibration assumes that the sensor is exposed to an atmospheric CO2 concentration of 400 ppm at least once per week.

Manual Calibration Procedure:

To manually calibrate the device, follow these steps:

- Place the device in a fresh air environment with a CO2 concentration of 400 ppm.
- While the sensor is in operation, press and hold the button.
- The “status” LED will start flashing once every second.
- After the 5th flash, the “status” LED will turn off and wait for the button to be released to initiate calibration.
- Release the button.
- The calibration procedure will begin, indicated by the “status” LED staying continuously lit for approximately 5 seconds.
- After a successful calibration, the “status” LED will flash 3 times in 1 second. In the case of a failure, it will flash rapidly (15 times within a 3-second period).
  Following the calibration, the device will enter its standard operation mode.

## 10. Factory default settings

Disconnect the sensor from the bus (switch off the power supply).

Press and hold the “config” button. Don’t release the button, connecting the sensor to the bus (switch on the power supply).

The “status” LED will be ON for 3 seconds and after this will flash for 7 seconds. After the 10-th second the LED will be ON.

Release the button. The sensor will restart with factory default settings.

## 11. Firmware update

The firmware of the sensor can be updated with a Teracom controller which supports

MODBUS RTU or MBRTU-Update software. For more details ask your dealer.

# 12. Modbus address table

| Register name | R/W | FC | PDU Address (Decimal) | Logical Address (Decimal) | Offset (Decimal) | Data size | Default | Valid values |
|---|---|---|---|---|---|---|---|---|
| RS-485 address | R/W | 03/06 | 10 | 40011 | 40001 | 16-bit uns. integer | 1 | 1-247 |
| Baud rate* | R/W | 03/06 | 11 | 40012 | 40001 | 16-bit uns. integer | 19200 | 2400, 4800, 9600, 19200, 38400, 57600 |
| Parity, data, stop bits * | R/W | 03/06 | 12 | 40013 | 40001 | 16-bit uns. integer | 1 | 1=E81, 2=O81, 3=N81 |
| Data order | R/W | 03/06 | 13 | 40014 | 40001 | 16-bit uns. integer | 1 | 1=MSWF (MSW, LSW) 2=LSWF (LSW, MSW) |
| Device code | R | 03 | 14 | 40015 | 40001 | 16-bit uns. integer | | 0x00C9 |
| FW version | R | 03 | 15 | 40016 | 40001 | 16-bit uns. integer | | |
| Vendor URL | R | 03 | 18 | 40019 | 40001 | 64 bytes UTF-8 | | teracomsystems.com |
| Float test value (MSWF) | R | 03 | 82 | 40083 | 40001 | 32-bit float | | -9.9(0xC11E6666) |
| Float test value (LSWF) | R | 03 | 84 | 40085 | 40001 | 32-bit float | | -9.9(0xC11E6666) |
| Signed integer test value | R | 03 | 86 | 40087 | 40001 | 16-bit sig. integer | | -999(0xFC19) |
| Signed integer test value (MSWF) | R | 03 | 87 | 40088 | 40001 | 32-bit sig. integer | | -99999(0xFFFE7961) |
| Signed integer test value (LSWF) | R | 03 | 89 | 40090 | 40001 | 32-bit sig. integer | | -99999(0xFFFE7961) |
| Unsigned integer test value | R | 03 | 91 | 40092 | 40001 | 16-bit uns. integer | | 999(0x03E7) |
| Unsigned integer test value (MSWF) | R | 03 | 92 | 40093 | 40001 | 32-bit uns. integer | | 99999(0x0001869F) |
| Unsigned integer test value (LSWF) | R | 03 | 94 | 40095 | 40001 | 32-bit uns. integer | | 99999(0x0001869F) |
| Temperature °C | R | 03 | 100 | 40101 | 40001 | 32-bit float | | |
| Humidity %RH | R | 03 | 102 | 40103 | 40001 | 32-bit float | | |
| Dew point °C | R | 03 | 104 | 40105 | 40001 | 32-bit float | | |
| $CO_2$, ppm | R | 03 | 106 | 40107 | 40001 | 32-bit float | | |
| Pressure, hPa | R | 03 | 108 | 40109 | 40001 | 32-bit float | | |
| Temperature °C | R | 03 | 200 | 40201 | 40001 | 32-bit float | | |
| Humidity %RH | R | 03 | 202 | 40203 | 40001 | 32-bit float | | |
| Dew point °C | R | 03 | 204 | 40205 | 40001 | 32-bit float | | |
| $CO_2$, ppm | R | 03 | 206 | 40207 | 40001 | 32-bit float | | |
| Pressure, mmHg | R | 03 | 208 | 40209 | 40001 | 32-bit float | | |
| Temperature °F | R | 03 | 400 | 40401 | 40001 | 32-bit float | | |
| Humidity %RH | R | 03 | 402 | 40403 | 40001 | 32-bit float | | |
| Dew point °F | R | 03 | 404 | 40405 | 40001 | 32-bit float | | |
| CO2, ppm | R | 03 | 406 | 40407 | 40001 | 32-bit float | | |
| Pressure, hPa | R | 03 | 408 | 40409 | 40001 | 32-bit float | | |
| Temperature °F | R | 03 | 500 | 40501 | 40001 | 32-bit float | | |
| Humidity %RH | R | 03 | 502 | 40503 | 40001 | 32-bit float | | |
| Dew point °F | R | 03 | 504 | 40505 | 40001 | 32-bit float | | |
| $CO_2$, ppm | R | 03 | 506 | 40507 | 40001 | 32-bit float | | |
| Pressure, mmHg | R | 03 | 508 | 40509 | 40001 | 32-bit float | | |
| Temperature °C x 100 | R | 03 | 600 | 40601 | 40001 | 16-bit sig. integer | | |
| Humidity %RH x 100 | R | 03 | 601 | 40602 | 40001 | 16-bit uns. integer | | |
| Dew point °C x 100 | R | 03 | 602 | 40603 | 40001 | 16-bit sig. integer | | |
| $CO_2$, ppm | R | 03 | 603 | 40604 | 40001 | 16-bit uns. integer | | |
| Pressure, hPa | R | 03 | 604 | 40605 | 40001 | 16-bit uns. integer | | |
| Temperature °C x 100 | R | 03 | 700 | 40701 | 40001 | 16-bit sig. integer | | |
| Humidity %RH x 100 | R | 03 | 701 | 40702 | 40001 | 16-bit uns. integer | | |
| Dew point °C x 100 | R | 03 | 702 | 40703 | 40001 | 16-bit sig. integer | | |
| $CO_2$, ppm | R | 03 | 703 | 40704 | 40001 | 16-bit uns. integer | | |
| Pressure High-Word, mmHg x 100 | R | 03 | 704 | 40705 | 40001 | 16-bit uns. integer | | |
| Pressure Low-Word, mmHg x 100 | R | 03 | 705 | 40706 | 40001 | 16-bit uns. integer | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Temperature °F x 100 | R | 03 | 900 | 40901 | 40001 | 16-bit sig. integer | | |
| Humidity %RH x 100 | R | 03 | 901 | 40902 | 40001 | 16-bit uns. integer | | |
| Dew point °F x 100 | R | 03 | 902 | 40903 | 40001 | 16-bit sig. integer | | |
| $CO_2$, ppm | R | 03 | 903 | 40904 | 40001 | 16-bit uns. integer | | |
| Pressure, hPa | R | 03 | 904 | 40905 | 40001 | 16-bit uns. integer | | |
| Temperature °F x 100 | R | 03 | 1000 | 41001 | 40001 | 16-bit sig. integer | | |
| Humidity %RH x 100 | R | 03 | 1001 | 41002 | 40001 | 16-bit uns. integer | | |
| Dew point °F x 100 | R | 03 | 1002 | 41003 | 40001 | 16-bit sig. integer | | |
| $CO_2$, ppm | R | 03 | 1003 | 41004 | 40001 | 16-bit uns. integer | | |
| Pressure High-Word, mmHg x 100 | R | 03 | 1004 | 41005 | 40001 | 16-bit uns. integer | | |
| Pressure Low-Word, mmHg x 100 | R | 03 | 1005 | 41006 | 40001 | 16-bit uns. integer | | |
| Automatic self-calibration (ASC) | R/W | 03/06 | 2002 | 42003 | 40001 | 16-bit uns. integer | 0 | 0-disable, 1-enable |
| Temperature multiplier ** | R/W | 03/16 | 2101 | 42102 | 40001 | 32-bit float | 1.000 | |
| Temperature offset °C ** | R/W | 03/16 | 2103 | 42104 | 40001 | 32-bit float | 0.000 | |
| Temperature offset °F ** | R | 03/16 | 2105 | 42106 | 40001 | 32-bit float | 0.000 | |
| Humidity multiplier ** | R/W | 03/16 | 2111 | 42112 | 40001 | 32-bit float | 1.000 | |
| Humidity offset ** | R/W | 03/16 | 2113 | 42114 | 40001 | 32-bit float | 0.000 | |
| $CO_2$ multiplier ** | R/W | 03/16 | 2115 | 42116 | 40001 | 32-bit float | 1.000 | |
| $CO_2$ offset ** | R/W | 03/16 | 2117 | 42118 | 40001 | 32-bit float | 0.000 | |
| Pressure multiplier ** | R/W | 03/16 | 2119 | 42120 | 40001 | 32-bit float | 1.000 | |
| Pressure hPa offset ** | R/W | 03/16 | 2121 | 42122 | 40001 | 32-bit float | 0.000 | |
| Pressure mmHg offset ** | R | 03 | 2123 | 42124 | 40001 | 32-bit float | 0.000 | |

The shown logic decimal addresses are calculated with offsets 40001 (holding registers).
MSWF - Most significant word first - (bits 31 … 16), (bits 15 … 0); LSWF - Least significant word first - (bits 15 … 0), (bits 31 … 16);
PDU address - Actual address bytes used in a Modbus Protocol Data unit
When a floating-point value is not available, the returned value is “NaN” (e.g. in case of measurement error).
When a 16-bit signed integer value is not available, the returned value is “-32768” (e.g. in case of measurement error).

* The settings will take effect after restarting the device by power-off, power-on.

** Measured sensor values can be corrected by employing a multiplier and an offset.
The corrections are the results of the following calculations:
Corrected Temperature (°C) = Measured Temperature (°C) × Temperature Multiplier + Temperature Offset (°C)
Corrected Humidity = Measured Humidity × Humidity Multiplier + Humidity Offset
Corrected $CO_2$ = Measured $CO_2$ × $CO_2$ Multiplier + $CO_2$ Offset
Corrected Pressure (hPa) = Measured Pressure (hPa) × Pressure Multiplier + Pressure Offset (hPa)

Using a multiplier and an offset allows precise adjustments to the sensor readings, ensuring accurate temperature, humidity, $CO_2$ and pressure values.
After obtaining the corrected temperature in Celsius, it can then be converted to Fahrenheit.
After obtaining the corrected pressure in hPa, it can then be converted to mmHg.

## 13. Recycling

Recycle all applicable material.



Do not dispose of with regular household refuse.

