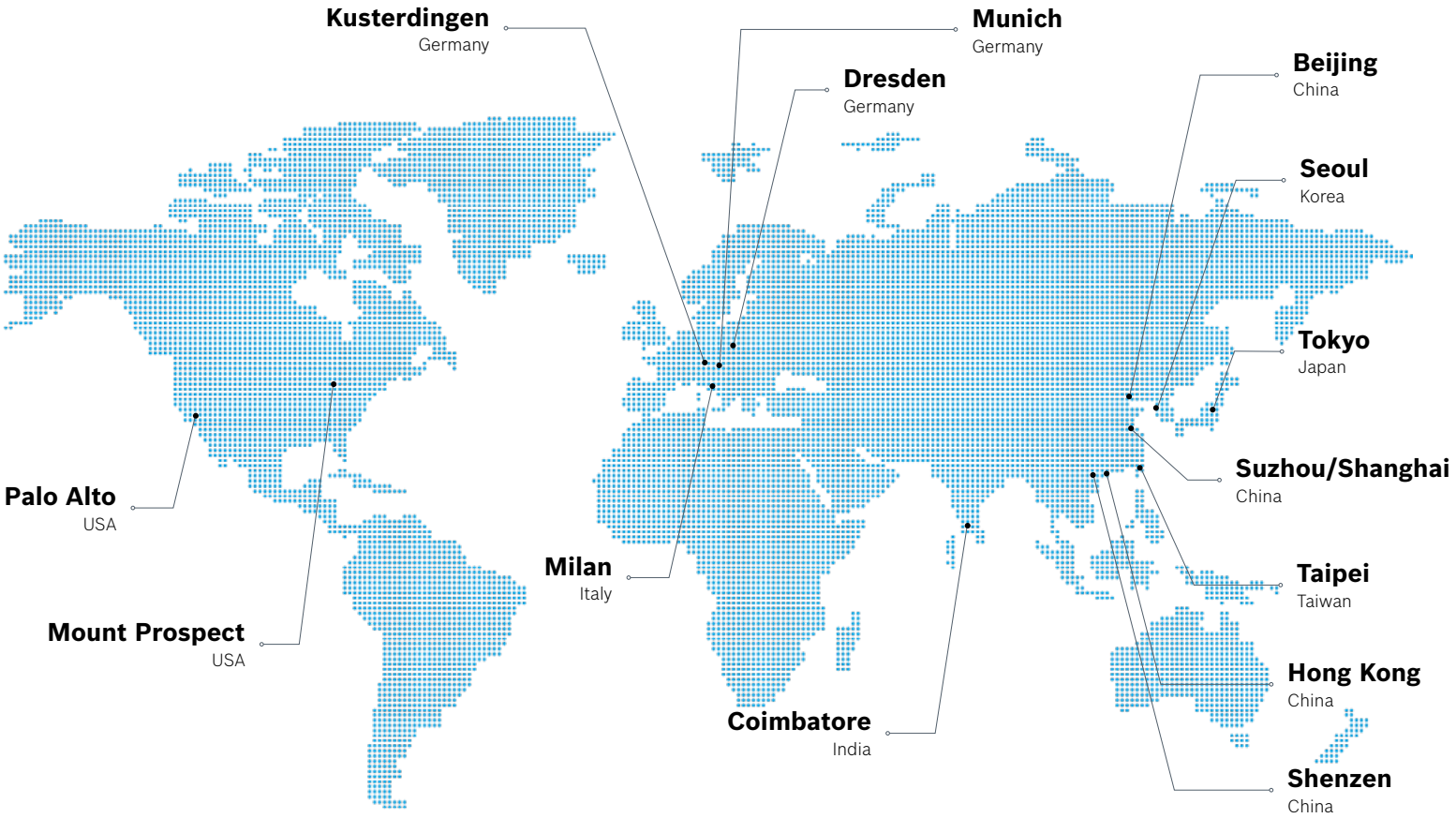
Bosch Sensortec MEMS sensors and solutions

Sensing our world

PRODUCT OVERVIEW

BOSCH
Invented for life

Bosch Sensortec – Worldwide presence

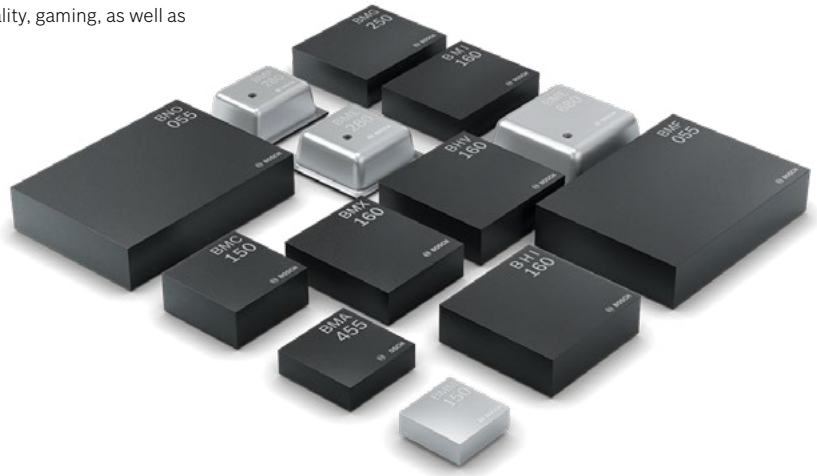


Bosch Sensortec – At the core of your everyday life

Our **broad and unique** component, software and system offerings make us **your preferred partner**

Inertial Sensors

Our portfolio of motion sensors includes products for motion, orientation and gesture detection. Motion sensors are designed for several consumer electronics and IoT applications in the field of smartphones, wearables, smart home, drones, toys, virtual and augmented reality, gaming, as well as industrial applications.



Smart Sensors

Our portfolio of intelligent sensor hubs is specifically designed for always-on sensor applications in smartphones, wearables and tracking devices. It offers you flexible, low-power solutions for motion sensing and sensor data processing. Additionally, the family of Application Specific Sensor Nodes (ASSNs) provides you an intelligent 9-axis "Absolute Orientation Sensor", including an accelerometer, gyroscope, magnetometer and a microcontroller running the BSX sensor data fusion in a single package. ASSNs are designed as a turnkey solution for applications such as robotics, drones, virtual reality and other industrial applications.

Environmental Sensors

Our portfolio of environmental sensors includes barometric pressure sensors, as well as integrated environmental sensors. These integrated environmental sensors combine barometric pressure, relative humidity, gas and ambient temperature sensing functions. Environmental sensors are ideally suited for indoor air quality measurement, sport & fitness monitoring, weather forecast, home automation control, Internet of Things, GPS-enhancement and indoor navigation.

Acceleration Sensors

The BMA is an advanced, ultra-small, triaxial, low-g acceleration sensor with digital interfaces, targeted for low-power applications. Featuring different digital resolutions (12 bit, 14 bit and 16 bit), the BMA family allows for very low-noise measurement of accelerations in three perpendicular axes and thus senses tilt, motion, shock and vibration in smartphones, man machine interfaces, wearables, smart home, as well as industrial applications. The BMA4XY family integrates embedded intelligence which enables precise low current step-counting and a multitude of other always on features. The BMA423 and BMA456 fit perfectly into wearable devices.

Product	Digital resolution	Range and sensitivity	Zero-g offset (typ.)
BMA253	12 bit	±2 g: 1024 LSB/g ±4 g: 512 LSB/g ±8 g: 256 LSB/g ±16 g: 128 LSB/g	±80 mg
BMA280	14 bit	±2 g: 4096 LSB/g ±4 g: 2048 LSB/g ±8 g: 1024 LSB/g ±16 g: 512 LSB/g	±50 mg
BMA423	12 bit	±2 g: 1024 LSB/g ±4 g: 512 LSB/g ±8 g: 256 LSB/g ±16 g: 128 LSB/g	±80 mg
BMA456	16 bit	±2 g: 16384 LSB/g ±4 g: 8192 LSB/g ±8 g: 4096 LSB/g ±16 g: 2048 LSB/g	±20 mg

Product	Noise density (typ.)	Bandwidths	Interfaces	Temperature range	Supply voltage	LGA package (mm^3)	FIFO	Features/ Interrupts	Power
BMA253	220 µg/√Hz	8 Hz ... 1000 Hz	SPI & I^2C, 2 × digital interrupt pins	–40 ... +85 °C	VDD: 1.62 ... 3.6 V VDDIO: 1.2 ... 3.6 V	2.0 × 2.0 × 0.95	32 Frames	▶ Any-/no-motion ▶ Freefall ▶ Orientation/Flat ▶ Low-g/High-g ▶ Tab/Double Tab	Full operation: 130 µA (@ 2 kHz data rate) Low-power mode: 6.5 µA (@ 40 Hz data rate)
BMA280	120 µg/√Hz	8 Hz ... 500 Hz	SPI & I^2C, 2 × digital interrupt pins	–40 ... +85 °C	VDD: 1.62 ... 3.6 V VDDIO: 1.2 ... 3.6 V	2.0 × 2.0 × 0.95	32 Frames	▶ Any-/no-motion ▶ Freefall ▶ Orientation/Flat ▶ Low-g/High-g ▶ Tab/Double Tab	Full operation: 130 µA (@ 2 kHz data rate) Low-power mode: 6.5 µA (@ 40 Hz data rate)
BMA423	140 µg/√Hz	5 Hz ... 684 Hz (ODR: 0.8 Hz ... 1600 Hz)	SPI & I^2C, 2 × digital interrupt pins	–40 ... +85 °C	VDD: 1.62 ... 3.6 V VDDIO: 1.2 ... 3.6 V	2.0 × 2.0 × 0.95	1 KB	▶ Step Counter/Step detector (optimized for wearables) ▶ Step Counter watermark ▶ Tilt on wrist ▶ Tab/Double Tab ▶ Any-/no-motion	Full operation: 150 µA Low-power mode:13 µA (@ 50 Hz data rate)
BMA456	120 µg/√Hz	5 Hz ... 684 Hz (ODR: 0.8 Hz ... 1600 Hz)	SPI & I^2C, 2 × digital interrupt pins	–40 ... +85 °C	VDD: 1.62 ... 3.6 V VDDIO: 1.2 ... 3.6 V	2.0 × 2.0 × 0.65	1 KB	▶ Step Counter/Step detector (optimized for wearables) ▶ Step Counter watermark ▶ Tilt on wrist ▶ Tab/Double Tab ▶ Any-/no-motion	Full operation: 150 µA Low-power mode:13 µA (@ 50 Hz data rate)

Gyroscopes

The BMG is an ultra-small, digital 3-axis angular rate sensor with a measurement range up to 2000 °/s and a digital resolution of 16 bit. The BMG family allows low-noise measurement of angular rates in three perpendicular axes and is designed for use in smartphones, handhelds, computer peripherals, man-machine interfaces, virtual reality features, remote and game controllers.

Product	Digital reso-lution	Range and sensitivity	Zero-g offset (typ., over life-time)	Zero-rate offset over tempera-ture	Noise density (typ.)	Date rates (program-mable)	Interfaces	Tempera-ture range	Supply voltage	LGA package (mm^3)	Power
BMG160	16 bit	±125 °/s: 262.4 LSB/°/s ±250 °/s: 131.2 LSB/°/s ±500 °/s: 65.6 LSB/°/s ±1000 °/s: 32.8 LSB/°/s ±2000 °/s: 16.4 LSB/°/s	±1 °/s	0.015 °/s/K	0.014 °/s/√Hz	2000, 1000, 400, 200, 100 Hz	SPI, I^2C, 2 × digital interrupts	–40 ... +85 °C	VDD: 2.4 ... 3.6 V VDDIO: 1.2 ... 3.6 V	3.0 × 3.0 × 0.95	Full operation: 5.0 mA Suspend mode: 5 µA
BMG250	16 bit	±125 °/s: 262.4 LSB/°/s ±250 °/s: 131.2 LSB/°/s ±500 °/s: 65.6 LSB/°/s ±1000 °/s: 32.8 LSB/°/s ±2000 °/s: 16.4 LSB/°/s	±3 °/s	0.05 °/s/K	0.007 °/s/√Hz	25 ... 3.200 Hz for UI IF 6.400 Hz for OIS/EIS IF	For primary UI IF: I^2C up to 1 MHz 3w / 4w SPI 2 × digital interrupts for se-condary OIS/EIS IF: 3w SPI up to 10 MHz	–40 ... +85 °C	VDD: 1.7 ... 3.6 V VDDIO: 1.2 ... 3.6 V	2.5 × 3.0 × 0.8	Full operation: 850 µA Suspend mode: 3 µA

Geomagnetic Sensors

The BMM is a low-power and low-noise 3-axis digital geomagnetic sensor to be used in compass applications, which include virtual reality, gaming and navigation on devices such as smartphones, tablets and robotics requiring magnetic heading information.

Product	Digital resolution	Zero-B offset	Magnetic range (typ.)	Digital interfaces	Temperature range	Average current consumption	Package (mm^3)	Supply voltage
BMM150	0.3 µT	±40 µT	±1300 µT (x,y-axis) ±2500 µT (z-axis)	I^2C and SPI (2 interrupt pins)	–40 ... +85 °C	170 µA (low-power preset) 500 µA (normal mode)	CSWLP- (12 pin) 1.56 × 1.56 × 0.6	VDD: 1.62 ... 3.6 V VDDIO: 1.2 ... 3.6 V

Inertial Measurement Units

The BMI allows very low-noise measurement of angular rates and accelerations in three perpendicular axes and thus senses tilt, motion, shock and vibration in smartphones, handheld devices, computer peripherals, man-machine interfaces, remote and game controllers.

* Qeexo FingerSense Compatible

Product	Acceleration			
	Digital resolution	Range and sensitivity	Zero-g offset (typ.)	Noise density (typ.)
BMI055	12 bit	±2 g: 1024 LSB/g ±4 g: 512 LSB/g ±8 g: 256 LSB/g ±16 g: 128 LSB/g	±70 mg	150 µg/√Hz
BMI160*	16 bit	±2 g: 16384 LSB/g ±4 g: 8192 LSB/g ±8 g: 4096 LSB/g ±16 g: 2048 LSB/g	±40 mg	180 µg/√Hz

Product	Gyroscope				Temperature range	Supply voltage	Digital inputs/ outputs	Power consumption	LGA package (mm^3)
	Digital resolution	Range and sensitivity	Zero-g offset (typ.)	Noise density (typ.)					
BMI055	16 bit	±125 °/s: 262.4 LSB/°/s ±250 °/s: 131.2 LSB/°/s ±500 °/s: 65.6 LSB/°/s ±1000 °/s: 32.8 LSB/°/s ±2000 °/s: 16.4 LSB/°/s	±1 °/s	0.014 °/s/√Hz	–40 ... +85 °C	VDD: 2.4 ... 3.6 V VDDIO: 1.2 ... 3.6 V	SPI, I^2C, 4× digital interrupts	Full operation: 5.15 mA Suspend mode: 6 µA	3.0×4.5×0.95
BMI160*	16 bit	±125 °/s: 262.4 LSB/°/s ±250 °/s: 131.2 LSB/°/s ±500 °/s: 65.6 LSB/°/s ±1000 °/s: 32.8 LSB/°/s ±2000 °/s: 16.4 LSB/°/s	±10 °/s	0.007 °/s/√Hz	–40 ... +85 °C	VDD: 1.71 ... 3.6 V VDDIO: 1.2 ... 3.6 V	SPI, I^2C, 4× digital interrupts	Full operation: 950 µA Suspend mode: 3 µA	2.5×3.0×0.8

Absolute Orientation Sensors

The BMX is a small, 9-axis sensor, consisting of a triaxial acceleration sensor, a triaxial gyroscope and a triaxial geomagnetic sensor. The BMX allows accurate measurement of angular rate and magnetic fields in three perpendicular axes within one device. With its ultra-small footprint, the BMX is unique in the class of low-noise 9-axis measurement units. The BMX is designed for motion detection applications, such as device orientation measurement, gaming, human machine interfaces, wearables, AR/VR and robotics.

Product	Acceleration				Gyroscope			
	Digital resolution	Range and sensitivity	Zero-g offset (typ.)	Noise density (typ.)	Digital resolution	Range and sensitivity	Zero-g offset (typ.)	Noise density (typ.)
BMX055	12 bit	±2 g: 1024 LSB/g ±4 g: 512 LSB/g ±8 g: 256 LSB/g ±16 g: 128 LSB/g	±70 mg	180 µg/√Hz	16 bit	±125 °/s: 262.4 LSB/°/s ±250 °/s: 131.2 LSB/°/s ±500 °/s: 65.6 LSB/°/s ±1000 °/s: 32.8 LSB/°/s ±2000 °/s: 16.4 LSB/°/s	±1 °/s	0.008 °/s/√Hz
BMX160*	16 bit	±2 g: 16384 LSB/g ±4 g: 8192 LSB/g ±8 g: 4096 LSB/g ±16 g: 2048 LSB/g	±40 mg	180 µg/√Hz	16 bit	±125 °/s: 262.4 LSB/°/s ±250 °/s: 131 LSB/°/s ±500 °/s: 65.6 LSB/°/s ±1000 °/s: 32.8 LSB/°/s ±2000 °/s: 16.4 LSB/°/s	±3 °/s	0.007 °/s/√Hz

Product	Geomagnetic			Temperature range	Supply voltage	Digital inputs/ outputs	Power consumption	LGA package (mm³)
	Resolution	Range	Offset					
BMX055	0.3 µT	±1200 µT (x,y), ±2500 µT (z)	±40 µT	−40 ... +85 °C	VDD: 2.4 ... 3.6 V VDDIO: 1.2 ... 3.6 V	I²C/SPI interface	Full operation: Gyro. + Acc. + Geomag. 1585 µA Suspend mode: 7 µA	3.0×4.5×0.95
BMX160*	0.3 µT	±1300 µT (x,y axis), ±2500 µT (z axis)	±2 µT	−40 ... +85 °C	VDD: 1.71 ... 3.6 V VDDIO: 1.2 ... 3.6 V	I²C/SPI interface	Full operation: Gyro. + Acc. + Geomag. 1585 µA Suspend mode: 7 µA	2.5×3.0×0.95

*Product is coming soon. Data and specifications are preliminary and subject to change without notice.

Application Specific Sensor Nodes (ASSNs)

The ASSN is a System-in Package (SiP) solution, integrating a triaxial 14 bit accelerometer, a triaxial 16 bit gyroscope, a triaxial geomagnetic sensor and a 32 bit cortex M0+ microcontroller. The ASSNs are suitable for applications such as robotics, augmented and virtual reality, drones, gaming, as well as other industrial applications.

Product	Acceleration	Gyroscope	Geomagnetic	Hardware	Fusion SW	Power consumption	Interfaces	Voltage	Temperature range	Package size (mm^3)
BMF055	14 bit	16 bit	±1300 µT (x,y-axis) ±2500 µT (z-axis)	ARM Cortex M0+	no	Depends on the custom specific sensor fusion	I^2C UART HID-I2C	VDD 2.4 ... 3.6 V VDDIO: 1.7 ... 3.6 V	–40 ... +85 °C	3.8×5.2×1.13
BNO055	14 bit	16 bit	±1300 µT (x,y-axis) ±2500 µT (z-axis)	ARM Cortex M0+	yes	Suspend mode: 40 µA 9DOF @100Hz Output data rate: 12.3 mA	I^2C UART HID-I2C	VDD 2.4 ... 3.6 V VDDIO: 1.7 ... 3.6 V	–40 ... +85 °C	3.8×5.2×1.13

Smart Hubs

The smart sensor hub is a small, low-power smart-hub with an integrated IMU and a triaxial accelerometer plus a programmable microcontroller containing pre-installed software and specific algorithms for activity recognition, it is specifically designed to enable always-on motion sensing. It perfectly matches the requirements of smartphones, wearables or any other application which demands highly accurate, real-time motion data at a very low-power consumption level.

Product	Acceleration	Gyro-scope	Geomagnetic	Integrated MCU	Integrated SW & Algos	Power consumption (including MCU)	Inter-faces	Supply voltage	Temperature range	Package size (mm^3)
BHA250	14 bit	n/a	Ready for p&p hub-connectivity of BMM150, AK09911, AK09912, YAS532	32 bit floating-point ARC EM4 MCU running at 10 MHz. 96 kByte ROM 48 kByte RAM	BSX fusion Activity recognition Gesture recognition Step detector Step counter	Suspend mode: 11 µA Hub+Acc @100 Hz ODR: 430 µA	I^2C up to 3.4 MBit/s 3×GPIO, 1×Host-INT	VDD: 1.71 ... 3.6 V VDDIO: 1.20 ... 3.6 V	–40 ... +85 °C	2.2×2.2 ×0.95
BHI160	16 bit	16 bit	Ready for p&p hub-connectivity of BMM150, AK09911, AK09912, YAS532	32 bit floating-point ARC EM4 MCU running at 10 MHz. 96 kByte ROM 48 kByte RAM	BSX fusion Activity recognition Gesture recognition Step detector Step counter	Suspend mode: 11 µA Hub+IMU @100 Hz ODR: 1.2 mA	I^2C up to 3.4 MBit/s 3×GPIO, 1×Host-INT	VDD: 1.71 ... 3.6 V VDDIO: 1.20 ... 3.6 V	–40 ... +85 °C	3.0×3.0 ×0.95

Barometric Pressure Sensors

The BMP280 is an absolute barometric pressure sensor especially designed for mobile applications. The sensor module is housed in an extremely compact package. Its small dimensions and low-power consumption allow for the implementation in battery powered devices such as smartphones, GPS modules, wearables, drones and tracking systems.

Product	Operation range	Relative accuracy 700…900 hPa (T = +25…+40 °C)	Absolute accuracy 300…1100 hPa (T = 0…+65 °C)	Power consumption	Supply voltage	Noise (lowest bandwidth, highest resolution)	Long term stability (1 year)	TCO	Inter-face	Package dimensions (mm^3)
BMP280	300 … 1100 hPa	±0.12 hPa (equivalent to ±1 m)	±1 hPa (typical)	2.74 µA @ 1 Hz	VDDIO: 1.2 … 3.6 V VDD: 1.71 … 3.6 V	0.2 Pa	±1 hPa	±1.5 Pa/K (equivalent to ±12.6 cm/K)	I^2C and SPI	8-Pin LGA with metal 2.0×2.5×0.95

The BMP388 is specifically designed and ideally suited for a wide range of altitude tracking applications. The sensor offers outstanding design flexibility, providing a single package solution that can be easily integrated into a multitude of existing and upcoming devices such as drones, wearables, GPS modules and smartphones.

Product	Operation range	Relative accuracy 700…900 hPa (T = +25…+40 °C)	Absolute accuracy 300…1100 hPa (T = -20…+65 °C)	Power consumption	Supply voltage	Noise (lowest bandwidth, highest resolution)	Long term stability (1 year)	TCO	Inter-face	Package dimensions (mm^3)
BMP388	300 … 1250 hPa	±0.06 hPa (equivalent to ±50 cm)	±0.50 hPa (typical)	2.0 µA @ 1 Hz	VDDIO: 1.2 V … 3.6 V VDD: 1.65 V … 3.6 V	0.03 Pa	±0.33 hPa	0.75 Pa/K (equiva-lent to ± 6.3 cm/K)	I^2C and SPI	10-pin LGA with metal lid 2.0 x 2.0 x 0.75

Integrated Environmental Units

The BME280 is an integrated environmental sensor developed specifically for IoT applications where size and low-power consumption are key design constraints. The unit combines individual high linearity, high accuracy sensors for pressure, humidity and temperature.

Product	Humidity				Pressure				Inter-face	Power	Package dimensions (mm³)
	Range	Response time ($T_{0-63\%}$)	Accuracy tolerance	Hysteresis	Range	Noise (lowest bandwidth, highest resolution)	TCO	Relative accuracy			
BME280	0 … 100 % rH	1 s	±3 % relative humidity	≤1 % relative humidity	300 … 1100 hPa	0.2 Pa	±1.5 Pa/K (equivalent to ±12.6 cm/K)	±0.12 hPa (±1 m)	I²C and SPI	Sleep mode 0.1 µA –1.8 µA @ 1 Hz (H, T) –3.6 µA @ 1 Hz (H, P, T)	2.5×2.5×0.93

The BME680 is an integrated environmental sensor developed specifically for mobile applications and wearables where size and low-power consumption are key requirements. The unit integrates for the first time low-power and highly accurate gas, pressure, humidity and temperature sensors in one tiny package.

Product	Gas (VOC)			Humidity			Pressure		Temperature	Inter-face	Power	Package dimensions (mm³)
	Range	Respon-se time ($T_{33-63\%}$)	Power consumption	Range	Response time ($T_{0-63\%}$)	Accuracy tolerance	Range	Relative accuracy	Absolute accuracy			
BME680	0 … 500 IAQ (equivalent to 0.2 … 20mg/m³ TVOC levels)	<1 s for new sensors	Ultra-low power mode (ULP): <0.1 mA Low-power mode (LP): <1 mA	0 … 100 % rH	8 s	±3 % relative humidity	300 … 1100 hPa	±0.12 hPa (±1m)	± 0.5 °C	I²C and SPI	2.1 µA @ 1 Hz (H, T) 3.1 µA @ 1 Hz (P, T) 3.7 µA @ 1 Hz (H, P, T) 0.09–12 mA for P/H/T/Gas depending on operation mode 0.15 µA in sleep mode	3.0 x 3.0 x 0.93

Sensor Data Fusion Software & Features

In order to support shorter time to market and architectures with varied power requirements, we provide a fully integrated software library “BSX” in BNO055 and BHI160 products. BSX features step counter, tilt detector, activity recognition, gestures, pedestrian dead reckoning and a multitude of other functionalities.
It is able to deliver extreme low-power consumption even for always-on applications such as activity recognition and supports different wakeup and non-wakeup batching sizes from sensor hubs. The BSXlite software is a feature reduced version of our BSX software and is available for a free download from our website for a quick prototype development with sensors such as BMI160 and BMM150.

Product	Key Features									
	Axis remapping	Offset correction	Soft Iron Correction	Accelerometer calibration	Magnetometer calibration	Magnetic disortion check	Gyroscope calibration	9-axis orientation processing	Compass orientation processing	Data fusion models
BSXlite (as web-download)	x	√	x	x	Classic: based on figure-of-eight motion	Basic	√	Basic	Basic (tilt compensation)	9-axis
BSX (full library) in BHI/BNO	√	√	√	√	Classic advanced (fast calibration)	Advanced	√	Advanced	Advanced (adaptive filtering, tilt compensation)	9-axis & 6-axis (IMU, M4G, eCompass)

Product	Outputs									
	Acceleration	Magnetometer	Gyroscope	Virtual gyroscope (M4G)	Quaternions	Orientation	Rotation matrix	Heading accuracy	Linear acceleration	Gravity
BSXlite (as web-download)	Raw	Raw, corrected	Raw, corrected	x	√	√ (unfiltered)	x	√	x	x
BSX (full library) in BHI/BNO	√	√	√	√	√	√	√	√	√	√

Product	Outputs			Output date rates (ODR)		
	Gestures	Step counter and step detector	Significant motion	Accelerometer	Magnetometer	Gyroscope
BSXlite (as web-download)	x	x (in BMI160 Hardware)	x (in BMI160 Hardware)	100 Hz	25 Hz	100 Hz
BSX (full library) in BHI/BNO	√	√	√	Multiple data rates	Multiple data rates	Multiple data rates

BSXlite software is available for download on our website: www.bosch-sensortec.com

BSEC Software & Features

The Bosch Software Environmental Cluster (BSEC) fusion library has been conceptualized to provide higher-level signal processing and fusion for the BME680. The library receives compensated sensor values from the sensor API. It processes the BME680 signals in combination with the additional phone sensors to provide the requested sensor outputs.

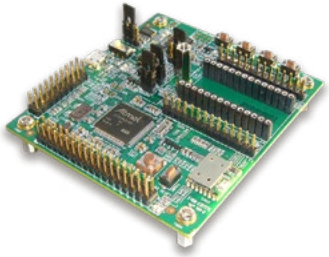
Product	Key features				Output				Output data rates (ODR)			
	Calculation of ambient air temperature outside the device	Calculation of ambient relative humidity outside the device	Calculation of pressure outside the device	Calculation of indoor air quality (IAQ) level outside the device	Gas	Humidity	Pressure	Temperature	Gas	Humidity	Pressure	Temperature
BSEC (as web-download)	√	√	√	√	IAQ index 0 ... 500 Raw resistance	Relative humidity, corrected	Raw, corrected	Raw, corrected	Ultra-low power mode (ULP): 3.3 mHz Low-power mode (LP) 0.33 Hz			

BSEC software is available for download on our website: www.bosch-sensortec.com

Application Boards

Our application board 2.0 is a versatile, demonstration and evaluation environment for our sensor products. It can be used to configure sensor parameters, plot and log the resulting sensor readings by means of PC based software (Development desktop). Sensor data can be read-out, displayed and captured on the attached PC.

Our application board 2.0 applies a flexible shuttle-board concept. All sensor shuttle boards have identical footprints and can be plugged into the application board's shuttleboard socket.



Development desktop software is available for download on our website: www.bosch-sensortec.com

Bosch Sensortec GmbH
Headquarters

Gerhard-Kindler-Strasse 9
72770 Reutlingen, Germany
Telephone +49 (0) 7121 3535-900

www.bosch-sensortec.com
twitter.com/boschMEMS
www.youtube.com/BoschSensortec
WeChat account ID: BoschSensortec

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