BME280

Combined humidity and pressure sensor

BME280 – Data sheet

Document revision	1.6
Document release date	September 2018
Document number	BST-BME280-DS002-15
Technical reference code	0 273 141 185
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 application

- 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)
- Home weather stations
- Flying toys
- Watches

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 (see chapter 5.2 for details).

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 V_{DD} and 1.2 to 3.6 V for the interface supply V_{DDIO}. 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 (see chapter 3.3):

- 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.

1. Specification

If not stated otherwise,

- All values are valid over the full voltage range
- All minimum/maximum values are given for the full accuracy temperature range
- Minimum/maximum values of drifts, offsets and temperature coefficients are ±3σ values over lifetime
- Typical values of currents and state machine timings are determined at 25 °C
- Minimum/maximum values of currents are determined using corner lots over complete temperature range
- Minimum/maximum values of state machine timings are determined using corner lots over 0…+65 °C temperature range

The specification tables are split into humidity, pressure, and temperature part of BME280.

1.1 General electrical specification

Table 1: Electrical parameter specification

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Supply Voltage Internal Domains	V_{DD}	ripple max. 50 mVpp	1.71	1.8	3.6	V
Supply Voltage I/O Domain	V_{DDIO}		1.2	1.8	3.6	V
Sleep current	I_{DDSL}			0.1	0.3	μA
Standby current (inactive period of normal mode)	I_{DDSB}			0.2	0.5	μA
Current during humidity measurement	I_{DDH}	Max value at 85 °C		340		μA
Current during pressure measurement	I_{DDP}	Max value at -40 °C		714		μA
Current during temperature measurement	I_{DDT}	Max value at 85 °C		350		μA
Start-up time	$t_{startup}$	Time to first communication after both V_{DD} > 1.58 V and V_{DDIO} > 0.65 V			2	ms
Power supply rejection ratio (DC)	PSRR	full V_{DD} range			±0.01 ±5	%RH/V Pa/V
Standby time accuracy	$\Delta t_{standby}$			±5	±25	%

1.2 Humidity parameter specification

Table 2: Humidity parameter specification

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Operating range[1]	R_H	For temperatures < 0 °C and > 60 °C see Figure 1	-40	25	85	°C
			0		100	%RH
Supply current	$I_{DD,H}$	1 Hz forced mode, humidity and temperature		1.8	2.8	µA
Absolute accuracy tolerance	A_H	20…80 %RH, 25 °C, including hysteresis		±3		%RH
Hysteresis[2]	H_H	10→90→10 %RH, 25 °C		±1		%RH
Nonlinearity[3]	NL_H	10→90 %RH, 25 °C		1		%RH
Response time to complete 63% of step[4]	$\tau_{63\%}$	90→0 or 0→90 %RH, 25°C		1		s
Resolution	R_H			0.008		%RH
Noise in humidity (RMS)	N_H	Highest oversampling, see chapter 3.6		0.02		%RH
Long term stability	ΔH_{stab}	10…90 %RH, 25 °C		0.5		%RH/ year

[1] When exceeding the operating range (e.g. for soldering), humidity sensing performance is temporarily degraded and reconditioning is recommended as described in section 7.8. Operating range only for non-condensing environment.
[2] For hysteresis measurement the sequence 10→30→50→70→90→70→50→30→10 %RH is used. The hysteresis is defined as the difference between measurements of the humidity up / down branch and the averaged curve of both branches
[3] Non-linear contributions to the sensor data are corrected during the calculation of the relative humidity by the compensation formulas described in section 4.2.3.
[4] The air-flow in direction to the vent-hole of the device has to be dimensioned in a way that a sufficient air exchange inside to outside will be possible. To observe effects on the response time-scale of the device an air-flow velocity of approx. 1 m/s is needed.

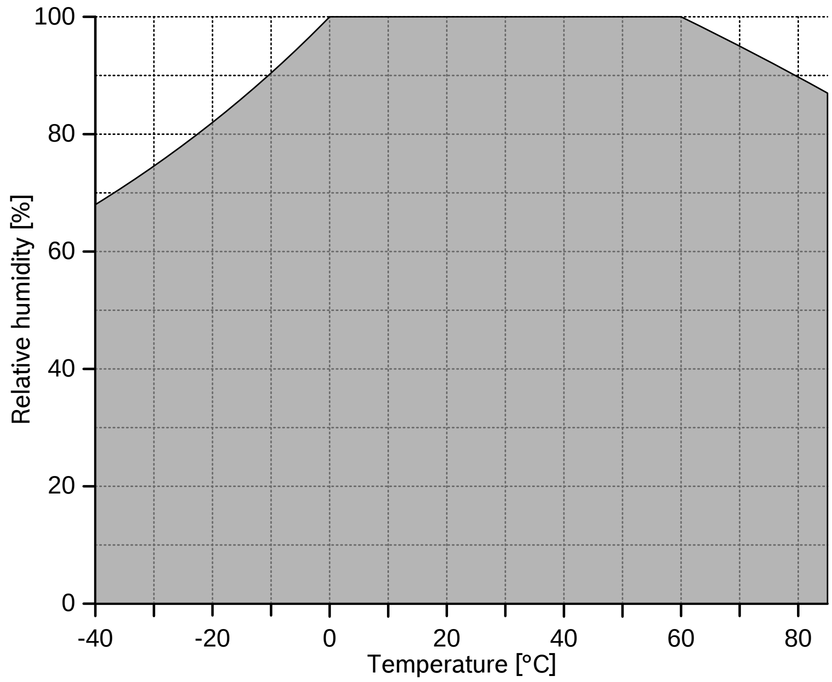


Figure 1: humidity sensor operating range

1.3 Pressure sensor specification

Table 3: Pressure parameter specification

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Operating temperature range	T_A	operational	-40	25	+85	°C
		full accuracy	0		+65	
Operating pressure range	P	full accuracy	300		1100	hPa
Supply current	$I_{DD,LP}$	1 Hz forced mode, pressure and temperature, lowest power		2.8	4.2	µA

Temperature coefficient of offset[5]	TCO_P	25…65 °C, 900 hPa		±1.5		Pa/K
				±12.6		cm/K
Absolute accuracy pressure	$A^P{}_{ext}$	300. . 1100 hPa -20 . . . 0 °C		±1.7		hPa
	$A_{P,full}$	300 . . . 1100 hPa 0 . . . 65 °C		±1.0		hPa
	A^P	1100 . . . 1250 hPa 25 . . . 40 °C		±1.5		hPa
Relative accuracy pressure V_{DD} = 3.3V	A_{rel}	700 ... 900hPa 25 . . . 40 °C		±0.12		hPa
Resolution of pressure output data	R_P	Highest oversampling		0.18		Pa
Noise in pressure	$N_{P,fullBW}$	Full bandwidth, highest oversampling See chapter 3.6		1.3		Pa
				11		cm
	$N_{P,filtered}$	Reduced bandwidth, highest oversampling See chapter 3.6		0.2		Pa
				1.7		cm
Solder drift		Minimum solder height 50µm	-0.5		+2.0	hPa
Long term stability[6]	ΔP_{stab}	per year		±1.0		hPa
Possible sampling rate	f_{sample_P}	Lowest oversampling, see chapter 9.2	157	182		Hz

1.4 Temperature sensor specification

Table 4: Temperature parameter specification

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Operating range	T	Operational	-40	25	85	°C
		Full accuracy	0		65	°C
Supply current	$I_{DD,T}$	1 Hz forced mode, temperature measurement only		1.0		µA
	$A_{T,25}$	25 °C		±0.5		°C

[5] When changing temperature by e.g. 10 °C at constant pressure / altitude, the measured pressure / altitude will change by (10 × TCO_P).
[6] Long term stability is specified in the full accuracy operating pressure range 0 ... 65 °C

Absolute accuracy temperature[7]	$A_{T,full}$	0…65 °C		±1.0		°C
	$A_{T,ext}$[8]	-20 …. 0 °C		±1.25		°C
	$A_{T,ext}$[9]	-40 … -20 °C		±1.5		°C
Output resolution	R_T	API output resolution		0.01		°C
RMS noise	N_T	Lowest oversampling		0.005		°C

[7] Temperature measured by the internal temperature sensor. This temperature value depends on the PCB temperature, sensor element self-heating and ambient temperature and is typically above ambient temperature.
[8] Target values & not guaranteed
[9] Target values & not guaranteed

2. Absolute maximum ratings

The absolute maximum ratings are determined over complete temperature range using corner lots. The values are provided in Table 5.

Table 5: Absolute maximum ratings

Parameter	Condition	Min	Max	Unit
Voltage at any supply pin	V_{DD} and V_{DDIO} pin	-0.3	4.25	V
Voltage at any interface pin		-0.3	V_{DDIO} + 0.3	V
Storage temperature	≤ 65% RH	-45	+85	°C
Pressure		0	20 000	hPa
ESD	HBM, at any pin		±2	kV
	CDM		±500	V
	Machine model		±200	V
Condensation	No power supplied	Allowed		

3. Functional description

3.1 Block diagram

Figure 2 shows a simplified block diagram of the BME280:

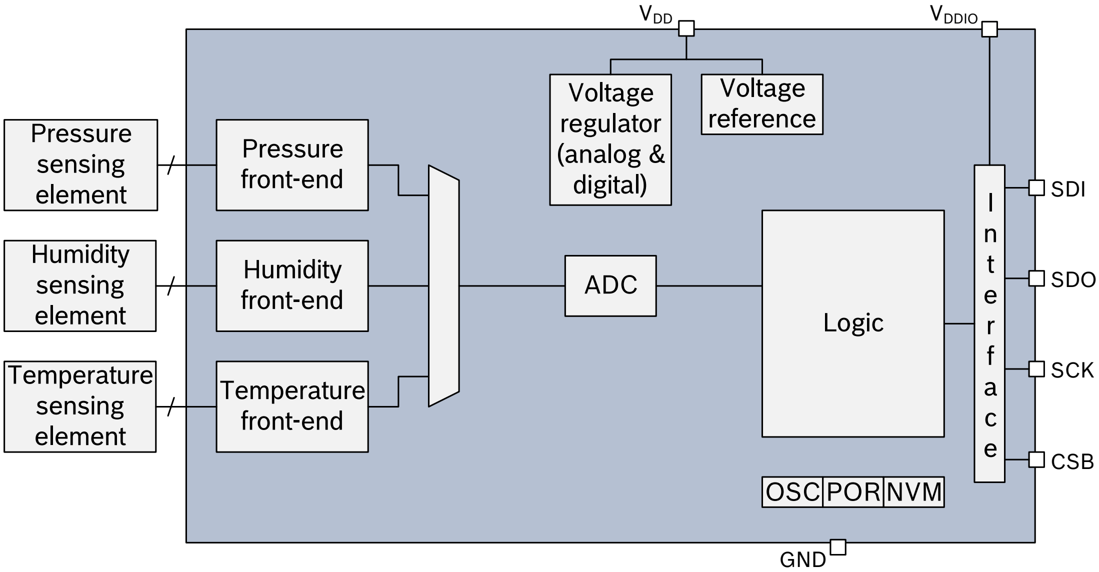


Figure 2: Block diagram of BME280

3.2 Power management

The BME280 has two distinct power supply pins

- V_{DD} is the main power supply for all internal analog and digital functional blocks
- V_{DDIO} is a separate power supply pin used for the supply of the digital interface

A power-on reset (POR) generator is built in; it resets the logic part and the register values after both V_{DD} and V_{DDIO} reach their minimum levels. There are no limitations on slope and sequence of raising the V_{DD} and V_{DDIO} levels. After powering up, the sensor settles in sleep mode (described in chapter 3.3.2).

It is prohibited to keep any interface pin (SDI, SDO, SCK or CSB) at a logical high level when V_{DDIO} is switched off. Such a configuration can permanently damage the device due an excessive current flow through the ESD protection diodes.

If V_{DDIO} is supplied, but V_{DD} is not, the interface pins are kept at a high-Z level. The bus can therefore already be used freely before the BME280 V_{DD} supply is established.

Resetting the sensor is possible by cycling V_{DD} level or by writing a soft reset command. Cycling the V_{DDIO} level will not cause a reset.

3.3 Sensor modes

The BME280 offers three sensor modes: sleep mode, forced mode and normal mode. These can be selected using the *mode*[1:0] setting (see chapter 5.4.5). The available modes are:

- Sleep mode: no operation, all registers accessible, lowest power, selected after startup
- Forced mode: perform one measurement, store results and return to sleep mode
- Normal mode: perpetual cycling of measurements and inactive periods.

7. Pin-out and connection diagram

7.1 Pin-out

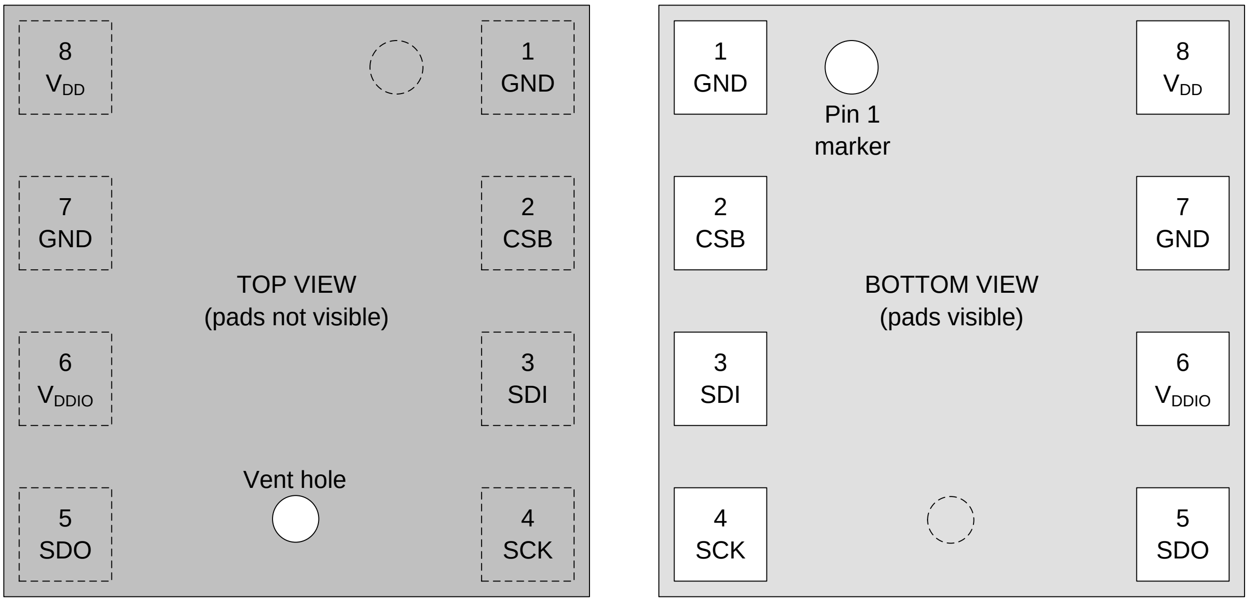


Figure 16: Pin-out top and bottom view

Note: The pin numbering of BME280 is performed in the untypical clockwise direction when seen in top view and counter-clockwise when seen in bottom view.

Table 35: Pin description

Pin	Name	I/O Type	Description	Connect to		
				SPI 4W	**SPI 3W**	**I²C**
1	GND	Supply	Ground	GND		
2	CSB	In	Chip select	CSB	CSB	V_{DDIO}
3	SDI	In/Out	Serial data input	SDI	SDI/SDO	SDA
4	SCK	In	Serial clock input	SCK	SCK	SCL
5	SDO	In/Out	Serial data output	SDO	DNC	GND for default address
6	V_{DDIO}	Supply	Digital / Interface supply	V_{DDIO}		
7	GND	Supply	Ground	GND		
8	V_{DD}	Supply	Analog supply	V_{DD}		

7.2 Connection diagram I²C

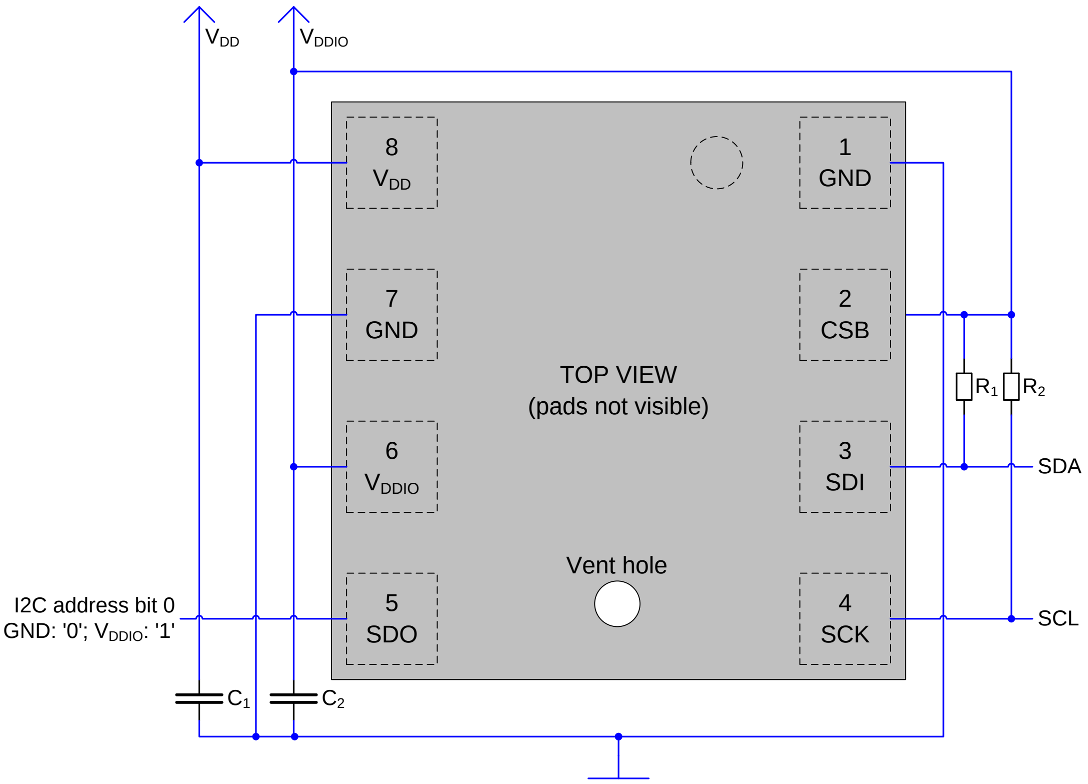


Figure 17: I²C connection diagram

Notes:

- The recommended value for C_1, C_2 is 100 nF
- The value for the pull-up resistors R_1, R_2 should be based on the interface timing and the bus load; a normal value is 4.7 kΩ
- A direct connection between CSB and V_{DDIO} is required

7.3 Connection diagram 4-wire SPI

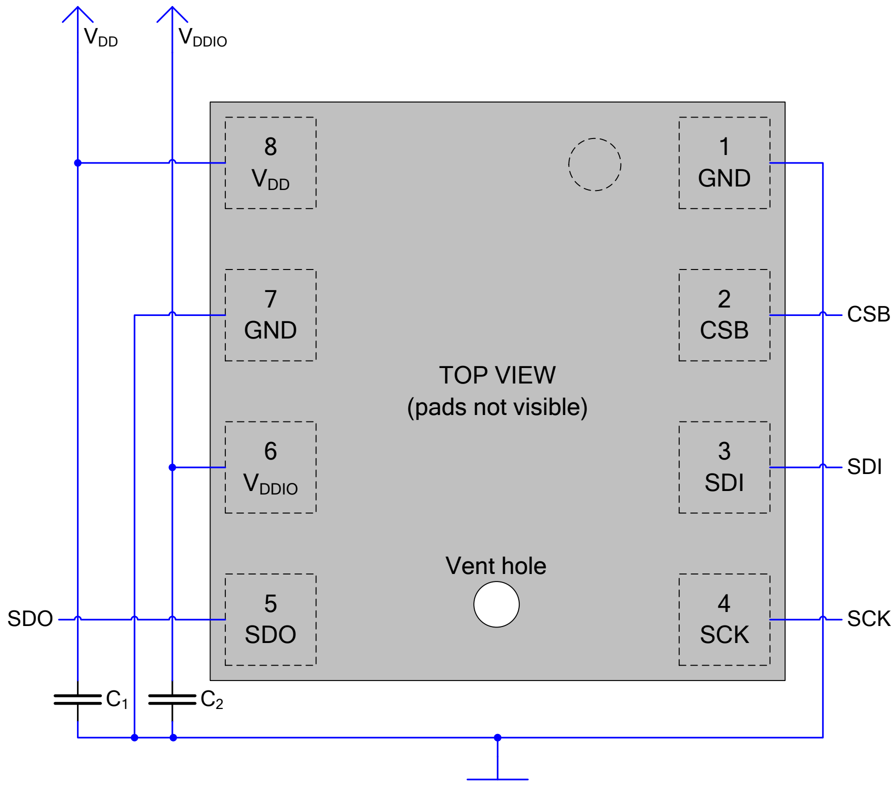


Figure 18: 4-wire SPI connection diagram

Note: The recommended value for C_1, C_2 is 100 nF

7.4 Connection diagram 3-wire SPI

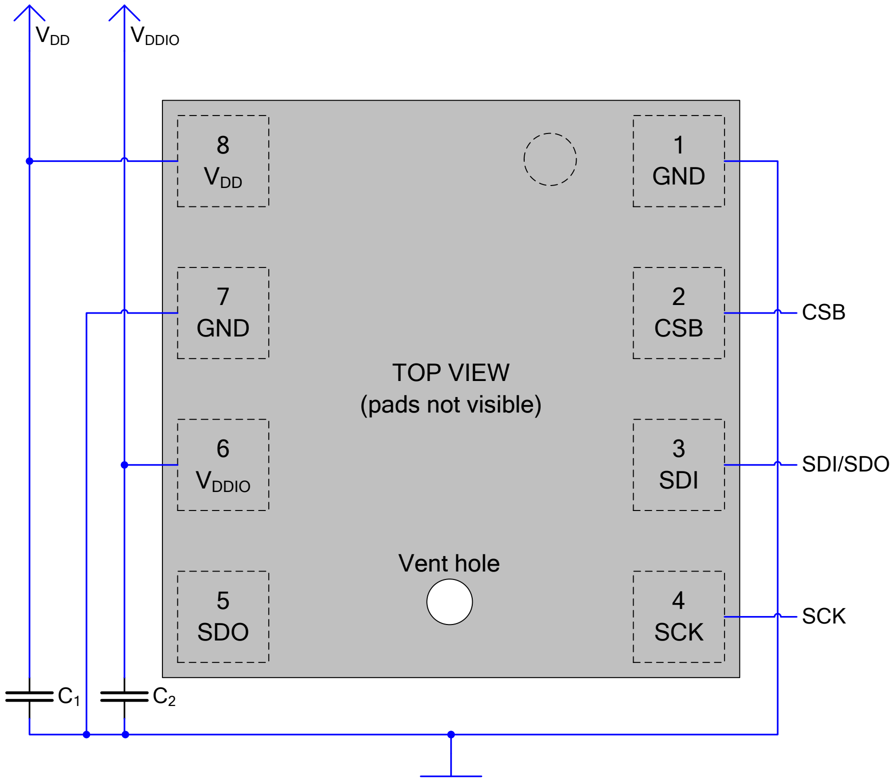
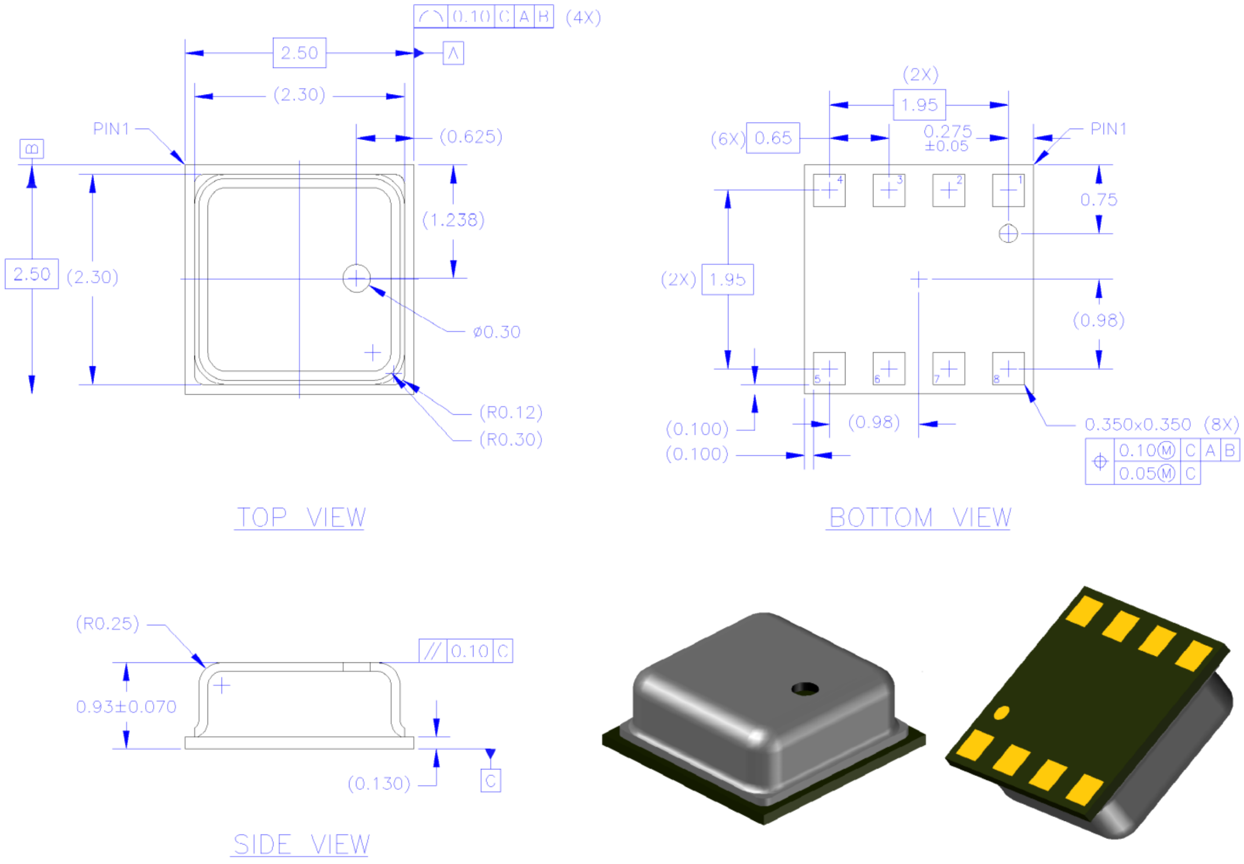


Figure 19: 3-wire SPI connection diagram

Note: The recommended value for C_1, C_2 is 100 nF

7.5 Package dimensions



PACKAGE TYPE CAVITY MEMS	BODY X 2.50	BODY Y 2.50	BODY Z 1.00(MAX)
LGA PITCH 0.65	LGA SIZE 0.350X0.350	LGA COUNT 8	BALL MATRIX N/A

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN MILLIMETERS

DECIMAL
X.X ±0.1
X.XX ±0.05
X.XXX ±0.030

ANGULAR
±1°

INTERPRET DIM AND TOL PER
ASME Y14.5M – 1994

Figure 20: Package dimensions for top, bottom and side view

7.6 Landing pattern recommendation

For the design of the landing pattern, the following dimensioning is recommended:

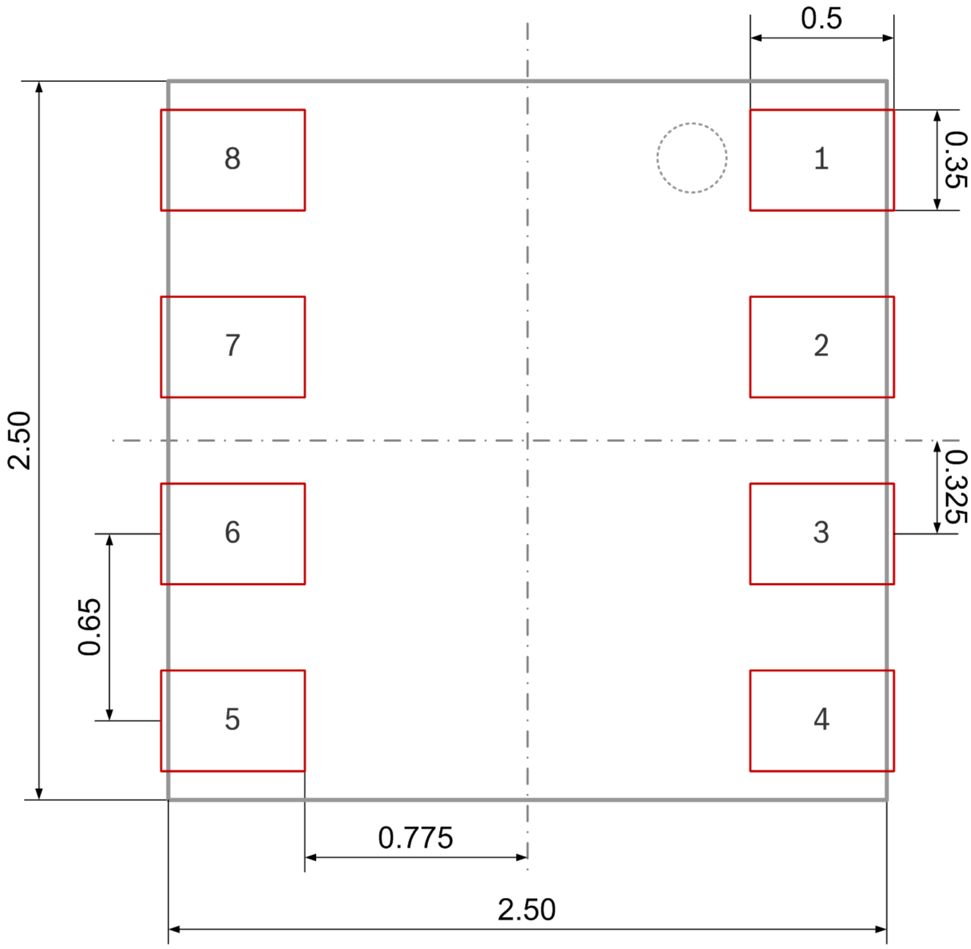


Figure 21: Recommended landing pattern (top view)

Note: red areas demark exposed PCB metal pads.

- In case of a solder mask defined (SMD) PCB process, the land dimensions should be defined by solder mask openings. The underlying metal pads are larger than these openings.
- In case of a non solder mask defined (NSMD) PCB process, the land dimensions should be defined in the metal layer. The mask openings are larger than these metal pads.

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Preliminary - specifications subject to change without notice
Document number: BST-BME280-DS002-15
Revision_1.6_092018