Data sheet

BMF055

Custom programmable 9-axis motion sensor

Bosch Sensortec

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BMF055: data sheet

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BMF055

Custom programmable 9-axis motion sensor

Basic Description

Key features:

• 3 sensors in one device	an advanced triaxial 16bit gyroscope, a versatile, leading edge triaxial 14bit accelerometer and a full performance geomagnetic sensor
• Small package	LGA package 28 pins Footprint 3.8 x 5.2 mm², height 1.13 mm²
• Common voltage supplies	V_{DD} voltage range: 2.4V to 3.6V
• Consumer electronics suite	MSL1, RoHS compliant, halogen-free Operating temperature: -40°C ... +85°C

Key features of integrated sensors:

Accelerometer features

• Programmable functionality	Acceleration ranges ±2g/±4g/±8g/±16g Low-pass filter bandwidths 1kHz - <8Hz Operation modes: - Normal - Suspend - Low power - Standby - Deep suspend
• On-chip interrupt controller	Motion-triggered interrupt-signal generation for - any-motion (slope) detection - slow or no motion recognition - high-g detection

Gyroscope features

- Programmable functionality

  Ranges switchable from ±125°/s to ±2000°/s
  Low-pass filter bandwidths 523Hz - 12Hz
  Operation modes:
  - Normal
  - Fast power up
  - Deep suspend
  - Suspend
  - Advanced power save
- On-chip interrupt controller

  Motion-triggered interrupt-signal generation for
  - any-motion (slope) detection
  - high rate

Magnetometer features

- Flexible functionality

  Magnetic field range typical ±1300µT (x-, y-axis); ±2500µT (z-axis)
  Magnetic field resolution of ~0.3µT
  Operating modes:
  - Low power
  - Regular
  - Enhanced regular
  - High Accuracy

  Power modes:
  - Normal
  - Sleep
  - Suspend
  - Force

Typical applications

- Navigation
- Robotics
- Fitness and well-being
- Augmented reality
- Context awareness
- Tablets and ultra-books

General description

The BMF055 is a System in Package (SiP), integrating a triaxial 14-bit accelerometer, a triaxial 16-bit gyroscope with a range of ±2000 degrees per second, a triaxial geomagnetic sensor and a 32-bit cortex M0+ microcontroller in a single package.

The corresponding chip-sets are integrated into one single 28-pin LGA 3.8mm x 5.2mm x 1.1 mm housing.

Contents

1. Specification

If not stated otherwise, the given values are over lifetime and full performance temperature and voltage ranges, minimum/maximum values are ±3 sigma.

1.1 Electrical specification

Table 1-1: Electrical parameter specification

OPERATING CONDITIONS BMF055						
Parameter	**Symbol**	**Condition**	**Min**	**Typ**	**Max**	**Unit**
Supply Voltage (only Sensors)	V_{DD}	--	2.4	--	3.6	V
Supply Voltage (µC and I/O Domain)	V_{DDIO}	--	1.7	--	3.6	V
Voltage Input Low Level (UART, I2C)	V_{DDIO_VIL}	V_{DDIO} = 1.7-2.7V	--	--	0.25	V_{DDIO}
		V_{DDIO} = 2.7-3.6V	--	--	0.3	V_{DDIO}
Voltage Input High Level (UART, I2C)	V_{DDIO_VIH}	V_{DDIO} = 1.7-2.7V	0.7	--	--	V_{DDIO}
		V_{DDIO} = 2.7-3.6V	0.55	--	--	V_{DDIO}
Voltage Output Low Level (UART, I2C)	V_{DDIO_VOL}	V_{DDIO} > 3V , I_{OL} =20mA	--	0.1	0.2	V_{DDIO}
Voltage Output High Level (UART, I2C)	V_{DDIO_VOH}	V_{DDIO} > 3V , I_{OH} =10mA	0.9	0.8	--	V_{DDIO}
POR Voltage threshold on VDDIO-IN rising	V_{DDIO_POT+}	V_{DDIO} falls at 1V/ms or slower	--	1.45	--	V
POR Voltage threshold on VDDIO-IN falling	V_{DDIO_POT-}		--	0.99	--	V
Operating Temperature	T_A	Min and Max are in this case simply min and max and not 3s values	-40	--	+85	°C

Note: Since the resulting total supply current is subject to vary depending on the custom specific firmware which runs in the sensor, there is no information mentioned for current consumption. For additional information with respect to the individual sensors (accelerometer, gyroscope and magnetometer) and to the MCU please refer the respective datasheet.

Electrical and physical characteristics, measurement performance

Table 1-2: Electrical characteristics BMF055

OPERATING CONDITIONS ACCELEROMETER						
Parameter	**Symbol**	**Condition**	**Min**	**Typ**	**Max**	**Units**
Acceleration Range	g_{FS2g}	Selectable via serial digital interface		±2		g
	g_{FS4g}			±4		g
	g_{FS8g}			±8		g
	g_{FS16g}			±16		g
OUTPUT SIGNAL ACCELEROMETER						
Parameter	**Symbol**	**Condition**	**Min**	**Typ**	**Max**	**Units**
Sensitivity	S	All g_{FSXg} Values, T_A=25°C		1		LSB/mg
Sensitivity tolerance	S_{tol}	Ta=25°C, g_{FS2g}		±1	±4	%
Sensitivity Temperature Drift	TCS	g_{FS2g}, Nominal V_{DD} supplies, Temp operating conditions		±0.03	±0.02	%/K
Sensitivity Supply Volt. Drift	S_{VDD}	g_{FS2g}, T_A=25°C, $V_{DD\_min} \le V_{DD} \le V_{DD\_max}$		0.05	0.2	%/V
Zero-g Offset (x,y.z)	Off_{xyz}	g_{FS2g}, T_A=25°C, nominal V_{DD} supplies, over life-time	-150	±80	+150	mg
Zero-g Offset Temperature Drift	TCO	g_{FS2g}, Nominal V_{DD} supplies		±1	+/-3.5	mg/K
Zero-g Offset Supply Volt. Drift	Off_{VDD}	g_{FS2g}, T_A=25°C, $V_{DD\_min} \le V_{DD} \le V_{DD\_max}$		0.5		mg/V
Bandwidth	bw_8	2nd order filter, bandwidth programmable		8		Hz
	bw_{16}			16		Hz
	bw_{31}			31		Hz
	bw_{63}			63		Hz
	bw_{125}			125		Hz
	bw_{250}			250		Hz
	bw_{500}			500		Hz
	bw_{1000}			1,000		Hz
Nonlinearity	NL	best fit straight line, g_{FS2g}		±0.5	+/-2	%FS
Output Noise Density	n_{rms}	g_{FS2g}, T_A=25°C Nominal V_{DD} supplies Normal mode		150	190	μg/√Hz
MECHANICAL CHARACTERISTICS ACCELEROMETER						
Parameter	**Symbol**	**Condition**	**Min**	**Typ**	**Max**	**Units**
Cross Axis Sensitivity	CAS	relative contribution between any two of the three axes		1	2	%
Alignment Error	E_A	relative to package outline		±0.5	2	°

Parameter	Symbol	Condition	Min	Typ	Max	Unit
OPERATING CONDITIONS GYROSCOPE						
Rate Range	R_{FS125}	Selectable via serial digital interface		125		°/s
	R_{FS250}			250		°/s
	R_{FS500}			500		°/s
	R_{FS1000}			1,000		°/s
	R_{FS2000}			2,000		°/s
OUTPUT SIGNAL GYROSCOPE						
Sensitivity via register Map	S	Ta=25°C		16.0 900		LSB/°/s rad/s
Sensitivity tolerance	S_{tol}	Ta=25°C, R_{FS2000}	--	±1	±3	%
Sensitivity Change over Temperature	TCS	Nominal V_{DD} supplies -40°C ≤ T_A ≤ +85°C R_{FS2000}		±0.03	±0.07	%/K
Sensitivity Supply Volt. Drift	S_{VDD}	T_A=25°C, $V_{DD\_min} \le V_{DD} \le V_{DD\_max}$		<0.4		%/V
Nonlinearity	NL	best fit straight line R_{FS1000}, R_{FS2000}		±0.05	±0.2	%FS
Zero-rate Offset	Off Ω_x Ω_y and Ω_z	Nominal V_{DD} supplies T_A=25°C, Slow and fast offset cancellation off	-3	±1	+3	°/s
Zero-Ω Offset Change over Temperature	TCO	Nominal V_{DD} supplies -40°C ≤ T_A ≤ +85°C R_{FS2000}		±0.015	±0.03	°/s per K
Zero-Ω Offset Supply Volt. Drift	$Off\Omega_{VDD}$	T_A=25°C, $V_{DD\_min} \le V_{DD} \le V_{DD\_max}$		0.1		°/s /V
Output Noise	n_{rms}	rms, BW=47Hz (@ 0.014°/s/√Hz)		0.1	0.3	°/s

Parameter	Symbol	Condition	Min	Typ	Max	Units
Bandwidth BW	f_{-3dB}			523 230 116 64 47 32 23 12		Hz
MECHANICAL CHARACTERISTICS GYROSCOPE						
Cross Axis Sensitivity	CAS	Sensitivity to stimuli in non-sense-direction		±1	±3	%
OPERATING CONDITIONS MAGNETOMETER						
Parameter	**Symbol**	**Condition**	**Min**	**Typ**	**Max**	**Units**
Magnetic field range[1]	Brg,xy	TA=25°C	±1200	±1300		µT
	Brg,z		±2000	±2500		µT
Magnetometer heading accuracy[2]	As heading	30µT horizontal geomagnetic field component, TA=25°C			±2.5	deg
MAGNETOMETER OUTPUT SIGNAL						
Parameter	**Symbol**	**Condition**	**Min**	**Typ**	**Max**	**Unit**
Device Resolution	$D_{res,m}$	T_A=25°C		0.3		µT
Gain error[3]	$G_{err,m}$	After API compensation T_A=25°C Nominal V_{DD} supplies		±5	±8	%
Sensitivity Temperature Drift	TCS_m	After API compensation -40°C ≤ T_A ≤ +85°C Nominal V_{DD} supplies		±0.01	±0.03	%/K
Zero-B offset	OFF_m	T_A=25°C		±40		µT
Zero-B offset Temperature Drift	TCO_m	-40°C ≤ T_A ≤ +85°C		±0.23	±0.37	µT/K
Full-scale Nonlinearity	$NL_{m, FS}$	best fit straight line			1	%FS

[1] Full linear measurement range considering sensor offsets.
[2] The heading accuracy depends on hardware and software. A fully calibrated sensor and ideal tilt compensation are assumed.
[3] Definition: *gain error = ((measured field after API compensation) / (applied field))* – 1

Output Noise	$n_{rms,lp,m,xy}$	Low power preset x, y-axis, T_A=25°C Nominal V_{DD} supplies		1.0		µT
	$n_{rms,lp,m,z}$	Low power preset z-axis, T_A=25°C Nominal V_{DD} supplies		1.4		µT
	$n_{rms,rg,m}$	Regular preset T_A=25°C Nominal V_{DD} supplies		0.6		µT
	$n_{rms,eh,m}$	Enhanced regular preset T_A=25°C Nominal V_{DD} supplies		0.5		µT
	$n_{rms,ha,m}$	High accuracy preset T_A=25°C Nominal V_{DD} supplies		0.3		µT
Power Supply Rejection Rate	$PSRR_m$	T_A=25°C Nominal V_{DD} supplies		±0.5		µT/V

2. Absolute Maximum Ratings

Table 2-1: Absolute maximum ratings (preliminary target values)

Parameter	Symbol	Condition	Min	Max	Units
Voltage at Supply Pin	V_{DD} Pin		-0.3	4.2	V
	V_{DDIO} Pin		-0.3	3.6	V
Voltage at any Logic Pin	$V_{non\text{-}supply}$ Pin		-0.3	V_{DDIO}+0.3	V
Passive Storage Temp. Range	Trps	≤ 65% rel. H.	-50	+150	°C
Mechanical Shock	$MechShock_{200\mu s}$	Duration ≤ 200µs		10,000	g
	$MechShock_{1ms}$	Duration ≤ 1.0ms		2,000	g
	$MechShock_{freefall}$	Free fall onto hard surfaces		1.8	m
ESD	ESD_{HBM}	HBM, at any Pin		2	kV
	ESD_{CDM}	CDM		400	V
	ESD_{MM}	MM		200	V

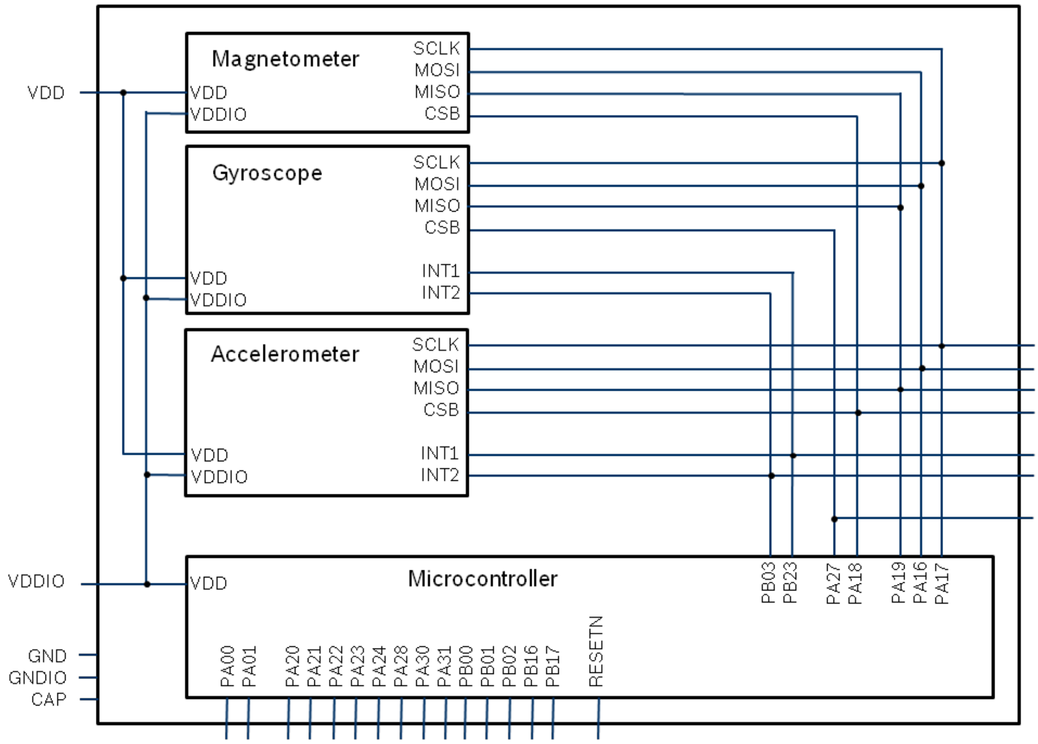
Note:
Stress above these limits may cause damage to the device. Exceeding the specified electrical limits may affect the device reliability or cause malfunction.

3. Functional Description

3.1 Architecture

The following figure shows the basic building blocks of the BMF055 device.

Figure 1: system architecture



3.2 Power management

The BMF055 has two distinct power supply pins:

- V_{DD} is the main power supply for the internal sensors
- V_{DDIO} is a separate power supply pin used for the supply of the µC and the digital interfaces

For the switching sequence of power supply V_{DD} and V_{DDIO} it is mandatory that V_{DD} is powered on and driven to the specified level before or at the same time as V_{DDIO} is powered ON. Otherwise there are no limitations on the voltage levels of both pins relative to each other, as long as they are used within the specified operating range.

When the V_{DDIO} supply is switched off, all interface pins (CSB, MOSI, MISO, SCLK) must be kept close to GND_{IO} potential.

4. Accelerometer

The accelerometer built into the BMF055 is equivalent to the BMA280. Please refer to the appropriate data sheet of that sensor for the functional description.

The performance values of the in-built accelerometer differ from the values stated at the BMA280 data sheet and can be found in this document.

5. Gyroscope

The gyroscope built into the BMF055 is equivalent to the BMG160. Please refer to the appropriate data sheet of that sensor for the functional description.

The performance values of the in-built gyroscope differ from the values stated at the BMG160 data sheet and can be found in this document.

6. Magnetometer

The magnetometer built into the BMF055 is equivalent to the BMM150. Please refer to the appropriate data sheet of that sensor for the functional description.

The performance values of the in-built magnetometer differ from the values stated at the BMM150 data sheet and can be found in this document.

7. Microcontroller

The microcontroller built into the BMF055 is a **Cortex-M0+** from Atmel:

- Atmel product family / series: **SAMD20** (general purpose microcontroller)
- Flash memory size: **256kB**
- SRAM memory size: **32kB**

Please refer to the appropriate data sheet from Atmel (SAM D20 datasheet) for further information.

8. System setup

8.1 Internal sensor connection

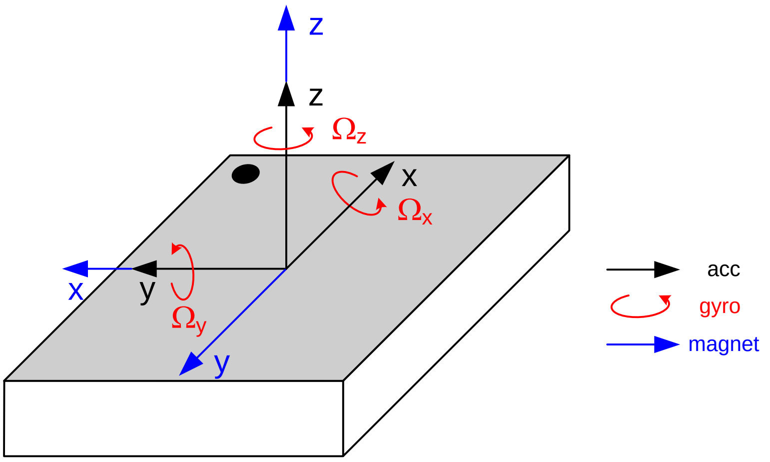
The sensors are connected to the MCU via SPI interface.

8.2 Programming and debug interface

The MCU can be programmed and debugged via Atmel debugging tools using the SWD interface.

8.3 Sensing Axes Orientation

The axis orientation is shown below.



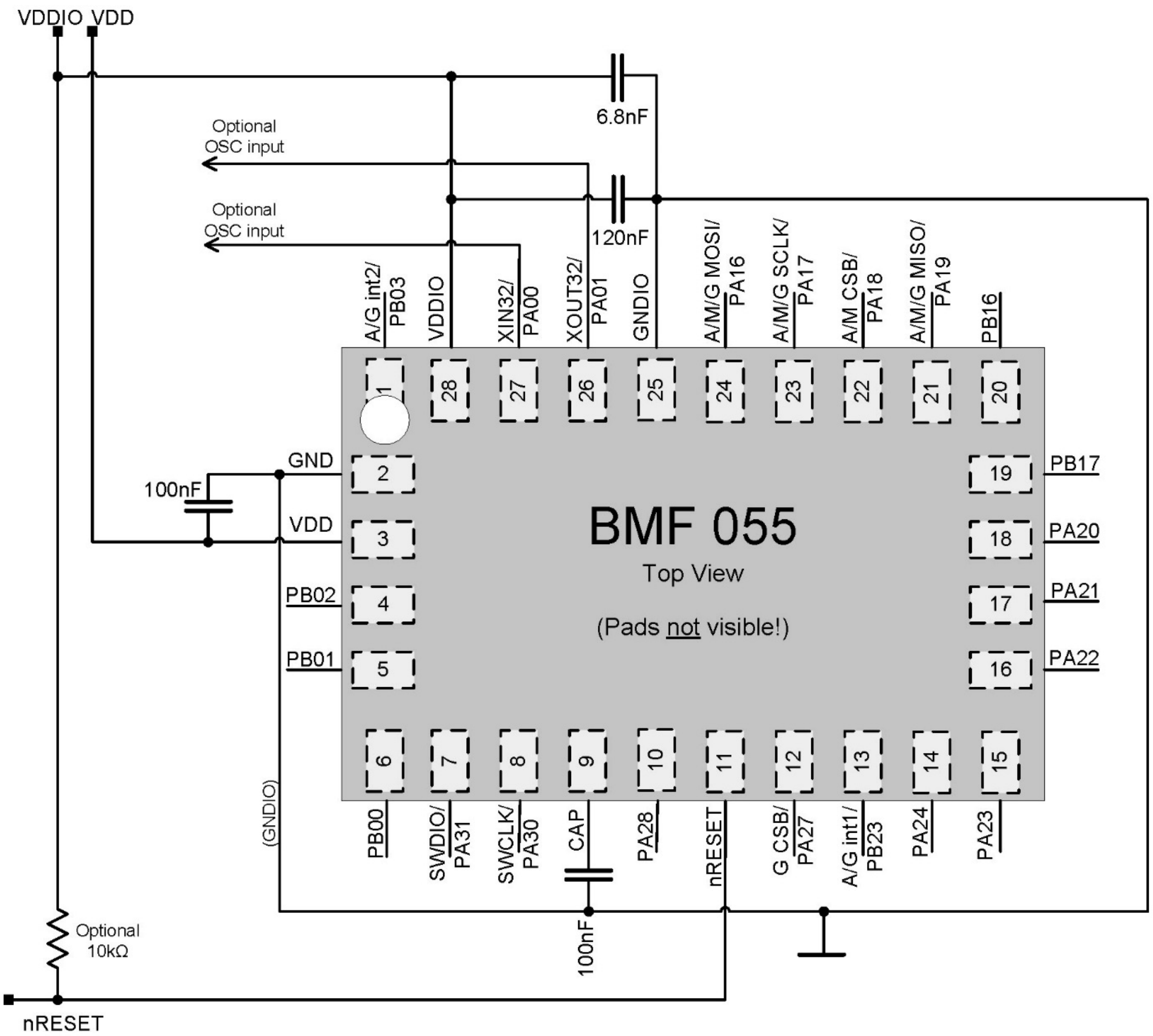
9. Pin-out and connection diagram

9.1 Pin description

If no port function is mentioned, the pin can be generally used as a general purpose IO. Details can be found in the Atmel SAM D20 datasheet. The pin names in this document are the same as in the microcontroller datasheet.

Pin No.	Pin Name	Internal connection	Port Function
1	PB03	X	Accelerometer / gyroscope INT2
2	GND	X	GND
3	VDD	X	VDD
4	PB02		
5	PB01		
6	PB00		
7	PA31		SWDIO
8	PA30		SWCLK
9	CAP		external capacitor
10	PA28		
11	RESETN		RESETN
12	PA27	X	Gyroscope CSB
13	PB23	X	Accelerometer / gyroscope INT1
14	PA24		
15	PA23		
16	PA22		
17	PA21		
18	PA20		
19	PB17		
20	PB16		
21	PA19	X	Internal SPI: MISO
22	PA18	X	Accelerometer / magnetometer CSB
23	PA17	X	Internal SPI: SCLK
24	PA16	X	Internal SPI: MOSI
25	GNDIO	X	GNDIO
26	PA01		optional: 32kHz Crystal Output
27	PA00		optional: 32kHz Crystal Input
28	VDDIO	X	VDDIO

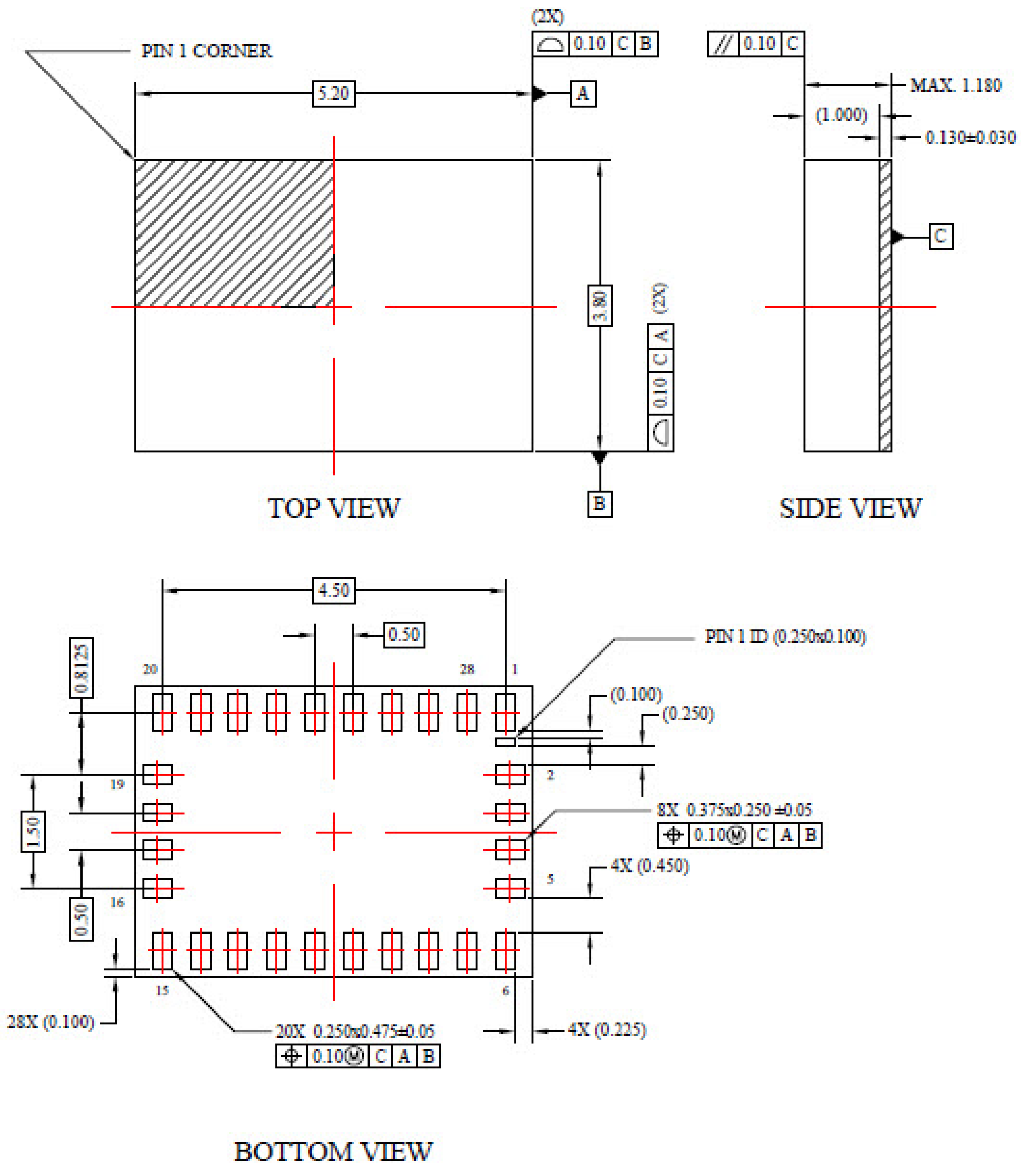
9.2 Connection diagram



10. Package

10.1 Outline dimensions

The sensor package is a standard LGA package; dimensions are shown in the following diagram. Units are in mm. Note: Unless otherwise specified tolerance = decimal ±0.1mm.

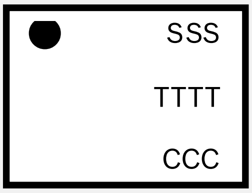


10.2 Landing pattern recommendation

Please refer to the Handling, mounting and soldering instructions document for BNO055.

10.3 Marking

Table 10-1: Marking of mass production parts

Labeling	Name	Symbol	Remark
	Pin 1 identifier	●	---
	First Row	S	Internal use
	Second Row	T	Internal use
	Third Row	C	Numerical counter

10.4 Soldering Guidelines

The moisture sensitivity level of the BMF055 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 standard, i.e. reflow soldering with a peak temperature up to 260°C.

10.5 Handling instructions

Micromechanical sensors are designed to sense acceleration with high accuracy even at low amplitudes and contain highly sensitive structures inside the sensor element. The MEMS sensor can tolerate mechanical shocks up to several thousand g's. However, these limits might be exceeded in conditions with extreme shock loads such as e.g. hammer blow on or next to the sensor, dropping of the sensor onto hard surfaces etc.

We recommend avoiding g-forces beyond the specified limits during transport, handling and mounting of the sensors in a defined and qualified installation process.

This device has built-in protections against high electrostatic discharges or electric fields (e.g. 2kV HBM); however, anti-static precautions should be taken as for any other CMOS component. Unless otherwise specified, proper operation can only occur when all terminal voltages are kept within the supply voltage range. Unused inputs must always be tied to a defined logic voltage level.

For more details on recommended handling, soldering and mounting please contact your local Bosch Sensortec sales representative and ask for the "Handling, soldering and mounting instructions" document.

10.6 Tape and reel specification

The BMF055 is shipped in a standard cardboard box. For details please refer to the BNO055 shipment details document.

10.7 Environmental safety

The BMF055 sensor meets the requirements of the EC restriction of hazardous substances (RoHS and RoHS2) directive, see also:

Directive 2002/95/EC of the European Parliament and of the Council of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment.

10.7.1 **Halogen content**

The BMF055 is halogen-free. For more details on the analysis results please contact your Bosch Sensortec representative.

11. Legal disclaimer

11.1 Engineering samples

Engineering Samples are marked with an asterisk (*) or (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.

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11.3 Application examples and hints

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12. Document history and modifications

Rev. No	Chapter	Description of modification/changes	Date
0.1		Initial version	2015-11-16

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