BME680
Self test

BME680 – Application Note

Document revision	1.6
Document release date	September 2020
Document number	BST-BME680-AN014-06
Technical reference code(s)	0 273 141 229; 0 273 141 312
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.

BME680

Digital low power gas, pressure, temperature & humidity sensor

The BME680 is a digital 4-in-1 sensor with gas, humidity, pressure and temperature measurement based on proven sensing principles. The sensor module is housed in an extremely compact metal-lid LGA package with a footprint of only 3.0 × 3.0 mm² with a maximum height of 1.00 mm (0.93 ± 0.07 mm). Its small dimensions and its low power consumption enable the integration in battery-powered or frequency-coupled devices, such as handsets or wearables.

Key features

- High performance gas, pressure, temperature and humidity sensors
- Very low power consumption: 3.6 µA @ 1 Hz humidity, pressure and temperature & 0.1–16 mA for p/h/T/gas depending on operation mode
- Very small 3.0 x 3.0 mm² footprint, height 1.0 mm
- Wide power supply range: 1.71 V ... 3.6 V
- Flexible digital interface to connect to host over I^2C or SPI

Typical applications

- Indoor air quality
- Home automation and control
- Internet of things
- Weather forecast
- 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
- Vertical velocity indication (rise/sink speed)

Target Devices

- Handsets such as mobile phones, tablet PCs, GPS devices
- Wearables
- Home weather stations
- Smart watches
- Navigation systems
- Gaming, e.g. flying toys
- IOT devices

Sensor features

The BME680 achieves high performance in all applications requiring gas, temperature, pressure and humidity measurement. Emerging applications such as home automation, indoor navigation, personalized weather stations and innovative sport and fitness tools require a gas sensor with quick response time, a pressure sensor with high relative accuracy and a low TCO, in combination with fast response, high accuracy, relative humidity and ambient temperature measurements. The BME680 is ideally suited for such barometer applications as the device features excellent relative accuracy of ±0.12 hPa (equivalent to ±1 m difference in altitude) and an offset temperature coefficient (TCO) of only 1.3 Pa/K (equivalent to 10.9 cm/K).

The gas sensor within the BME680 can detect a broad range of gases to measure indoor air quality for personal well-being. Gases that can be detected by the BME680 include: Volatile Organic Compounds (VOC) from paints (such as formaldehyde), lacquers, paint strippers, cleaning, supplies, furnishings, office equipment, glues, adhesives and alcohol.

The humidity sensor provides an extremely fast response time, particularly designed for fast context-awareness applications. In addition, it ensures a high accuracy over a wide temperature range. On the other hand, the integrated temperature sensor has been optimized for lowest noise and highest resolution. Its output is used for temperature compensation of the humidity, pressure and gas sensors and can also be used as well for estimation of the ambient temperature. Moreover, the pressure sensor is an absolute barometric pressure sensor with extremely high accuracy and resolution.

Technical specifications

The sensor provides both SPI (3-wire/4-wire) and I²C digital 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, the current consumption drops to 0.1 µA. Furthermore, a variety of oversampling modes, filter modes and data rates can be selected in order to tailor, for example the data rate, noise, response time and current consumption, to the requirements of the target application.

The sensor can be operated in 2 low-level power modes: sleep mode and forced mode. No measurements are performed during sleep mode for minimal power consumption. In forced mode, temperature, pressure, humidity and gas (TPHG) conversion are performed sequentially. The sensor automatically returns to sleep mode afterwards, the gas sensor heater only operates during gas sub-measurement.

The sensor module is housed in an extremely compact 8-pin metal-lid LGA package with a footprint of only 3.0 x 3.0 and 1.0 package height.

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1. Application note objective

This document provides an explanation to the self test code for the Bosch Sensortec BME680. The intention of this self-test is only to verify the functionality of new sensors after soldering at the production site. The code itself refers to the API (Application Programming Interface) of the sensor, which can be obtained from https://github.com/BoschSensortec/BME680_driver .

2. Self-Test Flow

The self-test starts by performing a soft reset of the device. After this, Chip-ID and trimming data are read and verified. A flow chart is given below in Figure 1.
Then temperature, pressure and humidity sensor signals are measured and compared against customisable plausibility limits. The default values for pressure, humidity and temperature plausible check limits are given in chapter 2.2. The Gas sensor signal self-test is described in chapter 2.3.

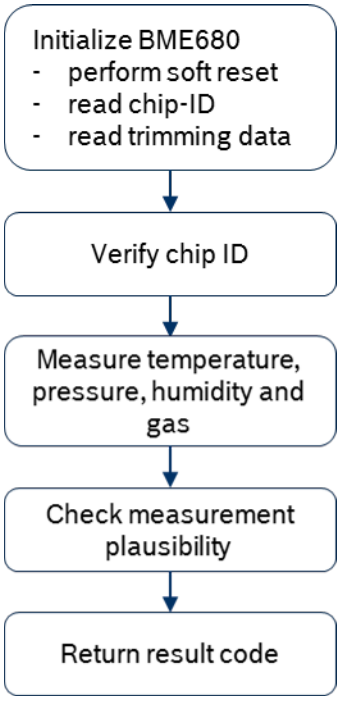

Figure 1: Self-test flow chart

2.1 Verification of Chip-ID

The Chip-ID is written in the register 0xD0 which needs to be read for the verification.

2.2 Pressure, Humidity and Temperature plausible check

For the plausibility check, the BME680 has to be operated in clean air. An operation time of at least 10 seconds is recommended to ensure stable signals.

The pressure, humidity and temperature signals are plausible if they are in the limits given in the table below.

Table 1: Pressure, Humidity and Temperature plausible check

Signal Parameter	Default Limit	Unit
Humidity	20…80	% r.H.
Pressure	900…1100	hPa
Temperature	0…60	°C

2.3 Gas functionality test

For the gas sensor functionality test, the following parameters need to be compared to verify the proper control of heater and gas sensor resistance:

- Heater ON for 1 s at 350 °C (readout IDAC). IDAC should not be 0x00 or 0xff
- Check if Gas_valid bit is available

For the gas sensing layer functionality test, the BME680 has to operate in the heater temperature cycling mode that is cycling between low to high temperatures. Please make sure that the BME680 sensors are operated in clean air (without reducing gases or silicone containing environments).

The test is being conducted by cycling the gas sensor heater between two temperature values that have a hold time of 2 seconds. The cycling mode contains cycling between high (350 °C) and low (150 °C) temperatures. The starting temperature shall be the high temperature. It is required, that at least 3 cycles are completed. An operation time of at least 12 seconds is recommended to ensure stable signals. See also the output resistance values in Figure 2.

Within the first 12 seconds of operation for the high (HT) and low (LT) heater temperatures, the baseline resistance shall be within the range >5 kΩ for HT and >30 kΩ for the LT heater temperatures. See also the data for a typical sensor in Figure 2.

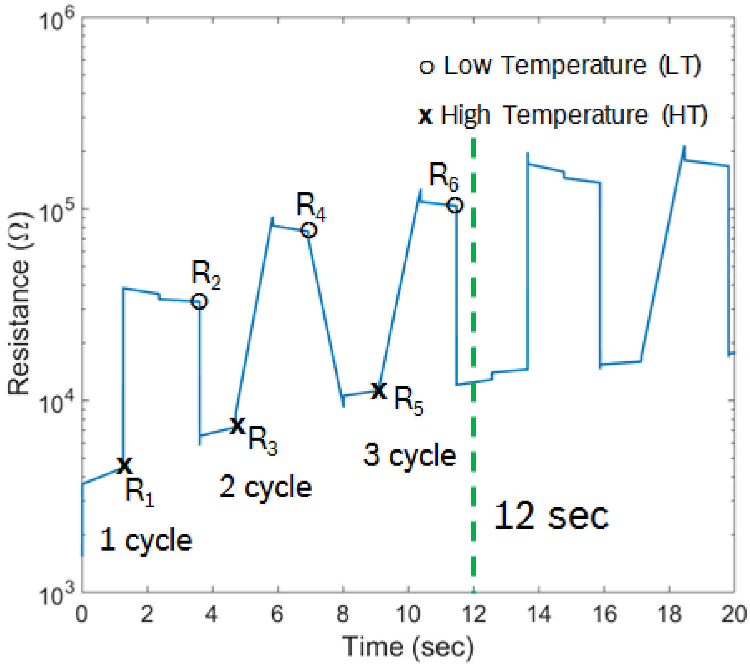

Figure 2: BME680 output resistance towards heater cycle temperatures. The marks are extracted baseline values for the high HT (x) and low LT (o) heater temperature values.

By having the information of HT and LT resistance values and considering it in the power on stabilization performance within the first time of operation a centroid resistance ratio between HT and LT has to be considered to extract the functionality.

For the calculation of the centroid resistance ratio, the two LT resistance values R_4 and R_6 and the HT resistance value R_5 are required. The resistance ratio is calculated as follows $CRR = 5 \cdot (R_4 + R_6)/(2 \cdot R_5)$.

In order to pass the functionality test, the centroid resistance ratio CRR values shall pass a certain threshold given in the API within the first 12 seconds of operation. See also the Figure 3:

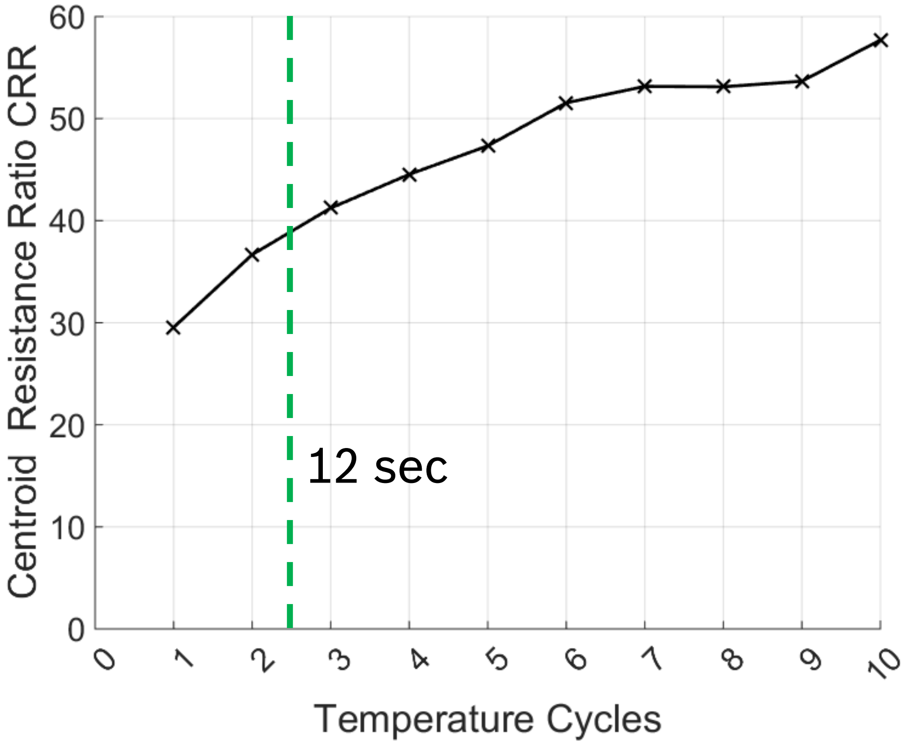

Figure 3: Resistance ratio over two subsequent temperature cycles. After the third temperature cycle (12sec) the centroid resistance ratio shall pass a certain threshold value given in the API

3. Function explanation

3.1 Communication test

This function attempts to read the Chip ID. If it is correct, a functioning communication is assumed. Note that the write function functionality is not explicitly tested.

3.2 Bond wire test

A gas, humidity, pressure and temperature measurement is performed and uncompensated pressure and temperature values are read out. If the measurement results are clipped to the respective minimum or maximum ADC values, this is usually caused by defective bond wires. However, a defective sensing element could also cause this test to fail.
Please note that some combinations of bond wire or sensing element defects do not result in clipping of the measurement value and will therefore not be detected with this test. These cases can be detected by the plausibility test instead.

3.3 Measurement plausibility test

The pressure and temperature values read out previously are compensated using the read out compensation parameters. The compensated temperature and pressure is compared against plausibility limits as shown in Table 1.

4. Legal disclaimer

4.1 Engineering samples

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5. Document history and modifications

Rev. No	Chapter	Description of modification/changes	Date
1.0		Initial release	July 2017
1.1		Additional comments that test only works with new sensors Updates of gas self test limits and all graphs based on current knowledge	August 2017
1.2		Update of Table 1 regarding plausible temperature range Revision of document format/update links to tables/chapters	September 2017
1.3	2.4	Update of threshold value of centroid resistance ratio	May 2018
1.4	2.4	Update of centroid resistance ratio graph	May 2018
1.5	2, 3	Update Self-test part aligned with self-test code on Github	June 2020
1.6		Technical reference code updated	September 2020

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Modifications reserved | Printed in Germany
Preliminary - specifications subject to change without notice
Document number: BST-BME680-AN014-06
Revision_1.6_092020