Application Note

Humidity Compensation for BME280: Impact of Material inside Device

Application Note

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Notes	Data and descriptions in this document are subject to change without notice. Product photos and pictures are for illustration purposes only and may differ from the real product appearance.

BME280
Digital Humidity, Pressure and Temperature Sensor

Key features

▶ Package	2.5 mm x 2.5 mm x 0.93 mm metal lid LGA
▶ Digital interface	I²C (up to 3.4 MHz) and SPI (3 and 4 wire, up to 10 MHz)
▶ Supply voltage	V_{DD} main supply voltage range: 1.71 V to 3.6 V V_{DDIO} interface voltage range: 1.2 V to 3.6 V
▶ Current consumption	1.8 µA @ 1 Hz humidity and temperature 2.8 µA @ 1 Hz pressure and temperature 3.6 µA @ 1 Hz humidity, pressure and temperature 0.1 µA in sleep mode
▶ Operating range	-40…+85 °C, 0…100 % rel. humidity, 300…1100 hPa

- Humidity sensor and pressure sensor can be independently enabled / disabled
- Register and performance compatible to Bosch Sensortec BMP280 digital pressure sensor
- RoHS compliant, halogen-free, MSL1

Key parameters for humidity sensor

▶ Response time ($\tau_{63\%}$)	1 s
▶ Accuracy tolerance	±3 % relative humidity
▶ Hysteresis	±1% relative humidity

Key parameters for pressure sensor

▶ RMS Noise	0.2 Pa, equiv. to 1.7 cm
▶ Offset temperature coefficient	±1.5 Pa/K, equiv. to ±12.6 cm at 1 °C temperature change

Typical applications

- Context awareness, e.g. skin detection, room change detection
- Fitness monitoring / well-being
  - Warning regarding dryness or high temperatures
  - Measurement of volume and air flow
- Home automation control
  - Control heating, venting, air conditioning (HVAC)
- Internet of things
- GPS enhancement (e.g. time-to-first-fix improvement, dead reckoning, slope detection)
- Indoor navigation (change of floor detection, elevator detection)
- Outdoor navigation, leisure and sports applications
- Weather forecast
- Vertical velocity indication (rise/sink speed)

Target Devices

- Handsets such as mobile phones, tablet PCs, GPS devices
- Navigation systems
- Gaming, e.g flying toys
- Camera (DSC, video)

General Description

The BME280 is as combined digital humidity, pressure and temperature sensor based on proven sensing principles. The sensor module is housed in an extremely compact metal-lid LGA package with a footprint of only 2.5 × 2.5 mm² with a height of 0.93 mm. Its small dimensions and its low power consumption allow the implementation in battery driven devices such as handsets, GPS modules or watches. The BME280 is register and performance compatible to the Bosch Sensortec BMP280 digital pressure sensor:

The BME280 achieves high performance in all applications requiring humidity and pressure measurement. These emerging applications of home automation control, in-door navigation, fitness as well as GPS refinement require a high accuracy and a low TCO at the same time.

The humidity sensor provides an extremely fast response time for fast context awareness applications and high overall accuracy over a wide temperature range.

The pressure sensor is an absolute barometric pressure sensor with extremely high accuracy and resolution and drastically lower noise than the Bosch Sensortec BMP180.

The integrated temperature sensor has been optimized for lowest noise and highest resolution. Its output is used for temperature compensation of the pressure and humidity sensors and can also be used for estimation of the ambient temperature.

The sensor provides both SPI and I²C interfaces and can be supplied using 1.71 to 3.6 V for the sensor supply VDD and 1.2 to 3.6 V for the interface supply VDDIO¬. Measurements can be triggered by the host or performed in regular intervals. When the sensor is disabled, current consumption drops to 0.1 µA.

BME280 can be operated in three power modes.

- sleep mode
- normal mode
- forced mode

In order to tailor data rate, noise, response time and current consumption to the needs of the user, a variety of oversampling modes, filter modes and data rates can be selected.

Please contact your regional Bosch Sensortec partner for more information about software packages.

Table of contents

1 Introduction

The relative humidity (rH) measured by a sensor integrated inside a device, e.g. a phone, can be influenced by some factors. Among those factors, one is material used near the sensor inside the device because it can 'pollute' the sensitive element, leading to errors in the humidity measurement. Therefore, a compensation is necessary for humidity measurement with high accuracy.

This compensation can be implemented by using a two-point-correction and reference salt method. Firstly, device with sensor is tested in environment with stable/known humidity (rH_{actu}), marked the reading of sensor as rH_{meas}, and this environment could be produced by using reference salt method (at least 2 different humidity levels, H1, H2). Secondly, a linear relationship $f(rH_{meas})$ between rH_{meas} and rH_{actu} is fitted according ($rH_{meas,H1}$, $rH_{actu,H1}$) and ($rH_{meas,H2}$, $rH_{actu,H2}$). Finally, the humidity reading of sensor is compensated: $rH_{comp}= f(rH_{meas})$.

This document describes how to implement humidity compensation for material impact.

2 Humidity measurements with reference salts

Using different salt is the most accurate way to get well defined relative humidity values in a cavity/gasket. The basic idea is saturated solution create a stable humidity environment in closing space. For more details, please see http://www.omega.com/temperature/z/pdf/z103.pdf

Using chemicals could be dangerous. Therefore, it is recommended using only non-critical chemicals for this test. The following chemicals are suggested:

- Potassium acetate (food additive) → Reference humidity at 23%rH
- Sodium Chloride (table salt) → Reference humidity at 75%Rh

Saturated solutions should be kept in an air tight box (e.g. Lock & Lock), as shown in Figure 1. After a certain time (depending on surface vs. volume in the box), the humidity will be stable. It may take up to 12h.

Figure 1: One example of an air tight box used for reference salt test: Lock & Lock

Please note: Three points have to be considered during salt test:

- The phones shouldn't be stacked in box, as shown in Figure 2.

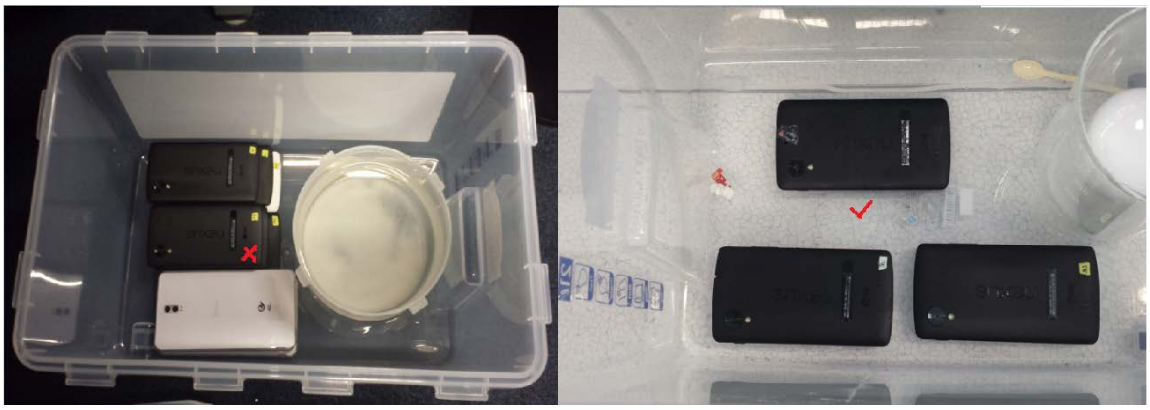

Figure 2: Guide how to place phone in box

- The saturated solution is placed in a cup or a bowel. The bigger surface of solution or the smaller volume of box will speed up stable time.
- Solubility of potassium acetate (Table 1): see http://en.wikipedia.org/wiki/Potassium_acetate. In order to get saturated potassium acetate solution it is recommend to use not too much water (100ml) because the solubility of potassium acetate under 25°C is 268.6 g/100 mL, while that of NaCl is 360g/L.

Table 1: Solubility of potassium acetate

Temperature (°C)	**0.1**	**10**	25	**40**	**96**
Solubility in water (g/100 mL)	216.7	233.8	**268.6**	320.8	390.7

3 Humidity compensation with 2-point correction

The compensation includes 2 steps: establishment of compensation model, and implementation of compensation.

In the first step,

- Select test devices: a significant number of test devices (min 5, marked as rH_{D1}, rH_{D2}...) is preferred because enough statistic among sensors/devices is necessary to avoid measuring variances of sensor/device structure as offset.
- Select test salt (humidity points) in reference salt method: a set of different humidity points (at least 2 points, e.g. potassium acetate 23%rH and sodium Chloride 75%rH, marked as rH_{H1}, rH_{H2}...) is used to fit a linear ship.
- Test these devices: note actual humidity as rH_{actu}, and record measured humidity as rH_{meas}.
- Collect all of data, as shown in Figure 3: ($rH_{meas,H1,D1}$, $rH_{actu,H1,D1}$), ($rH_{meas,H2,D1}$, $rH_{actu,H2,D1}$)...
- Fit a linear ship between rH_{meas} and rH_{actu}: $rH_{actu} = f(rH_{meas})$.

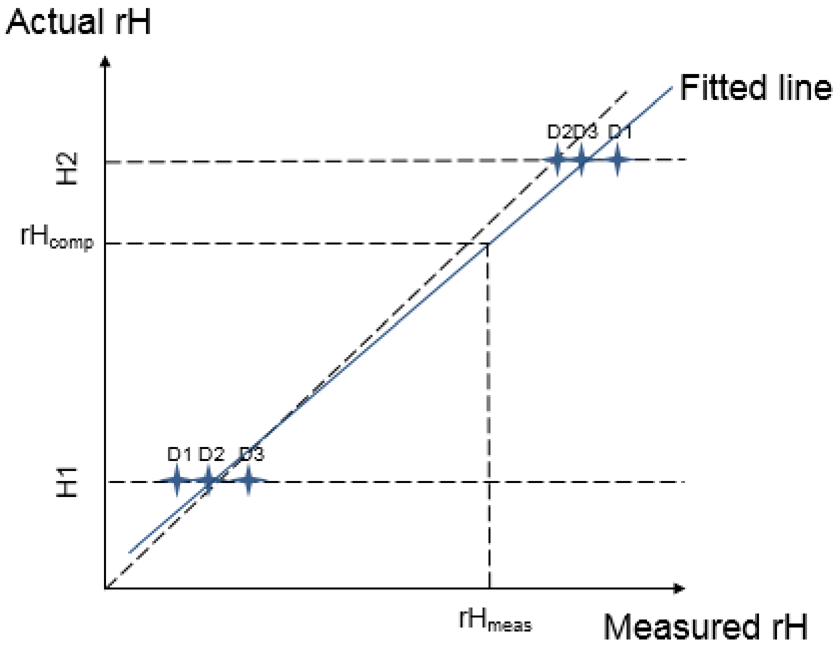

Figure 3: Shematic of humidity compensation

In the second step, the humidity reading of sensor is compensated: $rH_{comp} = f(rH_{meas})$.

Please note: some material will disappear after a certain time, while some will stay there and only disappear after reconditioning. Therefore, the test after reconditioning is recommended.

4 Legal disclaimer

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5 Document history and modifications

Rev. No	Chapter	Description of modification/changes	Date
1.0		Initial release	May 2017
1.1		Update secondary Interface	August 2018
1.2	4	Update Legal disclaimer	November 2019

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