

BME680

Low power gas, pressure, temperature & humidity sensor



BME680: Handling, Soldering and Mounting Instructions

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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 $3.0 \times 3.0 \text{ mm}^2$ with a maximum height of 1.00 mm ($0.93 \pm 0.07 \text{ mm}$). 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: $3.6 \mu\text{A}$ @ 1 Hz humidity, pressure and temperature & 0.1–16 mA for p/h/T/gas depending on operation mode
- Very small $3.0 \times 3.0 \text{ mm}^2$ footprint, height 1.0 mm
- Wide power supply range: 1.71 V ... 3.6 V
- Flexible digital interface to connect to host over I²C 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 1.5 Pa/K (equivalent to 12.6cm/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 μ A. 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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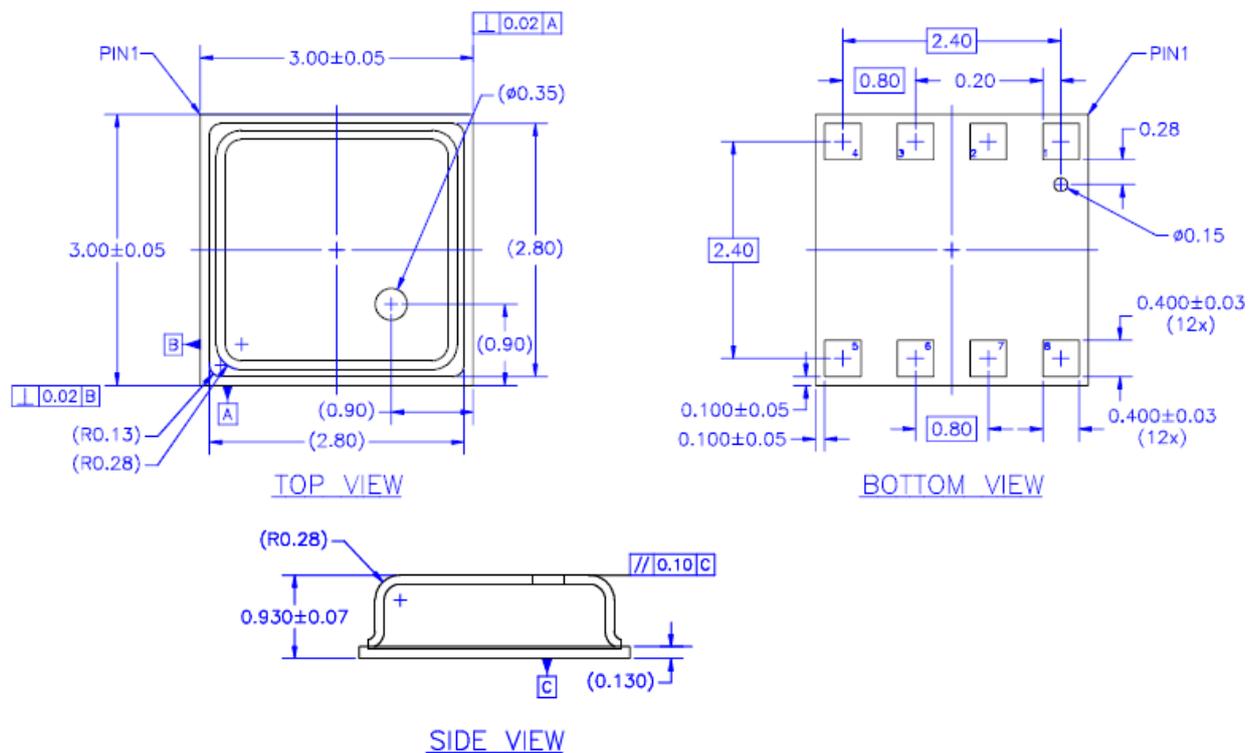
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1 Introduction

This technical note provides the main recommendations to handle, solder and mount the environmental sensor BME6xy. Using the instructions and guidelines presented herein will help to prevent the damage of the sensor and the resultant loss of warranty. Moreover, it is strongly advised to study the BME6xy datasheet prior the use of this document. For further information, please contact the nearest Bosch Sensortec representative.

2 Package Description

The sensor is packaged in a standard land grid array (LGA). The footprint of the package consists of 8 peripheral contact pads (0.4x0.4 mm²). A metal lid with a vent hole (Ø 0.35 mm) is attached to the top to protect the sensor yet enabling contact to the surrounding environment. The sensor can be electrically connected to a printed circuit board (PCB) either by the use of a socket or by soldering using a surface mount technology (SMD). Figure 1 illustrates the package dimensions in millimeters.



2. REFERENCE SPECIFICATIONS:
 - A. AWW SPEC #001-0531-2234: PACKING OPERATION PROCEDURE.
 - B. AWW SPEC #001-0519-2062: MARKING.

1. ALL DIMENSIONS AND TOLERANCES CONFORM TO ANSI Y14.5M-1994.

NOTES: UNLESS OTHERWISE SPECIFIED

Figure 1: BME6xy package dimensions (in millimeter) for top, bottom and side view

3 Device Marking

In order to facilitate traceability, a clear laser-marking is engraved on the metal housing. Tables 1 and 2 presents the marking for mass production parts and the engineering samples, respectively.

Table 1: Marking of mass production parts

Marking	Symbol	Description
	CCC	<u>Lot counter</u> : 3 alphanumeric digits, variable to generate mass production trace-code
	T	<u>Product number</u> : 1 alphanumeric digit, fixed to identify product type, T = "S" and "E" "S" is associated with the product BME680 (part number 0 273 141 229) "E" is associated with the product BME680 (part number 0 273 141 312)
	L	<u>Sub-contractor ID</u> : 1 alphanumeric digit, variable to identify sub-contractor (L = "P")

Table 2: Marking of engineering samples

Marking	Symbol	Description
	XX	Sample ID: 2 alphanumeric digits, variable to generate trace-code
	N	Eng. Sample ID: 1 alphanumeric digit, fixed to identify engineering sample, N = "*" or "e" or "E"
	CC	Counter ID: 2 alphanumeric digits, variable to generate trace-code

4 Soldering Instructions

The moisture sensitivity level of the BME680 sensors corresponds to JEDEC Level 1, see also:

- IPC/JEDEC J-STD-020C “Joint Industry Standard: Moisture/Reflow Sensitivity Classification for non-hermetic Solid State Surface Mount Devices”
- IPC/JEDEC J-STD-033A “Joint Industry Standard: Handling, Packing, Shipping and Use of Moisture/Reflow Sensitive Surface Mount Devices”

The sensor fulfils the lead-free soldering requirements of the above-mentioned IPC/JEDEC standards. Accordingly, reflow soldering with a peak temperature up to 260°C for 20 to 40 seconds shall be used (see Figure 2). The sensors can withstand up to 3 reflow soldering cycles; several cycles may be necessary when mounting for example devices on both sides of a PCB. It is also important to note that the minimum height of the solder after reflow should be at least 50 µm. This is required for a good mechanical decoupling between the sensor device and the PCB.

Profile Feature	Pb-Free Assembly
Average Ramp-Up Rate (Ts _{max} to Tp)	3° C/second max.
Preheat – Temperature Min (Ts _{min}) – Temperature Max (Ts _{max}) – Time (ts _{min} to ts _{max})	150 °C 200 °C 60-180 seconds
Time maintained above: – Temperature (T _L) – Time (t _L)	217 °C 60-150 seconds
Peak/Classification Temperature (Tp)	260 °C
Time within 5 °C of actual Peak Temperature (tp)	20-40 seconds
Ramp-Down Rate	6 °C/second max.
Time 25 °C to Peak Temperature	8 minutes max.

Note 1: All temperatures refer to topside of the package, measured on the package body surface.

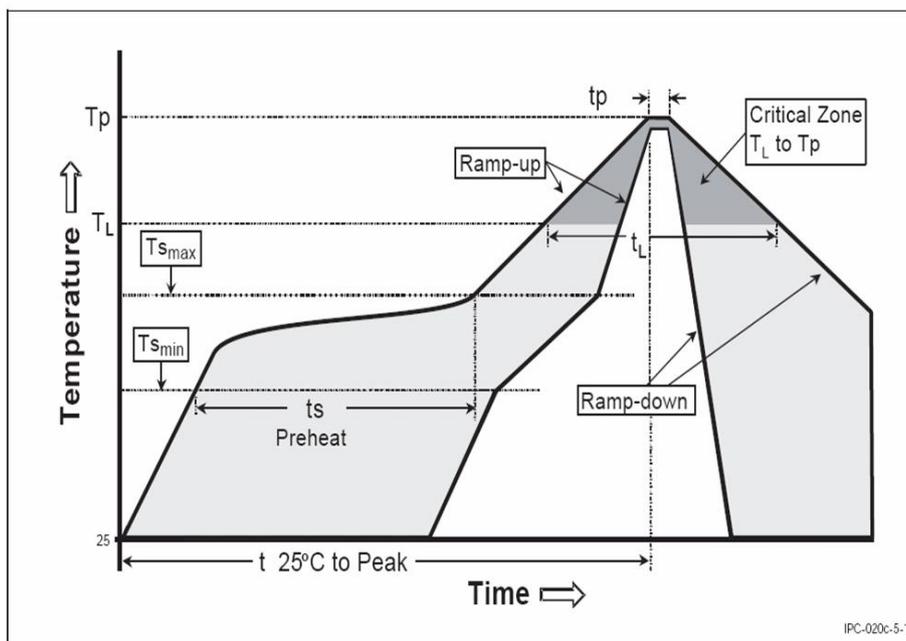


Figure 2: Soldering profile

5 Reconditioning Procedure

After exposing the device to operating conditions that exceed the limits specified in the datasheet (e.g. after reflow), the humidity sensor may possess an additional undesired offset. Therefore, the following reconditioning procedure is mandatory to restore the sensors' calibration state:

1. Dry-baking at 125 °C and <5% r.H. for 6 hours
2. Re-hydration at 25 °C and 80% r.H. for 24 hours
3. Rest period for one hour at room temperature

or alternatively

1. Do not perform Dry-Baking
2. Ambient Re-Hydration: 25 °C at >50% rH for >5d

6 Warnings and Precautions

The following list of instructions has to be carefully considered during handling, soldering and mounting of BME6xy:

- ESD protective measures in the workplace shall be generally ensured (e.g. use of wrist straps, tweezers with ceramic tips, etc.)
- The vent hole of the sensor shall be covered with a silicone-free protective layer during processing (e.g. cleaning, soldering, board wash etc.) to prevent possible contamination
- It is permitted only to use silicone-free gloves during handling of the sensors (e.g. Nitrile-based gloves for clean rooms are recommended to use)
- The sensors shall be stored in their original packaging (i.e. the original package do not emit odor or poisonous gases) and at the following conditions: temperature and humidity shall be within the ranges of 10–50°C and 20–60 % r.H., respectively
- Sensor characteristics may be impaired when exposed to undesired vapours, and thus, it is important not to employ vapour-phase ovens and to avoid working with adhesives/glues, lacquer-like polymers, cosmetics (e.g. hand lotion), or sprays (e.g. lubricants) close to the assembly line
- The sensors should not be operated in the following conditions:
 - Pure dry (synthetic) air
 - A zero or low oxygen atmosphere
 - A nitrogen-only atmosphere
- Permanent (> 12 hrs) exposition to unusual high concentration of smoke or gases above the recommended maximum level (0...100 mg/m³ TVOC / reducing gases or 0...10mg/m³ total of (NO_x+SO_x+O₃) / oxidizing gases) has to be avoided
- It is not permitted to expose high concentrations of reducing (e.g. >20 mg/m³ of TVOC) and/or oxidizing gases (>10 mg/m³ of NO_x+SO_x+O₃) to operating sensors for a long time
- Do not expose high concentrations of cigarette lighter and/or exhaust pipe gases to operating sensors
- It is not advised to put the sensors in close proximity to outgassing rubbers, and thus, it is recommended to use thermoplastic elastomers or highly filled rubbers (without or with a low content of plasticizers)
- The PCBs shall not be coated with materials containing and/or emitting siloxanes
- Soaking or splashing the sensors with liquids shall be avoided
- Strong air blast from an air pistol is forbidden
- To allow good reflow process, no excess solder paste shall be utilized
- Under no circumstances should the sensors be dry-baked before soldering
- Avoid manual disassembling of the sensors, particularly by exploiting higher temperatures (>260 °C) and/or longer heating durations (>40 s), because this may introduce irreversible changes in the sensor characteristics (e.g. offset shift)
- Do not remove lid during target device assembly or application; don't use in explosive sensitive area
- Prevent any sharp objects (e.g. tweezer tips) from getting inside the vent hole of the sensor
- The pressure sensor is vulnerable to damage if ultrasonic welding is used
- Avoid rear side handling of the sensor by using for example underfil or cleaning materials
- Avoid total or partial covering of the sensor by any protective material (e.g. epoxy resin coated on another IC component nearby); this may lead to clogging of the vent hole or result in an unsymmetrical mechanical stress distribution on the sensor package

- Avoid exposure of the sensor to the following components:
 - Bases and acids (e.g. NH_3 , NaOH , HCl , H_2SO_4 , HF , HNO_3 , $\text{H}_2\text{S}_2\text{O}_7$, etc.)
 - Corrosive gases (e.g. SO_x , Cl_2 , etc.)
 - Halogens (F_2 , Cl_2 , Br_2 , I_2), their salts (e.g. NaCl) and alkaline metals
 - High concentrations of O_3 or H_2O_2

7 Design Guidelines

MEMS sensors are in general high-precision measurement devices which consist of electronic as well as mechanical silicon structures. Moreover, BME6xy offers chemically sensitive structures culminating in a combined gas, temperature, humidity and/or pressure sensor. Accordingly, special care has to be given when these sensors are integrated inside cavities and mounted for example on printed-circuit boards (PCBs). In this chapter, guidelines about the design of the housing and placement of BME6xy on PCBs are presented to ensure accurate measurements as well as fast response times.

7.1 General Aspects

For the integration of BME6xy the following general instructions are recommended:

- Avoid usage of adhesive, PCB and housing materials that are emitting siloxanes and/or volatile organic compounds (VOCs)
- Avoid usage of materials within the cavity which are susceptible to moisture
- The sensor is sensitive to light, which can influence the accuracy of the measurement; therefore, the housing shall be designed to minimize light exposure to the vent hole
- Note that the use of a port protection membranes might influence the sensitivity and the response time of the gas as well as the humidity sensors

7.2 Position Aspects

Wrong placement of the sensor can impair the performance. Therefore, some guidelines are given below to ensure accurate measurements and relatively fast response times:

- The sensor should be placed as close as possible to the environment, i.e., ambient air
- The dead volume inside the cavity, where the sensor is placed, should be minimized
- The clearance above the metal lid of the sensor shall be at least 0.1 mm
- A large aperture and a short channel, through which the gas is diffusing to reach the sensor inside the system, are highly recommended

To have a better insight of how BME6xy is typically integrated, Figure 3 shows three different possible cavity designs. As depicted in the figure, a defined air flow/circulation has to be guaranteed to minimize the temperature deviations between the sensor and the surrounding environment. On a side note, an optional protection membrane at the aperture can be used. More details about the design dimensions are given in the BME680 integration guideline (BST-BME680-HS001-01) and the application handbook (BST-BME680-AN016-02).

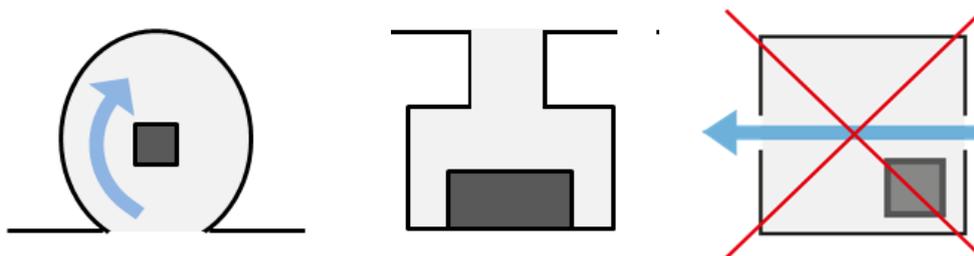


Figure 3: Cavity designs with: (left) defined air flow, (middle) small cavity, (right) large cavity volume and no direct air flow

7.3 Thermal Aspects

Thermal decoupling of the sensor to the PCB and housing is required to assure fast response for the temperature sensor as well as efficient heat conduction between heater of the gas sensor and the chemically sensitive layer. On the other hand, good thermal and air coupling of the sensor to the surrounding room-air is essential to accurately sense the target environment. Accordingly, the following operation and layout design rules are recommended (see Figure 4 and Figure 5):

- To avoid self-heating, the sensor should not be continuously active; the datasheet provides more information about how to minimize the power consumption at a particular resolution
- Protect the sensor from heated air flow to avoid heat convection and radiation, which might lead to undesired warming-up of the device and wrong (over- or underestimated) output results
- The sensor has to be placed at an adequate distance to any critical heat sources on the PCB or inside the system; trenches around the sensor can be utilized to reduce the thermal conduction
- The sensor has to be placed not in close vicinity to fast heating components ($>3\text{ }^{\circ}\text{C/s}$)
- The thickness of the metal interconnects to the sensor has to be minimized in order to ensure proper heat decoupling
- The sensor has to be placed as close as possible to the environment and also close to the edges of the device/system.

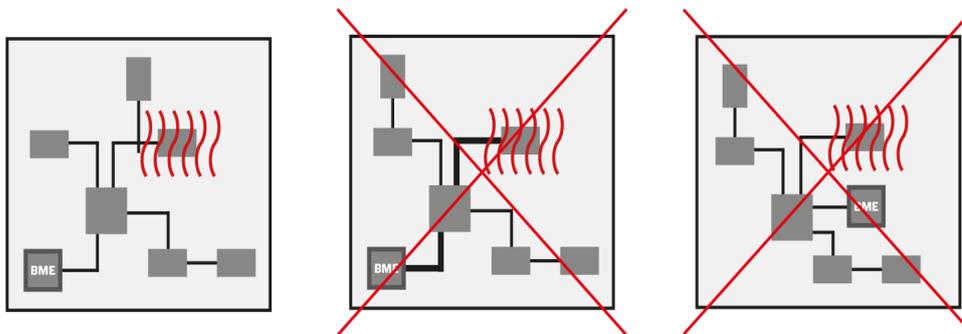


Figure 4: BME6xy placement on a PCB (red: heat radiation)

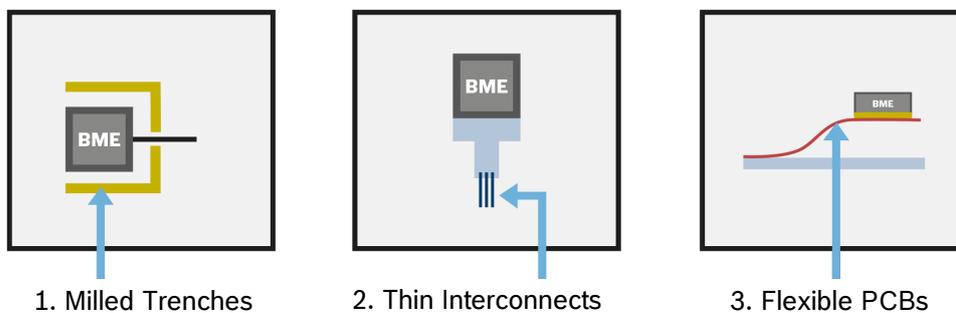


Figure 5: Three methods to thermally decouple the sensor from the PCB

7.4 Mechanical Aspects

Unnecessary mechanical stress induced on the sensor is not advisable. Referring to Figure 6, the following guidelines are recommended for a good PCB design practice:

- Place the sensor not nearby or directly beneath a push-button on the PCB
- Keep the sensor as far as possible from areas where any mechanical-stress induced on the PCB is maximum
- Mount the sensor at a reasonable distance from the anchor points (e.g. screw), where the PCB is typically attached to a base, shelf or similar
- Remove or unscrew any redundant PCB anchor points that induce an undesirable mechanical stress

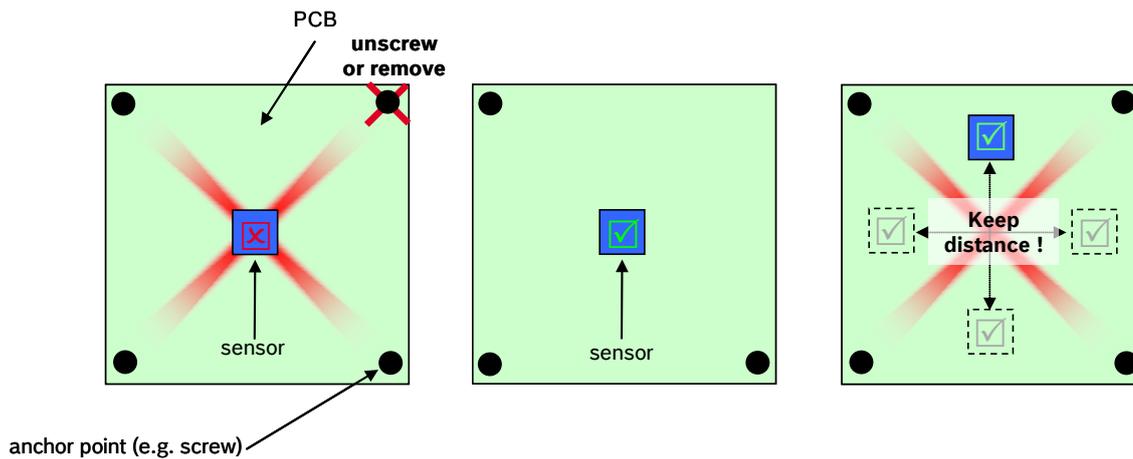


Figure 6: Methods to minimize mechanical stress on the sensor: (left) sensor is wrongly placed at a high mechanically-stressed location, (middle) redundant screw is removed to minimize stress, (right) sensor is properly placed at a reasonable distance from high mechanically-stressed areas

8 Environmental Safety

8.1 RoHS

The BME680 sensor meets the requirements of the EC restriction of hazardous substances (RoHS) directive, see also: *Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment.*

8.2 Lead and Halogen Content

The BME680 is lead (Pb) and halogen-free. For more details on the analysis results please contact your Bosch Sensortec representative.

8.3 Internal Package Structure

Within the scope of Bosch Sensortec's ambition to improve its products and secure the mass product supply, Bosch Sensortec qualifies additional sources (e.g. 2nd source) for the packaging and processing of the BME680.

While Bosch Sensortec took care that all of the technical packages parameters are described above are 100% identical for all sources, there can be differences in the chemical content and the internal structural between the different package sources.

However, as secured by the extensive product qualification process of Bosch Sensortec, this has no impact to the usage or to the quality of the BME680 product.

9 Legal disclaimer

9.1 Engineering samples

Engineering Samples are marked with an asterisk (*), (E) or (e). Samples may vary from the valid technical specifications of the product series contained in this data sheet. They are therefore not intended or fit for resale to third parties or for use in end products. Their sole purpose is internal client testing. The testing of an engineering sample may in no way replace the testing of a product series. Bosch Sensortec assumes no liability for the use of engineering samples. The Purchaser shall indemnify Bosch Sensortec from all claims arising from the use of engineering samples.

9.2 Product use

Bosch Sensortec products are developed for the consumer goods industry. They may only be used within the parameters of this product data sheet. They are not fit for use in life-sustaining or safety-critical systems. Safety-critical systems are those for which a malfunction is expected to lead to bodily harm, death or severe property damage. In addition, they shall not be used directly or indirectly for military purposes (including but not limited to nuclear, chemical or biological proliferation of weapons or development of missile technology), nuclear power, deep sea or space applications (including but not limited to satellite technology).

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9.3 Application examples and hints

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10 Document history and modifications

Rev. No	Chapter	Description of modification/changes	Date
1.0	all	Initial, preliminary release	29.07.2015
1.5	all	Revision of the entire document, public release	22.02.2017
1.6	title	Updated technical reference codes	28.11.2020
	3	Added new product marking "E"	
	9	Disclaimer update	



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