

Air Humidity, Temperature and Barometric Pressure Sensor Manual

The TBSHT05/TBSHTP05 is an air humidity, temperature and barometric pressure sensor with SDI-12 interface. The sensing elements are located on a PCB in the tip of the sensor. The acquisition circuit is completely over-moulded. Temperature measurement is carried out with a F0.1 precision PT1000. Humidity measurement is based on a precision sensing element on a ceramic substrate. An additional MEMS chip measures barometric pressure. The sensor tip is protected with a replaceable filter.

Each sensor is individually factory-calibrated.

With dimensions of only 100mm x 16mm, the sensor can easily be fitted into many standard radiation shields.

While the TBSHT05 measures air humidity and air temperature, the TBSHTP05 measures air humidity, air temperature and barometric pressure.



TBSHT05/TBSHTP05 air humidity, air temperature and barometric pressure sensor

Features

- Air humidity, temperature and barometric pressure sensor
- SDI-12 Interface
- Temperature sensor: PT1000 F0.1
- Air humidity sensor tolerance: $\pm 2\%$ RH (range: 0 – 100%)
- Barometric pressure sensor tolerance: : ± 0.5 hPa (range: 300-1250hPa)
- Replaceable PTFE filter cap, 10 μ m
- SDI-12 Standard V1.3
- 6 - 17V supply voltage
- Power consumption:
 - Active: 8 mA
 - Idle: 24 μ A

- Dimensions: 100 mm x 16 mm
- Operating Temperature Range:
- 20°C ... + 55°C

Target Applications

- SDI-12 Sensor Networks

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1 Introduction

Note: this user manual is relevant only to TBSHT05 and TBSHTP05 products which have their FW version starting with 14 (TBSHT05) or 15 (TBSHTP05).

For other FW versions, refer to user manual v1.2.

Checking TBSHT05/TBSHTP05 FW version:

- Send 0!!
- Response:
 - TBSHT05: 013TBSHT5rvE123456**1400105** => TBSHT05 FW version 14.0.xx.xx
 - TBSHTP05: 013TSHTP5rvE123456**1500105** => TBSHTP05 FW version 15.0.xx.xx

1.1 Product Features

TBSHT05/TBSHTP05 is based on a factory calibrated sensor chips, a low power controller and robust SDI-12 interface hardware:

- Measurement of air humidity, air temperature, barometric pressure (optional) and calculation of absolute air humidity, dew/frost point
- 5V, 1200 baud SDI-12 data interface with transient protection
- Power supply: 6 - 17V, current: 8 mA (active) / 24µA (idle)
- Sensor dimensions: 100 mm, Ø 16 mm
- Operating temperature range: -20°C ... +55°C

1.2 Calibration

Each sensor is individually factory calibrated. No further user calibration is required.

Nevertheless for some specific conditions, additional temperature calibration methods are available. The different options are further described in a [dedicated chapter](#).

1.3 Placement

Don't expose the sensor to direct sun or precipitation. Install it in a location with permanent shadow and protection from precipitation, inside a radiation shield or in an instrument shelter.

The sensor shall not be used in condensing environment nor exposed to salt or other chemicals as it may alter the measurement accuracy or even result in damages to the sensing elements.

1.4 Installation

The TBSHT05/TBSHTP05 is compatible with any data logger or remote telemetry unit with SDI-12 interface. Refer to the data logger or RTU manual and to chapter 2 of this datasheet.

The sensor is equipped with a PTFE filter cap with a pore size of 10 micron. It is advised to replace the filter cap every year.

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1.5 SDI-12

SDI-12 is a standard for interfacing data recorders with microprocessor-based sensors. SDI-12 stands for serial/digital interface at 1200 baud. It can connect multiple sensors with a single data recorder on one cable. It supports up to 60 meter cable between a sensor and a data logger.

Tekbox SDI-12 sensors have been installed in networks with cable lengths up to 200m and with up to 40 connected sensors.

The SDI-12 standard is prepared by

**SDI-12 Support Group
(Technical Committee)
165 East 500 South
River Heights, Utah
435-752-4200
435-752-1691 (FAX)
<http://www.sdi-12.org>**

The standard is available on the website of the SDI-12 Support Group.

More information on SDI-12 is presented in chapter 3.

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2 Application Examples

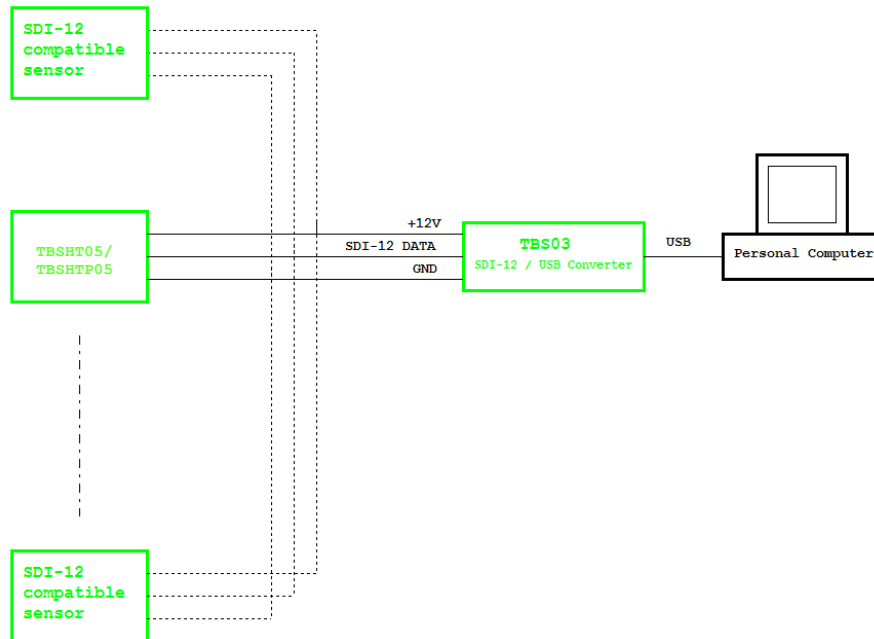


Figure 1 – TBSHT05/TBSHTP05 sensors connected to TBS03 SDI-12 to USB converter, setup for controlling / testing sensors and for PC based data recording

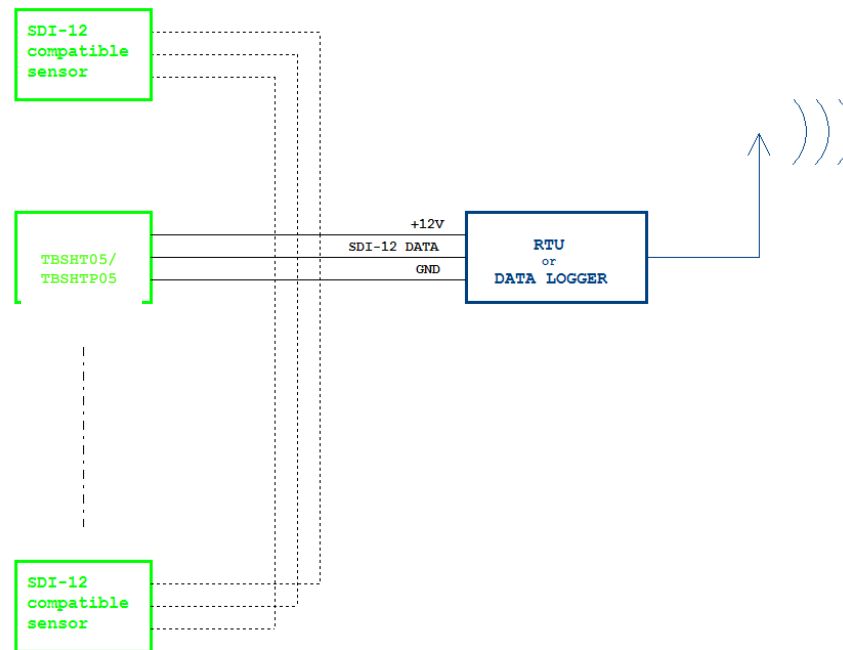


Figure 2 – TBSHT05/TBSHTP05 sensor(s) connected to Remote Telemetry Unit or Data Recorder

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3 Functional Description

3.1 Overview

The SDI-12 standard defines a set of commands to configure sensors and to initiate measurements. Upon receiving specific commands, the sensor may carry out internal tasks, respond with information on conversion time or send measurement data.

SDI-12 commands are typically ASCII strings which are generated by the data recorder/controller firmware. The TBSHT05/TBSHTP05 can be connected to a TBS03 SDI-12 to USB converter and controlled by a PC application or hyper terminal. TBS03 converts the command strings to the logic levels and baud rate specified by the SDI-12 standard. Furthermore, TBS03 handles breaks, marks and all other details of the SDI-12 protocol.

Upon receiving data or status information originated by the TBSHT05/TBSHTP05, the TBS03 extracts the corresponding ASCII strings and sends them to the USB Virtual COM Port of the PC.

In remote applications, the TBSHT05/TBSHTP05 can be connected to a data logger, a data terminal or a Radio Telemetry Unit with a SDI-12 interface.

3.2 SDI-12 Basics

The SDI-12 is a serial data communication standard for interfacing multiple sensors with a data recorder. SDI-12 uses a shared bus with 3 wires: power (+12V), data, ground Data rate: 1200 baud. Each sensor at the bus gets a unique address which is in the range ASCII [0-9, a-z, A-Z]. The default address of every sensor is ASCII[0]. When setting up a SDI-12 sensor network, every sensor needs to be configured with a unique address. This can be done using the Change Address Command. A sensor can typically measure one or more parameters. Sensor manufacturers usually specify '*Extended Commands*' to configure or calibrate sensors. These commands are specified by the manufacturer, but they follow the command structure specified by SDI-12.

A typical recorder/sensor measurement sequence proceeds as follows:

- 1) The data recorder wakes all sensors on the SDI-12 bus with a break.
- 2) The recorder transmits a command to a specific, addressed sensor, instructing it to make a measurement.
- 3) The addressed sensor responds within 15.0 milliseconds, returning the maximum time until the measurement data will be ready and the number of data values it will return.
- 4) If the measurement is immediately available, the recorder transmits a command to the sensor instructing it to return the measurement result(s). If the measurement is not ready, the data recorder waits for the sensor to send a request to the recorder, which indicates that the data is ready. The recorder then transmits a command to get the data.
- 5) The sensor responds, returning one or more measurement results.

SDI-12 Command Structure:

Each SDI-12 command is an ASCII string with up to 5 characters, starting with the sensor address and terminated by a "!" character.

Example:

Send Identification Command **0!!**

0 is the sensor address (sensor zero). Upon receiving this command, the sensor will send an ASCII string containing sensor address, SDI-12 compatibility number, company name, sensor model number, sensor version number and sensor serial number.

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The standard process to carry out a measurement is to send a measurement request upon which the sensor responds with the time that is required to carry out the measurement and the number of data items being returned. After waiting the time that the sensor requires to carry out the measurement, the data recorder sends a “*Read Command*” to get the measurement results.

Example:

Start Measurement Command **0M!**

Sensor 0 may respond **00053** which means the sensor will take 5 second to deliver 3 measurement values.

After min. 5 seconds, the data recorder can send the “*Read Data Command*” **0D0!** to which Sensor 0 replies **0+68.83+25.29+19.1626**. +68.83+25.29+19.1626 are the three measurement results corresponding to air humidity (68.83), air temperature (25.29) and dew point (19.1626).

The response string of a sensor is always in ASCII format and may contain up to 40 or up to 80 characters, depending on the type of command. Out of 40 or 80 characters, the values part of the response string may contain up to 35 or 75 characters.

3.3 Sensor Identification

The air humidity temperature sensor interface will respond with a string of the following format when sending the “*Send Identification*” command **all!**:

```
allccccccmmmmmmvvvxxxxxxxxxxxxxx<CR><LF>
```

Example: 013**TEKBOXVN****TSHTP5****rvE****123456**1500105<CR><LF>

Where:	0	SDI-12 Sensor address
	13	SDI-12 version number, version 1.3
	TEKBOXVN	Company name
	TSHTP5	Model Name
	rvE	HW version
	123456	Serial number
	1500105	FW version

Remark about the model name field *mmmmmm*:

- For TBSHTP05: *mmmmmm* is TSHTP5
- For TBSHT05: *mmmmmm* is TBSHT5

3.4 Sensor Address

Each TBSHT05/TBSHTP05 is delivered with a default address of “0”

The TBSHT05/TBSHTP05 accepts SDI-12 addresses in the range “0” to “9”, “A” to “Z” and “a” to “z”. Setting the TBSHT05/TBSHTP05 address can be done using the “*Change Address Command*” **aAb!**.

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Note:

- If the new address is invalid, the current address will be kept.
- The TBSHT05/TBSHTP05 will remain unresponsive for approximately 1 second while the new address is saved in the EEPROM memory.
- The TBSHT05/TBSHTP05 interface supports “?” as an address only for “Acknowledge Active” Command **a!**.

3.5 Measurement

The TBSHT05/TBSHTP05 sensor interface accepts the “Start Measurement” Command **aM!**, “Additional Measurement” Commands **aMn!** and “Start Concurrent Measurement” Command **aC!**, “Additional Concurrent Measurement” Commands **aCn!** for obtaining calibrated values from the probe.

The TBSHT05/TBSHTP05 sensor interface will not support the “Continuous Measurement” Command **aRn!** and “Continuous Measurement and Request CRC” Command **aRCn!**. The TBSHT05/TBSHTP05 sensor will respond with its address followed by <CR><LF> in response to this command.

The response to “Start Measurement” **aM!**, “Additional Measurement” Commands **aMn!** and “Start Concurrent Measurement” Command **aC!**, the “Additional Concurrent Measurement” Command **aCn!** reports how many sensor values will be sent. In order to receive the desired sensor values, the recorder needs to issue the corresponding “Send Data” Command(s) **aDn!**.

Note: The TBSHT05/TBSHTP05 sensor interface uses a format of “sign” followed by n digits (The n maximum is seven -7), followed by the decimal point, followed by m digits (The m maximum is one - 1) (+n.m) return readings.

3.6 Commands – Quick Reference

Measurement commands:

Commands	Parameters	Units	Example: measurements returned by 0D0! (TBSHTP05)
aM! aMC! aC! aCC!	Relative humidity, Air temperature, Dew/Frost point, Barometric pressure(*)	% °C / °F °C / °F hPa	0+68.83+25.29+19.1626+1006.53
aM1! aMC1! aC1! aCC1!	Absolute humidity, Cloud base, Altitude(*)	g/m ³ m m	0+16.14+748.433+58.2094

(*): TBSHTP05 only

Extended SDI-12 commands:

aXC!	Set temperature unit to Celsius (default factory setting)
aXF!	Set temperature unit to Fahrenheit
aXM<m>!	Select the measurement mode
aXLS<pid><rid><mid><coeff>!	Set the custom calibration parameters and coefficients
aXLG<pid><rid><mid>!	Get the custom calibration parameters and coefficients
aXG!	Get previous extended SDI-12 command execution status

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3.7 Parameters

3.7.1 Measured parameters

Only 3 parameters are actually measured while others are calculated from these values.

Parameter	Sensor	Operating range
Temperature	PT1000 Class F0.1	-20 °C to +55 °C
Relative humidity	Digital IC	0 – 100%
Barometric pressure	Digital IC (TBSHTP05)	300 – 1250 hPa

Refer to the [technical specification](#) for further details.

3.7.2 Calculated parameters

Given the below measured parameters:

- R_H : relative humidity [%]
- T : temperature [°C] (T_K : temperature in Kelvin [K])
- P_B : barometric pressure [hPa]

The following parameters are estimated:

- T_D : dew point temperature [°C]
- P_V : vapour pressure [hPa]
- P_{Vsat} : saturated vapour pressure [hPa]
- C_E : estimated cloud base [m]
- A_H = absolute humidity in g water vapour per m³ of air
- h_E : estimated altitude [m]

Using following formulas (these are given for reference only as there are many different implementations available depending on the environment and expected tolerance):

Saturated vapour pressure

It is calculated based on Tetens formula for temperature equal or above zero degree Celcius:

$$P_{Vsat} = 6.1078 * e^{17.27T/(T+237.3)}$$

And the Murray's variant is applied for negative temperatures:

$$P_{Vsat} = 6.1078 * e^{21.87T/(T+265.5)}$$

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Vapour pressure

$$P_V = (R_H / 100) * P_{Vsat}$$

Dew point (Temperature ≥ 0) / frost point (Temperature < 0)

$$T_D = (b * \alpha(T, R_H)) / (a - \alpha(T, R_H))$$

Where:

$$\alpha(T, R_H) = \ln(R_H/100) + aT/(b+T)$$

a=17.625 and b=243.04 are the Magnus coefficients values as recommended by Alduchov and Eskridge.

Absolute humidity

Temperature in Kelvin: $T_K = T + 273.15$

$$A_H = 10^5 * (m_w / R^*) * (P_V / T_K)$$

Where:

- $R^* = 8314.3 \text{ J/(kmol} \cdot \text{K)}$ (molar gas constant)
- $m_w = 18.016 \text{ kg}$ (molecular weight of water vapour)

Estimated cloud base

$$C_E = (T - T_D) * 122$$

Estimated altitude

From the barometric pressure formula, the estimated altitude is

$$h_E = - \frac{R^* T}{g * M} * \ln\left(\frac{P}{P_0}\right)$$

Where:

- $P_0 = 1013.25 \text{ hPa}$ (pressure at sea level)
- $R = 8.31432 \text{ N.m/(mol.K)}$ (universal gas constant)
- $M = 0.0289644 \text{ kg/mol}$ (air molar mass)
- $g = 9.81 \text{ m/s}^2$ (acceleration due to gravity)
- P : pressure [hPa]
- T_K : temperature [K]

3.8 Temperature and humidity calibration

TBSHT(P)05 uses a high precision PT1k Class F0.1 sensing element to measure the temperature, which ensures the following tolerance (in °C) : $0.1 + 0.0017 * |T|$.

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However the [use of a protective PTFE filter cap](#) impacts the sensor's response time depending on ambient conditions and an additional calibration might be required if there's a need to reduce it.

3.8.1 Temperature calibration

The external command **XM** allows switching between different measurement modes:

- Raw values: in that mode, no calibration is applied to the temperature measurements
 - Command: **XM0!**
- Custom calibration: in this mode, it is possible to define a custom calibration to be applied on top of temperature raw measurements by using extended command **XLS**
 - Command: **XM1!**

When the custom calibration is enabled with **XM1!**, a 2 levels custom calibration for temperature measurement can be configured by using **XLS** extended command and selecting the right index (however it's also possible to apply just one calibration method – cf below for details).

Given T_{raw} the raw temperature measured by the digital IC, the following 2 levels calibration is performed so T_{final} is returned by SDI-12 measurement command:

- First calibration level (**XLS0**): $T_{Cal_lvl1} = T_{raw} + M_{lvl1}(T_{raw})$
- Second calibration level (**XLS1**): $T_{final} = T_{Cal_lvl1} + M_{lvl2}(T_{Cal_lvl1})$

Where M_{lvl1} and M_{lvl2} are one of the 4 available calibration methods.

4 different calibration methods are available on top of temperature raw values over the $[T_{Min}; T_{Max}]$ operating range:

- Method (O) - Offset: $T_{Meas} = T_{raw} + Offset$
- Method (L) – Linear: $T_{Meas} = aT_{raw} + b$
- Method (P) – Polynomial: $T_{Meas} = aT_{raw}^3 + bT_{raw}^2 + cT_{raw} + d$
- Method (R) – Multi ranges polynomials: same as above but up to 3 polynomials can be applied to 3 different and consecutive temperature ranges covering the whole operating range.

Notes:

- If only the first level is required, then the second level shall be configured with **XLS100min,max,0!**
 - This is the default configuration.
- The first calibration level is configured at production time for each TBSHT(P)05 by applying an individual offset to reduce the response time which is impacted by the use of thermal tape and PTFE filter.
 - It is advised to keep this factory calibration enabled.

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Example:

TBSHT05 is deployed in an area where the actual temperature ranges from -10 °C to +25 °C. The factory calibration for the first level is kept as an offset calibration (first method: O).

On top of it, a multi-ranges polynomials calibration is applied for the second calibration level (method R):

- Polynomial P₁ when temperature is within [-10 °C; 0 °C]
- Polynomial P₂ when temperature is within [0 °C; +10 °C]
- Polynomial P₃ when temperature is within [+10 °C; +25 °C]

The **second method** applied is multi polynomials calibration over these 3 temperature ranges:

- Range 0: -10 °C to 0 °C – Polynomial P₁ with coefficients a_1, b_1, c_1, d_1
 - 0XLS10R-10,0, a_1, b_1, c_1, d_1 !
- Range 1: 0 °C to 10 °C – Polynomial P₂ with coefficients a_2, b_2, c_2, d_2
 - 0XLS11R0,10, a_2, b_2, c_2, d_2 !
- Range 2: 10 °C to 25 °C – Polynomial P₃ with coefficients a_3, b_3, c_3, d_3
 - 0XLS12R10,25, a_3, b_3, c_3, d_3 !

The calibration coefficients can be retrieved by using commands XLG/XG for a given parameter calibration index and calibration method.

For instance in the case of a polynomial calibration (parameter calibration index 2 and method P):

```
0XLS20P0,100,0.00009,-0.0129,0.6216,-6.784!
```

```
0Receive_OK
```

```
0XLG20P!
```

```
0Receive_OK
```

```
0XG!
```

```
0P+0,+100,+0.00009,-0.0129,+0.62159,-6.78399
```

3.8.2 Humidity calibration

TBSHT(P)05 measures the air humidity level through a digital IC and does not apply any compensation of this measurement.

Would there be a need to adjust the measured humidity, the commands **XLS** can still be used but with the calibration index set to 2 or 3:

- **XLS2...** to configure the first calibration level
- **XLS3...** to configure the second calibration level

Besides the specific calibration indexes used for humidity calibration, XLS command shall be used exactly as described in previous chapter.

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3.9 Supported SDI-12 Commands

Following commands are supported by the TBSHT05/TBSHTP05:

Command	Description	Response
a!	Acknowledge Active	a<CR><LF>
a!	Send Identification	Identification information a13TEKBOXVN<mmmmmm>rv<h><nnnnnn><ffffff><CR><LF> With: <ul style="list-style-type: none"> ◦ <a>: SDI-12 address ◦ <mmmmmm>: model name <ul style="list-style-type: none"> ◦ TBSHT05: <i>TBSHT5</i> ◦ TBSHTP05: <i>TSHTP5</i> ◦ <h>: HW revision (one letter) ◦ <nnnnnn>: serial number (6 digits) ◦ <ffffff>: firmware version (7 digits) Example: 013TEKBOXVNTSHTP5rvE1234561500100<CR><LF>
aAb!	Change Address	b<CR><LF> Changing the probe sensor address
?!	Address Query	a<CR><LF>
aM!	Start Measurement Measures: <ul style="list-style-type: none"> ◦ relative humidity [%] ◦ air temperature [°C or °F] ◦ dew/frost point [°C or °F] ◦ barometric pressure^(*) [hPa] 	TBSHT05: a0043<CR><LF> Delay (4) seconds and number of values (3) TBSHTP05: a0044<CR><LF> Delay (4) seconds and number of values (4)
aM1!	Additional Measurement Measures: <ul style="list-style-type: none"> ◦ absolute humidity [g/m³] ◦ cloud base [m] ◦ altitude^(*) [m] 	TBSHT05: a0042<CR><LF> Delay (4) seconds and number of values (2) TBSHTP05: a0043<CR><LF> Delay (4) seconds and number of values (3)
aMC!	Start Measurement and Request CRC	TBSHT05: a0043<CR><LF> Delay (4) seconds and number of values (3)

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	Measures: <ul style="list-style-type: none"> ○ relative humidity [%] ○ air temperature [°C or °F] ○ dew/frost point [°C or °F] ○ barometric pressure^(*) [hPa] 	TBSHTP05: a0044<CR><LF> Delay (4) seconds and number of values (4)
aMC1!	Additional Measurement and Request CRC Measures: <ul style="list-style-type: none"> ○ absolute humidity [g/m³] ○ cloud base [m] ○ altitude^(*) [m] 	TBSHT05: a0042<CR><LF> Delay (4) seconds and number of values (2) TBSHTP05: a0043<CR><LF> Delay (4) seconds and number of values (3)
aC!	Start Concurrent Measurement Measures: <ul style="list-style-type: none"> ○ relative humidity [%] ○ air temperature [°C or °F] ○ dew/frost point [°C or °F] ○ barometric pressure^(*) [hPa] 	TBSHT05: a00403<CR><LF> Delay (4) seconds and number of values (3) TBSHTP05: a00404<CR><LF> Delay (4) seconds and number of values (4)
aC1!	Additional Concurrent Measurement Measures: <ul style="list-style-type: none"> ○ absolute humidity [g/m³] ○ cloud base [m] ○ altitude^(*) [m] 	TBSHT05: a00402<CR><LF> Delay (4) seconds and number of values (2) TBSHTP05: a00403<CR><LF> Delay (4) seconds and number of values (3)
aCC!	Start Concurrent Measurement and Request CRC Measures: <ul style="list-style-type: none"> ○ relative humidity [%] ○ air temperature [°C or °F] ○ dew/frost point [°C or °F] ○ barometric pressure^(*) [hPa] 	TBSHT05: a00403<CR><LF> Delay (4) seconds and number of values (3) TBSHTP05: a00404<CR><LF> Delay (4) seconds and number of values (4)

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aCC1!	Additional Concurrent Measurement and Request CRC Measures: <ul style="list-style-type: none"> absolute humidity [g/m³] cloud base [m] altitude(*) [m] 	TBSHT05: a00402<CR><LF> Delay (4) seconds and number of values (2) TBSHTP05: a00403<CR><LF> Delay (4) seconds and number of values (3)
aV!	Start Verification	a0000<CR><LF> Not supported
aRn!	Continuous Measurement	a<CR><LF> Not supported
aRCn!	Continuous Measurement and Request CRC	a<CRC><CR><LF> Not supported

(*): TBSHTP05 only

Table 1 – Standard SDI-12 commands

3.10 Supported Extended Commands

Command	Description	Response
aXC!	Temperature unit Celsius (default factory setting)	aReceive_OK<CR><LF>
aXF!	Temperature unit Fahrenheit	aReceive_OK<CR><LF>
aXM<m>!	Temperature measurement mode: temperature is reported <m>: calibration method <ul style="list-style-type: none"> 0: as raw values 1: with custom calibration (default) 	aReceive_OK<CR><LF>
aXLS<pid><rid><mid><coeff>!	Sets custom calibration parameters – aXM1! must be sent beforehand. <pid>: parameter calibration index <ul style="list-style-type: none"> 0: 1st calibration method applied to temperature 1: 2nd calibration method applied to temperature 2: 1st calibration method applied to humidity 3: 2nd calibration method applied to humidity <rid>: range index (0 – 2) when multi-polynomial method is used (mid=R). Set to zero otherwise.	aReceive_OK<CR><LF>

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	<p><mid>: calibration method index</p> <ul style="list-style-type: none"> ○ O: Offset ○ L: Linear ○ P: Polynomial ○ R: multi-ranges polynomials <p><coeff>: coefficients list, depends on <mid> setting</p> <ul style="list-style-type: none"> ○ O: <i>min,max,offset</i> ○ L: <i>min,max,a,b</i> ○ P: <i>min,max,a,b,c,d</i> ○ R: <i>min,max,a,b,c,d</i> ○ Where: <ul style="list-style-type: none"> ○ <i>min/max/offset/a/b/c/d</i> are float numbers ○ <i>a/b/c/d</i> are polynomial coefficients (maximum of 5 decimal digits) ○ <i>min/max</i>: whole temperature or humidity operating range. In case the multi-range polynomial method is used, it defines the boundaries of each range (selected by <i>rid</i>). 	
aXLG<pid><rid><mid>!	<p>Select custom calibration coefficients to be retrieved depending on calibration index <i>pid</i> and calibration method <i>mid</i>.</p> <p>If <i>mid</i>=R then <i>rid</i> can hold indexes 0, 1 or 2, otherwise this parameter must be set to zero.</p> <p>The values can then be retrieved using aXG! Command.</p>	aReceive_OK<CR><LF>
aXG!	<p>Get the status of previously executed extended SDI-12 command.</p> <p>If aXLG command has been previously executed, it will return the calibration coefficients</p> <p>Returned coefficients have the same format than SDI-12 data command aDx! response</p>	<p>aX_OK<CR><LF></p> <p>or</p> <p>aX_FAIL<CR><LF></p> <p>or</p> <p>a<coeff><CR><LF></p> <p>Where: <coeff>: coefficients list, depends on <mid> setting</p>

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		<ul style="list-style-type: none"> ○ O: <i>min,max,offset</i> ○ L: <i>min,max,a,b</i> ○ P: <i>min,max,a,b,c,d</i> ○ R: <i>min,max,a,b,c,d</i>
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Table 2 – Extended SDI-12 Commands

4 Technical specification

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Electrical characteristics						
I _s	Supply current	Active mode		8		mA
I _s	Supply current	Sleep mode		24		μA
V _s	Supply voltage		6	12	17	V
Temperature sensor						
α	Temperature coefficient	As defined in IEC60751		3850		ppm/K
T _{Class}	Tolerance class	As defined in IEC60751	F 0.1			
T _{Drift}	Long-term stability	At 1000h at maximum operating temperature		< 0.04		%
t _{0.63}	Response time	At air wind speed: 1 m/s		1.2		s
T _{res}	Temperature resolution			0.01		°C
T _{range}	Temperature measurement range		-40		+85	°C
Humidity sensor						
RH _{range}	Relative humidity measurement range		0		100	%RH
RH _{res}	Relative humidity resolution			0.01		%RH
RH _{tol}	Relative humidity accuracy tolerance			±2	see Figure 3	%RH
RH _h	Relative humidity hysteresis	At 25 °C		±0.8		%RH
RH _{rep}	Relative humidity repeatability	Medium		±0.15		%RH
RH _{drift}	Relative humidity long term drift			<0.25		%RH / year
Pressure sensor						

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Symbol	Parameter	Conditions	Min	Typ	Max	Unit
P	Barometric pressure range	With temperature between -40 °C and +85 °C (full accuracy: 0°C and +65 °C)	300	-	1250	hPa
A _{rel}	Relative pressure accuracy	700 ... 1100 hPa +25 °C to +40 °C 10kPa steps		±0.03		hPa
A ^P _{full}	Absolute pressure accuracy	900 hPa +25 °C		±0.33		hPa
A ^P _{full}		300 ... 1100 hPa 0 ... +65 °C		±0.50		hPa
A ^P _{ext}		900 ... 1100 hPa +25 °C ... +40 °C		±0.40		hPa
A ^P		1100 ... 1250 hPa 0 °C ... +65 °C		±0.50		hPa
A ^P		300 ... 1100 hPa -20 °C		±0.50		hPa
TCO	Temperature coefficient offset	900 hPa, +25 °C to +40 °C		±0.6		Pa/K
ΔP _{Stab}	Long term stability	12 months		±0.16		hPa

Table 3 – Technical specification

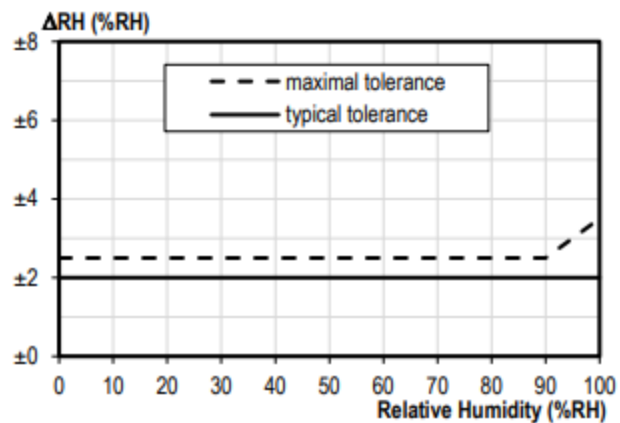


Figure 3 – RH, typical and maximum tolerance at 25°C

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5 Environmental Specifications

Symbol	Parameter	Conditions	Min	Max	Unit
T_A	Operating Ambient Temperature Range		-20	+55	°C
T_{STG}	Storage Temperature Range		-50	+90	°C
	Humidity level		0	100	%

Table 4 - Environmental Specifications

6 Cable Connection

Cable Colour	Signal Assignment
Blue	SDI-12 Power
Yellow	SDI-12 Data
Brown	GND
Black	Shield (GND)

Table 5 – Cable Connection

7 Ordering Information

Part Number	Description
TBSHT05	Air Humidity, Temperature, SDI-12 Interface
TBSHTP05	Air Humidity, Temperature, Barometric Pressure sensor, SDI-12 Interface
ATRH_FIL	Replacement filter cap, PTFE, 10µm pore diameter

Table 6 – Ordering Information

8 History

Version	Date	Author	Changes
V1.0	5.04.2015	Mayerhofer	Creation of the document

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V1.1	20.12.2019	Mayerhofer	Table 4 update
V1.2	18.03.2020	Mayerhofer	Update from TBSHT(P)03 to new version TBSHT(P)05
V2.0	25.05.2023	Philippe Hervieu	Update SDI-12 commands description following FW upgrade and pressure sensor change ((BMP390)
V2.1	16.10.2023	Philippe Hervieu	Temperature tolerance with/without filter cap
V2.2	31.10.2023	Michael Mayerhofer	Internal release
V2.3	01.12.2023	Philippe Hervieu	SDI-12 calibration commands / sensing elements specification
V2.4	03.01.2024	Philippe Hervieu	Update example in 3.2
V2.5	14.10.2024	Philippe Hervieu	Modify extended commands related to calibration / Update chapter 3.7 (calibration)
V2.6	07.11.2024	Philippe Hervieu	Update operating temperature range

Table 7 – History